University of London

MSc in Telecommunications

A One-Year Full-time Course

Module Descriptions

Introduction to Telecommunication Networks (ITN)
Communication Systems Modelling (CSM)
Switching and Signalling (S&S)
Mobile and Personal Communications (MPC)
Software for Network and Services Design (SNS)
Public Telecommunication Networks (PTN)
ATM and Broadband Networking (ABN)
Network Planning and Performance (NPP)
Data Networks and Protocols (DNP)
Telecommunications Transmission Systems (TTS)

University College London
In association with
Imperial College
King's College
Queen Mary and Westfield College

Introduction to Telecommunication Networks (ITN)

This module provides a wide perspective of available Networks and their properties. The following topics are addressed: networks and services; network hardware; ISO model and data networks; sources and signal characteristics; PCM systems; integrated services digital network (ISDN); plesiochronous digital hierarchy (PDH); synchronous digital hierarchy (SDH); synchronous transport networks; teletraffic engineering and performance evaluation; network control and signalling; management of networks; network integration and evolution towards B ISDN.

Module Manager: Professor John O'Reily
Industrial Monitor: BNR Europe Ltd SEE PAPER

Communication Systems Modelling (CSM)

This module provides in-depth exposure to analytic and numerical techniques appropriate to the representation, analysis and performance evaluation of communication systems. Being predominantly analytic in nature the course requires a reasonable mathematical background such as is provided by an honours degree in electronic engineering or physics. Topics addressed include: deterministic signal representation and analysis, Fourier techniques, Hubert transforms, analytic carrier and complex envelope representations for narrow band signals, spectral characterisation of various signals and modulation formats, probability and stochastic processes, generating functions, bounds and approximations, random point processes, Markov processes and queuing theory. The role of simulation in the modelling of communications systems will be discussed and illustrated by reference to commercial time- and event-driven software tools. Some of the problems encountered in mapping the analytic techniques to a computer based implementation will also be discussed.

Module Manager: Professor John O'Reilly
Industrial Monitor: GEC Research Centre SEE PAPER

Switching and Signalling (S&S)

This module provides coverage of telecommunications switching principles and practice, of switching systems control and of the associated signalling systems and networks. Topics addressed include: development of switching systems; space switching and time switching; circuit, message and packet switching principles; switching network theory; digital switching and stored programme control (SPC), data structures for SPC software, specification and design using SDL; signalling requirements, channel associated signalling, common channel signalling and CCITT SS7; signalling networks and switching systems control, call processing; integrity, numbering, routing and charging; future trends and the requirements for broadband multiservice networks.

Module Manager: Professor Laurie Cuthbert
Industrial Monitor: AT&T SEE PAPER

Mobile and Personal Communications (MPC)

This module provides detailed coverage of current practice and emerging systems for cellular mobile radio systems and sets this alongside the increasing demand for truly personal communications. Topics addressed include: cellular radio system principles; frequency planning; cell splitting; teletraffic and performance engineering for cellular systems; analogue system options and case studies; options for digital cellular including CDMA; the Global System for Mobile communications (GSM); DECT; CT2; DCS 1800; PCN; terminal and personal mobility; implementing roaming,; mobility within the fixed network; contrast of the USM solution with IN implementations of mobility; future systems; UMTS, FPLMTS and MBS.

SEE PAPER

Software for Network and Services Design (SNS)

This course is primarily experimental in nature. Lectures, hands-on activities and demonstrations are combined to provide exposure to, and experience of, a range of software skills appropriate to communications engineering. Following a period spent gaining familiarity with Unix and C programming, the concept of object oriented design is introduced. This introduction is re-inforced through a set of laboratory exercises which will introduce and teach JAVA and the concept of distributed computing. Techniques appropriate to the development and optimisation of code will be introduced and discussed. Some of the concepts and techniques appropriate to the development of easy-to use interfaces are presented. This module will be assessed through a set of coding and written assignments, some of which will be carried out during the module.

Module Manager: Dr Mark Sear/c
Industrial Monitor: BT Laboratories SEE PAPER

Public Telecommunication Networks (PTN)

This module identifies and develops the main attributes of the public telecommunications network, building upon the foundation laid in Introduction to Telecommunications Networks. Topics addressed include: the public switched telephone network (PSTN); mobile radio networks, satellite and submarine international links as part of the global network; integrated services digital network (ISDN), ISDN applications and services, asynchronous transfer mode (AIM) principles and networking, numbering routing and charging, local access and internodal signalling, customer premises equipment (CPE) and the customer interface, role of optical fibres in the access network, drivers for public network evolution.

Module Manager: Professor John O'Reilly
Industrial Monitor: BT SEE PAPER

ATM and Broadband Networking (ABN)

Topics addressed include. introduction to ATM, ATM layer, ATM adaptation layer (AAL), traffic sources, statistical parameters of sources, introduction to source modelling, levels of time resolution, deterministic process, Bernoulli/geometric process, discrete-time discrete 2-state Markov process superposition and GMDP, source models and superposition, parameterisation of models, Poisson process and its superposition/decomposition, continuous time discrete state Markov models, models for traffic sources (e.g. autoregressive, DMAP), case study on statistical multiplexing of voice traffic, ATM switching and modelling issues, Banyan switches, sort-Banyan switches, output buffered switches/design of large switches, statistical multiplexing, introduction to traffic control/resource management, connection admission control, usage parameter control, performance evaluation techniques, physical layer and network elements.

Module Manager: Professor Laurie Cuthbert
Industrial Monitor: GPT Ltd. SEE PAPER

Network Planning and Performance (NPP)

Planning overview; An extended network planning case study – ACNE Island; quality of service, performance engineering, forecasting and traffic measurement, traffic management, numbering and addressing, teletraffic theory, traffic routing and dimensioning, network planning, computer support systems, evolution of internet, planning asynchronous transfer mode (AIM) networks.

Module Manager: Professor Keith Ward
Industrial Monitor: BT SEE PAPER

Data Networks and Protocols (DNP)

This module is concerned primarily with the architecture and technology of data flows in networks. The OSI model is examined in some detail along with protocols for error and flow control, dynamic routing and congestion control. The application of WAN, MAN, and LAN technologies is reviewed with emphasis given to standard realisations. Routing, bridging and service aspects of inter networking are examined. Various applications are reviewed including X25, X400 and the principles underlying multi-media services are developed. Topics addressed include: services and protocols; connection-oriented and connectionless services; layering and the OSI model; data link layer; protocols for error and flow control; mesh type data networks; dynamic routing and congestion control; broadcast WANs; local area networks: IEEE model, CSMA-CD, Ethernet, token passing and FDDI; metropolitan area networks; naming and addressing; internetworking; service and protocol relays, routers and bridges; transport layer; session layer; presentation layer; applications layer structure,' email - X400- as an example 081 application; multi-media services.

Module Manager: Professor Steve Wilbur
Industrial Monitor: HP Laboratories SEE PAPER

Telecommunications Transmission Systems (TTS)

This module addresses mainly physical layer issues associated with three main transmission technologies - copper, radio and fibre. Transmission fundamentals and techniques are explored and placed in the context of telecommunications access, core, and international network realisation and applications. `topics addressed include: characteristics of copper cables, optical fibres, and radio channels, digital transmission; optical fibre systems; modulation and coding for radio systems - including channel error control and multiple access techniques. Practical cases of fixed and mobile radio systems are explored. The role of optics in the network is examined with performance limitations - transmitter, fibre, receiver and optical amplifier-regenerator related issues - being considered in some detail. The capabilities of optical fibre and optical amplifiers to provide for very high capacity, very long haul transmission - as with trans-national and international links - is examined and performance limiting factors are explored. The use of fibre and radio plesiochronous and synchronous (SDH and SONET) networks is illustrated. The role of fibre in the access network -e.g. via remote multiplexers/concentrators - is examined and the prospects for further penetration are explored. The use of digital signal processing (DSP) techniques to enhance the capabilities of the copper access network to support high capacity transmission are discussed, including asymmetric digital subscriber line (ADSL) and high speed digital subscriber line (HDSL) and inverse multiplexing schemes.

Module Manager: Professor John O'Reilly
Industrial Monitor: Alcatel SEE PAPER

University of London

Masters Programmes in Telecommunications

Introduction to Telecommunication Networks

Examination 1998/99

Notes:

* This paper comprises five (5) questions

* The marks allocated to parts of questions are indicated for guidance

* Candidates are required to answer three (3) questions

* Time allowed 2 Hours

MSc in Telecommunications
MRes in Telecommunications
IGDP `Telecommunications for Industry'

Question 1.

(a) Outline briefly the principles underlying pulse code modulation (PCM), indicating how the key system parameters are determined.

[25%]

(b) PCM applied to telephony makes use of companding. Explain what this is and what benefits it provides in this context.

[25%]

(c) PCM systems make use of time division multiplexing to combine several channels onto a single bearer. This is achieved somewhat differently in the USA and some other parts of the world compared with Europe. Outline briefly the key features of each arrangement. Comment in particular on the implications of the US signalling arrangement for speech quality and the available digital networking `clear channel' data rate.

[50%]

Question 2.

Wireless Loops Ltd has recently recruited a new Senior Design Engineer for its radio section. She is to be known in the company as SDE-R - and she is hoping to make an early impact in her new post: she has her eye firmly on advancement to senior management and beyond!

She observes that WLL is making use of a specification document from the European Telecommunications Standards Institute (ETSI) relating to 38GHz digital radio systems that states that the `background bit error rate' (BBER) for the equipment should be not greater than.10^{-10}. The document further states that the measurement time should not exceed 20 hours.

She asserts that WLL's new ISDN local loop product for the consumer market should not be evaluated against this standard.

Her managers who has extensive experience with 38GHz digital radio systems offering `self-provided links' for mobile network operators, challenges this assertion. Indeed, he feels rather pleased to have this early opportunity to demonstrate his superior knowledge and expertise.

A somewhat heated debate ensues which leads to WLL reviewing very carefully its evaluation requirements for this new product. In the eventuality, SDE-R is vindicated.

Explain why you think this was the case and where the experienced radio engineer slipped up technically (as opposed to slipping up managerially in `losing his cool'!).

[100%]

Question 3.

(a) Outline the frame structure and principles of operation of the synchronous digital hierarchy (SDH). Indicate how and to what extent this addresses the limitations of the established plesiochronous transmission systems.

[50%]

(b) In the USA and certain other parts of the world the SONET rather then SDH standard has been adopted. Indicate the main differences between SONET and SDH and suggest why

you think different standards were adopted.

[25%]

(c) It has been suggested that:

"*SDH is a World standard, with SONET a local variant*".

Comment on this statement with particular reference to interworking considerations.

[25%]

Question 4.

Just three years ago the headline of an advertising poster from a major telecommunications equipment and `network solutions' supplier was made the subject of an examination question by adding the directive `discuss':

"*ATM is the answer What is the Question?"* - Discuss.

In 1998 this might easily read:

"*JP is the answer What is the question?"* - Discuss

Discuss!

[100%]

Question 5.

(a) Outline the key features of a cellular mobile telecommunications network, indicating how calls are established between users on a fixed network and users on the mobile network.

[50%]

(b) There are three basic multiple access techniques, all of which have been used as the basis for mobile communications. Indicate what these are and how they differ from one another in their basic operation.

[25%]

(c) Comment on the relative merits in the UK of 900 MHz and 1800 MHz operation for GSM systems and on what consequential benefits this affords an operator licensed to provide service in both frequency bands.

[25%]

END OF PAPER

University of London

Masters Programmes in Telecommunications

Communication Systems Modelling

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MSc in Telecommunications
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Question 1.

Consider the time domain signal x(t) shown in figure 1.

(i) Represent this analytically using Woodward' s notation.

[25%]

(ii) Hence obtain an analytic expression for the Fourier transform, X(/).

[25%]

(iii) Indicate the form of X(f) graphically.

[25%]

(iv) Obtain an analytic expression for and sketch the Energy Density Spectrum S/I).

[25%]

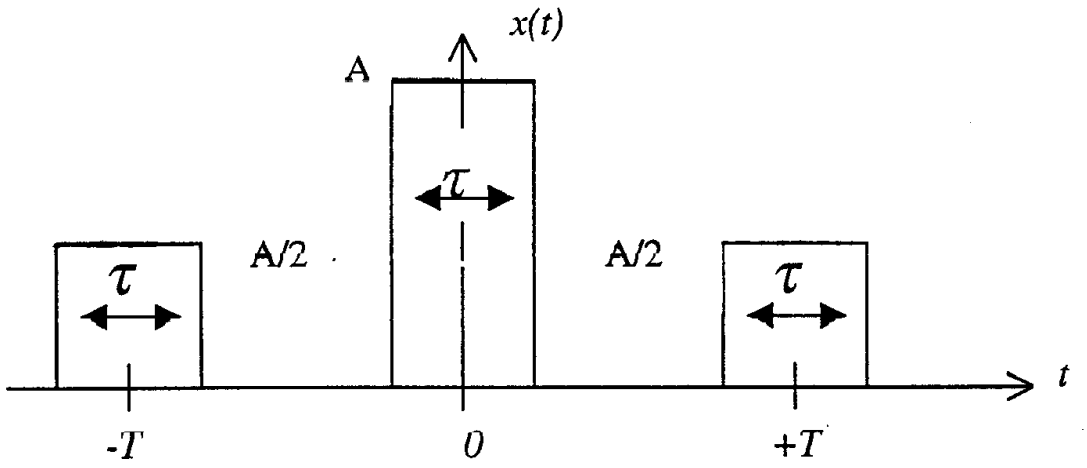

Figure Q1

Question 2

(i) State a simple form of the sampling theorem, identifying clearly restrictions/limitations to its applicability.

[25%]

(ii) Explain what is meant by the term `sub-Nyquist' sampling in the context of signal representation and recovery.

[25%]

Now consider a signal x(:) strictly bandlimited to W < |f |< 2W.

(iii) Show that x(t) may be represented by - and in principle recovered distortion free from - sample values x(nT). n integer, provided T is chosen appropriately.

[25%]

(iv) Determine with the aid of Woodward's notation (supporting/interpreting your analysis graphically) the maximum allowable value for T if x(t) is to be recoverable and indicate the form required for the recovery filter.

[25%]

TURN OVER

Question 3.

(i) Consider a random variable X taking non-negative integer values, with probability distribution $\{f_n\}$. Define the corresponding probability generating function $F_X(z)$ and moment generating function $M_X(s)$.

[25%]

(ii) Show that both the individual probabilities and the moments of X may be recovered from $F_X(z)$

[25%]

(iii) In view of (ii) above indicate why in general we find it convenient to define and make use of the moment generating function rather than limit ourselves to just the probability generating function.

[25%]

(iv) A compound Poisson process has events occurring independently at random at rate A. The number of events occurring in a given fixed time interval T is defined as a random variable X with probability distribution {f}. Events are marked by a positive integer valued random variable Y with probability distribution {g}. A random variable W is defined as the sum of the weighted events occurring in T and has probability distribution {h} and corresponding probability generating function H(z).

Determine analytically H(z) and hence obtain an expression for the variance of W in terms of λ and the variance of Y.

[25%]

Question 4.

(i) Consider a signal x(t) with Fourier spectrum X(f) processed by an instantaneous non-linearity the form of which is such that the output y is related to the input x by:

$$y = x + b.x^2 + cx^2; \text{ with } b, c << 1$$

Show how the output spectrum Y(f) is related analytically to the input spectrum X(f).

[25%]

(ii) For the non-linear operation of (i) above and the input signal spectrum shown in Figure Q4 below, determine and sketch the corresponding output spectral components. If c=0 indicate how a distortion-free output signal may be obtained despite the non-linear nature of this signal processing operation.

[25%]

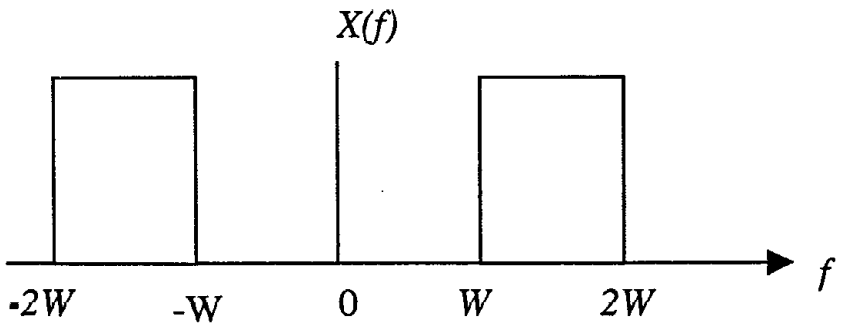

Figure Q4

(iii) The Hilbert transform, analytic carrier and complex envelope provide powerful tools for the representation and analysis of bandpass signals. Indicate how each is

defined and thereby obtain a time-domain representation for a single-sideband signal, x(t), occupying the band F_c to $F_c + W$.

[25%]

(iv) Consider a bandpass noise process n(t). Show how this may be represented in `quadrature carrier' form, indicating how the parameters of your representation relate to the spectral density and bandwidth of the noise process.

[25%]

Question 5.

(i) Discuss the general role of simulation in communications systems studies. In particular, indicate what you see as the relative merits and demerits of formal analytic investigation compared with an investigation based upon simulation.

[25%]

(ii) Distinguish clearly between time-driven and event-driven simulation. Provide a practical example of each type of simulator applicable to communication systems and networks studies, indicating clearly the general nature of system investigations for which each is likely to be employed.

[25%]

(iii) Physical-layer communication systems simulation sometimes makes use of so-called `Quasi-Analytic' (QA) techniques. Explain what is meant by this, why QA techniques are needed/appropriate and in what circumstances.

[25%]

(iv) A digital microwave radio system is to be simulated with a view to determining the `margin' in received radio signal power under normal, `unfaded' propagation conditions. The operational requirements call for a residual bit error rate (RBER) of less than 10^{-11}. Suggest what special challenges this presents to the designers of the simulation and how they might be addressed.

[25%]

END OF PAPER

University of London

Masters Programmes in Telecommunications

Switching and Signalling

Examination: 1998/99

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MSc in Telecommunications
MRes in Telecommunications
IGDP `Telecommunications for Industry'

Question 1.

Describe, with sketches, how an audio indication of an incoming call is given:

(i) on 3 analogue telephones connected in parallel. Show, and explain, the components required to avoid interaction between the speech path, the signalling and the use of the other parallel telephones.

[40%]

(ii) on ISDN telephones on an I.420 bus. It may be assumed that one of the B-channels is already in use and hence Layer 1 is already established. Make clear the layer to which all messages relate.

[60%]

In both cases describe how an indication is passed to the exchange that the call has been answered by the lifting of the handset.

Question 2.

(1) Describe briefly the attributes of Circuit, Message, Packet and Fast Packet Switching techniques and mention the advantages and disadvantages of each of them.

[30%]

(ii) Show with the aid of a diagram how problems can occur in Stop and Wait, even with only one packet on a link, when you do not number everything.

[10%]

(ii) If the routing decisions are based on the metrics of traffic on the links then it is more likely that there could be unstable routing. Give an example of this, by using diagrams, with a small network where the metrics for the routing are given by the traffic flows on the links.

[20%]

(iv) Design the optimum frame size for the following X.25 Go-Back-N protocol. The link is 200 km in length and you can assume that the propagation speed is 3×10^8 m/s. The bit error rate (BER) on the link is 8.34×10^{-7} and the transmission speed is 43 Mb/s.

[40%]

Some Useful Summations

$$\sum_{i=0}^{\infty} p^i = \frac{1}{1-p}, \qquad 0 < p < 1; \qquad \sum_{i=1}^{\infty} p^i = \sum_{i=0}^{\infty} p^i - 1 = \frac{1}{1-p} - 1 = \frac{p}{1-p}$$

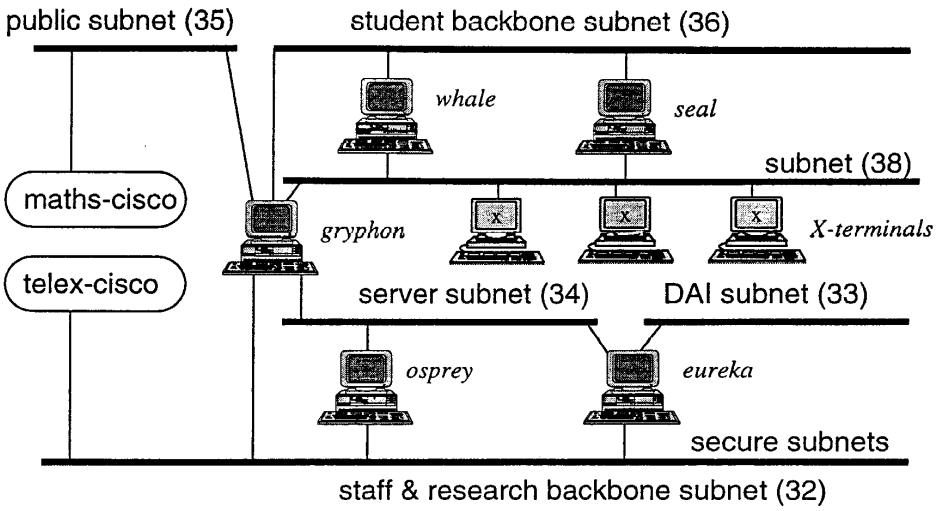
$$\sum_{i=0}^{\infty} i p^i = \sum_{i=0}^{\infty} p \frac{d}{dp} p^i = p \frac{d}{dp} \sum_{i=0}^{\infty} p^i = p \frac{d}{dp} \frac{1}{1-p} = p \frac{1}{(1-p)^2} = \frac{p}{(1-p)^2}$$

$$\sum_{i=0}^{\infty} (i+1) p^i = \sum_{i=0}^{\infty} \frac{d}{dp} p^{i+1} = \frac{d}{dp} p \sum_{i=0}^{\infty} p^i = \frac{d}{dp} p \frac{1}{1-p} = \frac{1}{(1-p)^2}$$

$$\sum_{i=0}^{N} p^i = \sum_{i=0}^{\infty} p^i - \sum_{i=N+1}^{\infty} p^i = \frac{1}{1-p} - \sum_{i=0}^{\infty} p^{N+1} p^i = \frac{1}{1-p} - \frac{p^{N+1}}{1-p} = \frac{1-p^{N+1}}{1-p}$$

Question 3.

The following diagram shows part of the LAN, within the Department of Electronic Engineering at Queen Mary and Westfield College:



(i) Answer the following questions about features that have been implemented in this LAN:

(a) What is meant by the term "secure" for subnet 32; why is it secure and what features of TCP/IP make such security possible?

[20%]

(b) Explain why the X-terminals for the student's service are connected to the 38 subnet, not to the student 36 subnet.

[20%]

(c) Osprey, gryphon and eureka are servers: suggest why it is a good idea for them to be connected together by a separate subnet.

[20%]

(ii) The diagram shows a network connected using routers: suggest, with the aid of a diagram, how similar functionality could be obtained using Ethernet switches and how this might offer advantages.

[40%]

Question 4.

I) Using diagrams as appropriate, discuss the advantages and disadvantages of input versus output buffering in ATM switching.

[60%]

ii) Derive a recurrence formula for the calculation of the state probabilities in an ATM output buffered switch, and indicate how these probabilities can be used to estimate the cell loss probability (CLP) in the output buffer. Discuss any weaknesses inherent in this approach.

[40%]

Question 5

With reference to a 3-stage non-blocking space division switch:

(i) show, using diagrams as appropriate, how to derive the condition for strict-sense non-blocking,

[40%]

(ii) derive the formula for the optimum subgroup size, and explain why this formula is approximate,

[40%]

(iii) discuss and explain what is meant by another sense of non-blocking, not strict-sense.

[20%]

END OF PAPER

University of London

Masters Programmes in Telecommunications

Mobile and Personal Communications

Examination 1998/99

Time allowed: 2 hours

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MSc in Telecommunications
MRes in Telecommunications
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Question 1.

(i) Discuss the difference between the way HSCSD and GPRS handle IP packet data. In your answer consider signalling, efficiency with which the air interface is used, perception of the service as seen by a user, and anything else you consider relevant.

[60%]

(ii) There are two air interface standards defined for UMTS - FDD and TDD. Discuss the expected role of these two, and then give, and justify, your view as to whether both will survive in the marketplace.

[40%]

Question 2.

(i) A GSM user has a subscription with a UK based service provider who uses one of the UK GSM network operators. Describe in detail what happens when a telephone in the fixed network in Germany calls the GSM user who happens to be on holiday in France. The user's phone is already switched on and registered with the French network.

[60%]

(ii) GSM uses a fairly complex framing structure to map logical channels onto the available physical channels.

(a) What is meant by the term "physical channel"?

[10%]

(b) Give a brief overview of how the mapping is realised.

[30%]

Question 3.

You are a technical advisor to a venture capital fund manager who has a number of cases that she needs to assess as to their suitability for investment. Prepare a short technical report for her that will guide her decision for each of the following scenarios:

(i) Two companies are competing for funds to develop equipment to provide short-range data connectivity between a personal digital assistant (PDA) and a mobile phone. One company is proposing to use IrDA, and the other is proposing to use Bluetooth. Contrast the two systems for your boss in the context of this application.

[50%]

(ii) A company is requesting funds to develop a "long-range" GSM system for very sparsely populated regions. The company is proposing to use cells whose radius exceed 100 km. Write a report that identifies why a standard GSM solution cannot be adopted for this application and identify a possible method that might be used to achieve this range extension.

[50%]

TURN OVER

Question 4.

At a recent European conference there was a debate with the following motion:

"UMTS is too little and too late".

Outline what you think are the main issues in contention here, organising these as two sets of `briefing notes' to be used `for' and `against' the motion.

[100%]

Question 5.

(i) Outline the general system architecture and main elements of a cellular communication system.

[25%]

(ii) Indicate how the cellular structure and frequency re-use patterns employed in mobile communications systems, influence attainable system capacity.

[25%]

(iii) Efficient speech coding is crucial to the success of a digital mobile system. With reference to GSM indicate in general terms techniques employed to achieve speech encoding at bit rates much lower than the normal 64kb/s normally employed in the fixed telephone network.

[25%]

(iv) Many GSM networks now support a half-rate speech coder and an enhanced full rate (EFR) coder as well as the original full rate coder. Indicate the different motivations for these two developments and comment on the implications for network capacity

[25%]

END OF PAPER

Assignment

To be completed by 14th May 1999

Answer all parts of the question

a) Complete the programs you were set for each part of the tutorial.

* the Day of the week calculating program described in tutorial 1
* the Networking program described in tutorial 2
* the Roots of a quadratic program of tutorial 3

30%

b) For each of the above programs perform the exercise of "reverse engineering" these through the inception and detailing software engineering phases using UML notation.

30%

a) Write a program, using UML in the design process where appropriate, to perform the task illustrated in figure 1. The diagram shows a schematic for translating a Fully Qualified Domain Name (FQDN) into an IP address.

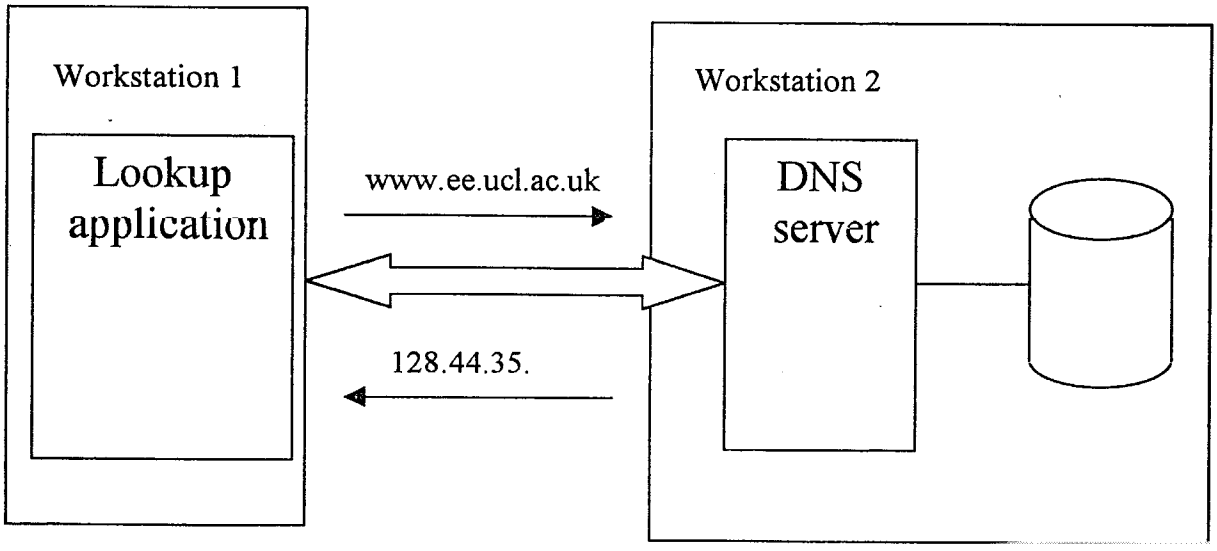


Figure 1

Write two applications, one for the lookup DNS server and one for the user application. The components of the program are as follows:

1) A database consists of records with two fields, the FQDN and the IP address. It is not necessary to write administration software to facilitate, for example, the addition of database entries. It is sufficient to either read a list from a file or define a static table. The database could be implemented using a hash table.

2) A DNS server can receive a request containing the FQDN and use this to lookup the database entry.

3) An application makes a single request from the server using a single input parameter, the FQDN. The application should check the general syntax of the input parameter. The reply from the server will be either an IP address or an error message. For example, the following is a suggested input:

java lookup www.ee.ucl.ac.uk

which should receive the reply:

www.ee.ucl.ac.uk -> 128.44.35.1

or possibly

www.ee.ucl.ac.uk -> No entry found

Hint: You can make use of the code from the Networking tutorial for the inter-workstation communications.

40%

University of London

Masters Programmes in Telecommunications

Public Telecommunication Networks

Assignment: 1998/00

Notes:

For the purposes of this assignment, you are a member of a strategy group for a new public network operator wanting to compete with incumbent operators such as BT and C&W As part of this work you need to provide responses to consultative calls from Oftel so that their developing polices and regulations favour your company's market position. Specifically, the company sees added value services such as Free Phone, Local Rate and eventually corporate VPN access as major re venue earners. The company also sees a strong market as an alternative national and international carrier where it is not an access provider

You are required to complete all Three parts of the assignment Each section carries equal weight The total length of the report should be limited to 10 pages.

The hand in date is ith January 1999

1GDP' Telecommunications for Industry'
MRes In Telecommunications
MSc In Telecommunications

Memo

To: Head of Network Strategy

From: Technical Director

CC: Telecommunications Programme

Date: 25/11/98

Re: Numbering strategy

I note from your recent report to the Managing Director that there are some serious omissions in regards to our strategy for the numbering of services. It is of the utmost importance that we develop our understanding and come up with a strategy. The board wishes to meet by 15'" January 1999 to discuss the situation. I need to ask you to write three reports that will strengthen our position in relation to these issues.

1) For our Managing Director

Needless to say, our MD is far to busy to read lengthy technical reports on how the new numbering scheme is supposed to look and how it relates to current services (e.g. what will happen to 0345?). To prepare for the board meeting she needs a summary report on how the forthcoming number organisation will work, including information about which services will come under the various headings. She needs to know, in brief what impact these changes might have on our equipment and who are the important `players' so far as regulation is concerned. The MD is also a little unclear about the issues related Carrier Pre-select. Could you make sure you include a description.

2) From our company to Oftel:

We need to strengthen the company's influence with the authorities controlling the number plans. Given our company's global mission concept (i.e. where we expect to earn money); we need to ensure that Oftel is aware of our concerns. Particularly, we have to ensure that there will be enough number ranges available to support our key services. Would you please draft an initial response to Oftel with regard to their number allocation plans arguing the case for uniform prefixes for our added value services. Also, argue the case for why more space should be allocated to these.

3) For our Network Planners:

Clearly, there will be some impact on both the maintenance and upgrade plans of our existing switching equipment. Also, as you know, we are intending to purchase an IN platform to co-locate with the one of the new DMSU switches currently being deployed. However, the Head of Planning tells me this will take at least another 2 years to complete. Could you please make some notes for the Planning Department as to which pieces of equipment will be impacted and explaining what the demands will be on our present SPC equipment and our planned IN role out.

I should point out that your position within this company is under review. Your performance in these activities will have an immediate impact on your future within the company.

University of London

Masters Programmes in Telecommunications

ATM & Broadband Networks

4th February 1999

Notes:

* This paper is organised into two sections: A and B

* Candidates are required to answer **3 (three)** questions at least **one** from **each** section

* The marks allocated to parts of questions are indicated for guidance

* Time allowed 2 Hours

MSc in Telecommunications
MRes in Telecommunications
IGDP `Telecommunications for Industry'

SECTION A

Question 1

You are the product design manager for a new telecommunications service which offers domestic customers very high definition, large screen conferencing. It is primarily intended to use the spare bandwidth available outside the busy commercial hours by encouraging social communication between friends and within families.

a. What bandwidths might be required; justify your answer. What network topologies could be used in:

   i) The customers premises
   ii) The access network
   iii) The core network

   Explain your answers giving the relative merits of alternatives.

[40%]

b. On what basis would you charge for the service? Compare and contrast the alternatives.

[30%]

c. Outline the information that would be required to specify:

   i) The Bearer service to be employed
   ii) The Teleservice

[30%]

Question 2

Describe the way buffering affects an end to end connection at the cell level in an ATM network, discussing those analytical models for performance prediction that you have available, and all sources of error you would encounter in using these techniques.

[100%]

Question 3

An approximation for the cell loss from an N*D/D/i queue is given by

$$Q(x) = \exp\left[-2x\left(\frac{x}{N} + \frac{1-\mathrm{r}}{\mathrm{r}}\right)\right]$$

(a) Explain how the parameters relate to the queueing system being analysed.

(25%)

(b) As an equation to determine cell loss, there are two approximations involved. Briefly explain what these approximations are and their impact on the results.

(25%)

(c) Sketch graphs of loss against buffer capacity using the equation and demonstrate the effect of the parameters. How does this compare with a similar approximation for the M/D/1 queue?

(25%)

(d) Show how the equation could be used in an admission control scheme. If the M/D/1 analysis is used instead as a basis for admission control, what difference would it make to the admissible load?

(25%)

SECTION B

Question 4

i) Explain the difference between a time series and a counting process.

[12%]

ii) Explain what is meant by a Markov Process.

[8%]

iii) A two - state Discrete Time Discrete State Markov Model has a transition probabilities P_{ij} where i= 0, 1 and j = 0,1. Within each state the number of packet arrivals within a time interval is d_i where i = 0, 1. Derive expressions for the equilibrium probability distribution [π_i] and hence obtain expression for the mean, variance and autocovariance.

[40%]

iv) A two - state Discrete Time Discrete State Markov Model is used to model a bursty source. Calculate the mean variance and autocovariance fot a lag of 1, given that the transition matrix [P] is.

$$[P] = \begin{bmatrix} 0.96 & 0.04 \\ 0.1 & 0.9 \end{bmatrix}$$

and the number of packet arrivals within a time interval are:

$$d_0 = 5, \quad d_1 = 10$$

Explain the physical meaning of the autocovariance.

[40%]

Question 5

(a) Describe, with the aid of a diagram, how the self-routing function is achieved in a banyan network. Describe the internal structure of the 2 X 2 switch elements used in such a network, with particular attention to how contention is resolved, and how buffering is performed.

[30%]

(b) Explain how routing is performed in a tandem banyan network. Explain why cell sequence may not be preserved on a virtual channel in such a switch and suggest a method for overcoming this deficiency of the switch architecture.

[20%]

(c) (i) Derive a recursive formula for the throughput of a bufferless banyan network with 2" inputs.

[20%]

(ii) Hence, or otherwise, determine the probability of cell loss in a 16-input banyan network with two banyans in tandem. You may assume infinite buffer capacity at the output multiplexor, and a 100% offered load balanced across all output ports of the switch.

[30%]

UNIVERSITY OF LONDON

Masters Programmes in Telecommunications

Network Planning and Performance 1998/99

Assignment
Issued 28th April 1999

Notes:

* The paper comprises 5 questions

* The marks allocated to parts of questions are indicated for guidance

- Candidates are required to answer 3 (three) questions

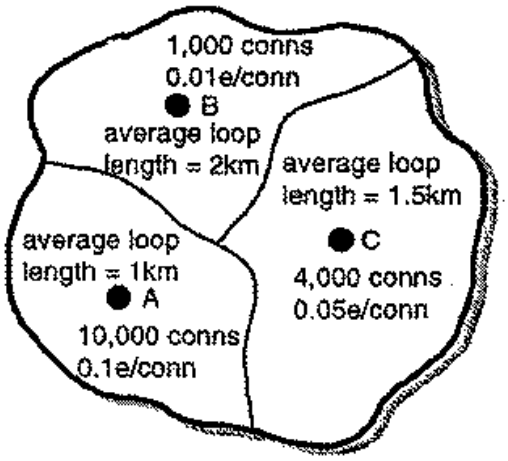
* Assignment to be handed in by 10th June 1999

IGDP Telecommunications for Industry'
MRes in Telecommunications
MSc in Telecommunications

Network Planning and Performance Assignment 1998/99

Question One

Q1[a] The area shown in the figure has a forecast customer distribution grouped around three potential local exchange locations, namely A which is in a predominantly business district, B which is mostly residential and C which is a mix of the two.



Determine the optimum number of exchanges for serving the area at minimum cost, given that:

* Loop cost = £1000/pair km [includes duct] [note - 1 pair/connection]
* Junction cost = £10,000/route + £1000/circuit km [includes cable & transmission]
* Junction duct = £10,000/km
* Building cost = £lm+ £100/connection [includes site]
* Switching cost = £lm + £50/conn + £100/e
* Circuit efficiency = 0.5e/circuit
* Traffic distribution = 20% own exchange, outgoing in proportion to distant end conns

The distance between the potential exchange locations is 3km; hence, extending pairs from one location to another adds 3km to their average length.

marks - 25%

Ql[b] An Internet service has been provided by an ISP [Internet Service Provider] located in area B. It is predicted that 50% of customers will take up the service and 50% of these will make calls to the ISP of one hour duration between 7 pm and 8 pm on Sunday evenings. What is the effect on the optimum network derived in part [a] of the question.

marks - 25%

Ql[c] Discuss the results of part [b] of the question and develop a justified, by reasoned argument, strategy for the network operator to cater with the Internet demand in the most economic manner.

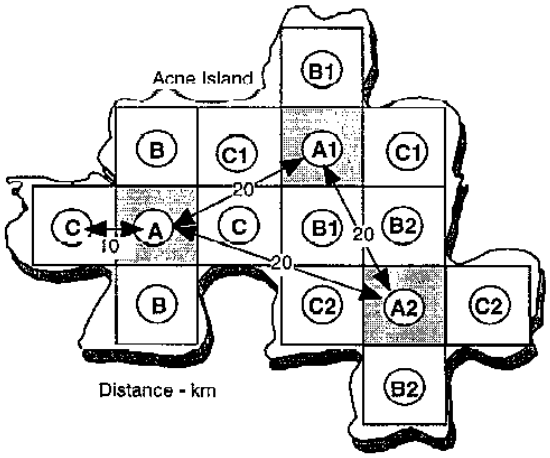
marks - 50%

Question Two

Q2[a] A Telco has decided to compete overseas in the country of Acne. It will initially offer a trunk by pass service for cheap trunk calls, gaining access to the customers via interconnect to the incumbent's, network [shown in the figure]. Each of the incumbent's exchanges serves 10,000 customers but the A exchanges also serve as fully interconnected trunk exchanges, and traffic is evenly distributed between all exchanges. The competing Telco is forecasting a market share of 10%. You are required to design a cost optimum network given that:

* The tree options are: interconnecting at exchange Al, interconnecting at exchanges A, Al and A2, interconnecting at all exchanges.
* The busy hour calling rate for trunk calls is 0.Ole per customer with a call holding time of 3 minutes.
* Exchange capital cost = £O.5m + £100 per switched erlang.
* Exchange accounting life = 10 years.
* Exchange operating cost = £0.03m per exchange
* Circuit efficiency = 0.5e/circuit
* Transmission capital cost [radio] = £0.01m per route + £1,000'per circuit km
* Transmission accounting life = 15 years
* Transmission maintenance cost = £0.02m per route
* Day: busy hour ratio = 10:1 [assume all days in the year are the same]
* Interconnect charges [for ingress and egress] for one point of interconnect = £0.05 per call minute
* Interconnect charges for points of interconnect at three trunk exchanges = £0.02 per call minute
* Interconnect charges for points of interconnect at all exchanges = £0.01 per call minute

marks - 50



Q2[b] The competing Telco is complaining to the regulator that the interconnect charges levied by the incumbent are too high because they are based on "fully allocated" costs. The Telco is proposing that the interconnect charges should he based on "long run incremental costs [LRIC]".

Explain the difference between the two costs and the reasoning behind the requirement for charges bused un LRIC.

marks - 20%

How would you determine LRIC for the incumbents network.

marks - 30%

Question Three

Variable bit-rate (VBR) traffic is to be multiplexed onto a 155.52 Mbit/s link through a buffer with 10 waiting spaces. Each VBR call is described by peak and mean cell rates (20000 cell/s and 2000 cell/s respectively), the performance requirements are a cell loss probability of le-8, and a probability that the cell delay exceeds 5 cell slots of le-5.
Give specific details of the CAC algorithm(s) required to ensure that the performance requirements are met. Explain your approach, giving reasons for any assumptions and simplifications, and assess their likely impact.
Implement your algorithm(s) (e.g. in a spreadsheet, or using a Maths tool, or as a program) and calculate how many connections can be admitted such that the performance requirements are met. With the number of connections you have calculated, find the actual values of cell loss and cell delay performance.

Question Four

Priority control is an important traffic control mechanism, both in ATM networks and, increasingly, in IF networks incorporating some sort of quality of service differentiation. Investigate the behaviour of a simulation model of a time-priority queueing system, which has five Bernoulli sources, and one Poisson source, as input. The Bernoulli sources feed ATM cells into a high priority buffer, and the Poisson source feeds ATM cells into a low priority buffer. If there are any cells in the high priority buffer, the server serves a high priority cell. The server only serves a low priority cell if the high priority buffer is empty.
Build a simulation model for this system (e.g. in a spreadsheet, as a program, or using a maths or simulation package).
Run your model for the following scenarios:

* each Bernoulli source has a mean load of p = 0.15 cells/slot, and the Poisson source has a load of λ = 0.15 cells/slot
* each Bernoulli source has a mean load of p = 0.09 cells/slot, and the Poisson source has a load of λ = 0.45 cells/slot
* each Bernoulli source has a mean load of p = 0.02 cells/slot, and the Poisson source has a load of λ = 0.8 cells/slot

In each case simulate the system for at least 1000 cell slots, but preferably 1 or 2 orders of magnitude more.

(a) Briefly describe how you modelled the sources and the priority queueing system, and how you processed the results.

(b) For each of the three scenarios, plot the queue state probabilities for the high and low priority buffers separately, and for the queueing system as a whole. Show your results both as tables of values, and as graphs.

(c) Comment on the results you obtain for the different scenarios - which results are similar, which are different, and why? Discuss the types of traffic which would benefit from this priority mechanism, and derive general planning rules for partitioning the traffic among priority levels, and for partitioning buffer space between the priority buffers.

Question Five

BT and Ford motors have entered into a joint venture to introduce a Web based electronic car customisation and purchasing service using the Internet. BT will undertake end-to-end service management for the service.

a] Construct enterprise models for the service to illustrate the processing, storage and messaging components necessary for the service.

30 marks

bI Determine the Quality of Service parameters necessary to give good customer satisfaction and speculate on their likely values.

30 Marks

c] Discuss the functionality necessary to ensure that these QOS parameter values are achieved.

40 marks

University of London

Masters Programmes in Telecommunications

Data Networks and Protocols

15th June 1999

Notes:

* This paper comprises five (5) questions

* The marks allocated to parts of questions are indicated for guidance

* Candidates are required to answer three (3) questions

* Time allowed 2 Hours

MSc in Telecommunications
MRes in Telecommunications
IGDP `Telecommunications for Industry'

QUESTION 1

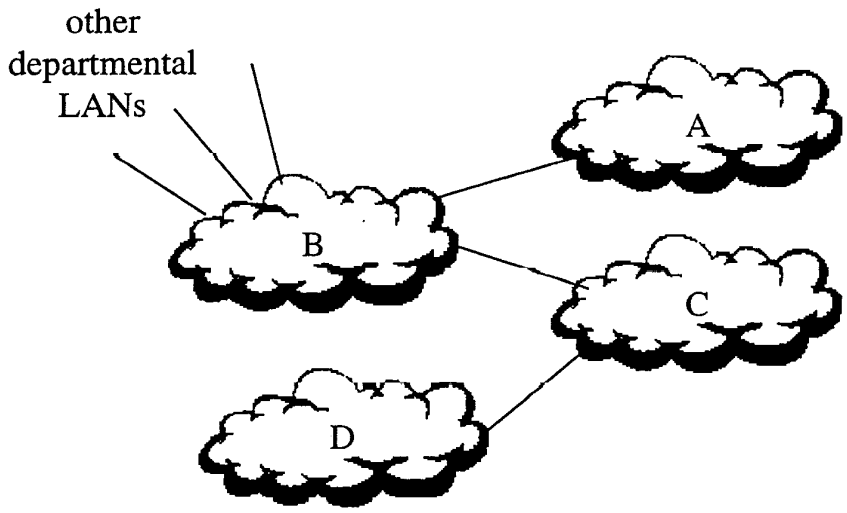
a) Describe the main factors that limit the use of CSMA/CD techniques for constructing large high speed LANs. By use of numerical examples with data rates of 10Mb/s and l00Mb/s, show how this is the case on a CSMA/CD based LAN which has a length of 2.5Km (take the speed of electro-magnetic propagation to be 10^8 mIs).

[33%]

b) Considering your answer to a), how is it that "Fast Ethernet" systems can operate at l00Mb/s? illustrate your answer with a numerical example for 100Mb/s.

[18%]

c) The figure below shows an on-site campus network set-up



The clouds A, B, C and D represent networks that are used as follows:

* A is a general, low data rate (less than l0Mb/s) departmental LAN, not used for any special or demanding purposes, but runs many applications that are client-server oriented.
* B is a site-wide backbone used to interconnect many large departmental LANs (assume tat all these LANs are used in a similar fashion as network A, i.e. general use) as well as access to some central, campus-wide servers.

* C is a small LAN environment to be used by for real-time, multimedia applications that have particular quality of service requirements and must work in a connectionless environment at data rates up to 100Mb/s.
* D is a WAN that must provide high-speed (l55Mbits/s and greater) access for Network C.

Suggest suitable technologies for use in each of the networks A, B, C and D, and briefly list reasons for your choice in each case.

OUESTION 2

a) What are the advantages of a datagram network protocol (such as the Internet Protocol) compared to a purely circuit-switched network for general data applications?

Explain how some of these advantageous characteristics that you list for general data applications pose problems when trying to offer QoS (quality of service) capability to applications over datagram networks.

[33%]

b) Describe how the use of RSVP with the INTSERV (Integrated Services) model tries to solve the problems that you have posed in part a) above for rn-based networks? (Your answer should include a description of the purpose and the operation of RSVP.)

[33%]

c) List the drawbacks of the RSVP/TNTSERV approach as described in your answer to part b) above. Describe briefly the principals and general features of an alternative QoS mechanism, DIFFSERV (Differentiated Services), that may help to overcome some of these drawbacks. (Your answer should consider the impact on the network and the applications when comparing the DIFFSERV approach to that of the RSVP/INTSERV approach.)

[33%]

OUESTION 3

a) Describe and discuss the differences between a **secret-key** encryption system and a **public-key** encryption system.

[24%]

b) Describe how a public-key encryption system used with a hash function (also called a **message digest** function) can be used to create a **digital signature** for a message. Use a diagram to help illustrate your answer. Your answer should begin with a description of the function of the message digest algorithm and the purpose of a digital signature.

[46%]

c) Describe the security services that have been defined for IP in the IPSEC work and why certain services can not be easily provided at the IP layer (e.g. protection against message deletion). Your answer need not include a description of the details of the IPSEC work (e.g. extension header formats) but reference should be made to the security services and security mechanisms used in IPSEC.

[30%]

OUESTION 4

a) Describe the operation of the basic congestion control algorithm used in TCP (Transmission Control Protocol).

[27%]

b) Describe, with the aid of a graph, the change in data-rate, over time, of a TCP flow from a source, A, to a destination, B, using the following information:

* each time unit, it, is a single RTT (round trip time) between A and B

* the unit of data to be used in the description should be a TCP segment

* the graph should plot the changes of data-rate in the TCP flow from t =0 to t = 16

* the receiver window size at B remains at 8 segments throughout

* there are lost ACKs (TCP acknowledgements) from B just before t = 6 and t = 13.

(The graph does not have to be to scale, but points on the graph should be accurately plotted.)

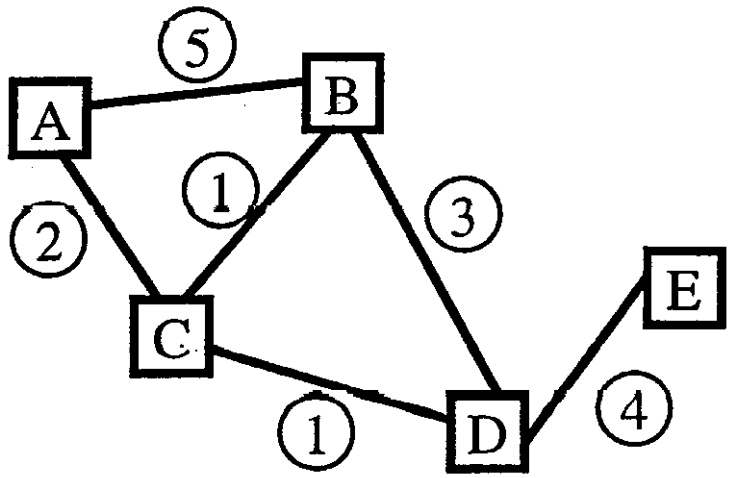
[27%]

b) TCP provides an ordered, byte-stream service with sequenced, reliable delivery and automatic, adaptive flow control and congestion control. Why is such a service unsuitable for real-time data? Illustrate you answer by using a real-time voice flow as an example. Your answer should include a description of the relevant mechanisms that are used in the operation of TCP.

[46%]

OUESTION 5

a) The figure below shows some interconnected routers, labelled A to E. The encircled numbers indicate the delay along the links between the nodes at a particular instant in time.



Write a description of Dijkstra's Algorithm and use it to generate the routing table for node C. Show each stage of your working clearly with a simple diagram.

[58%]

b) Three individual network sites exist at London (UK), Madrid (Spain) and Rome (Italy) for a single organisation, FlumpCo. The three sites do not have any interconnection between them. Describe in detail how they might be interconnected in order to give the impression of single private network using IP, based on the following data:

* each FlumpCo site network requires 128Kb/s connectivity

* the individual office sites can not afford direct site-to-site international connectivity

* the flumpCo site offices exchange sensitive data regarding their employees and customers so must ensure that the contents of network traffic is not visible outside the three FlumpCo site offices (details of security mechanisms need not be given but the minimum security services required should be specified).

You answer should include a clearly labelled diagram showing details of use of IP addresses, routing placement and connectivity services required.

[42%]

University of London

Masters Programmes in Telecommunications

Telecommunication Transmission Systems

Examination 1998199

Time allowed: 2 hours

Notes:
* This paper comprises five (5) questions
* Candidates are required to answer three (3) questions
* The distribution of marks among parts of questions is indicated for guidance

MSc in Telecommunications
MRes in Telecommunications
IGDS `Telecommunications for Industry'

Question 1.

A 38 GHz digital radio system supporting 2 M bit/s data transmission is to be acquired.

In developing the system selection requirements it emerges that a general appraisal is required of the relative merits of two specific digital modulation schemes:

* 16QAM
* I6PSK

You are asked to provide this assessment and recommend which option is likely to be most appropriate. To guide the assessment you are asked to address the following issues:

(i) To what extent do spectral efficiency considerations influence the choice of modulation scheme?

(ii) Which modulation scheme should be selected in the interests of transmitted RF power efficiency?

(iii) The unfaded (background/residual) bit error rate (BER) is required to be $< 10^{-11}$. What equipment/circuit performance factors are likely to be of particular importance in this context'!

(iv) Identify and provide advice on any other factors that might favour one modulation scheme relative to the other.

Since power efficiency is considered to be particularly important you are specifically asked to provide detailed analytic/quantitative support for your arguments relating to item (ii).

[100%]

Question 2.

Consider baseband digital transmission.

(I) Indicate the appropriate time domain properties for a signal element waveform to produce zero intersymbol interference.

[25%]

(ii) Indicate the `minimum bandwidth' waveform and its spectrum and comment upon its appropriateness as a basis for practical signal design for digital transmission.

[25%]

(iii) Explain what is meant by the term `horizontal eye opening'. Indicate analytically and/or graphically the key time domain criteria to ensure that a binary eye exhibits maximum vertical and horizontal eye opening. Comment upon the implications in the frequency domain.

[25%]

(iv) Explain what is meant by the term `raised cosine family' in the context of signals for digital transmission and comment upon circumstances in which individual members might be likely to find practical application in digital telecommunications transmission.

[25%]

TURN OVER

Question 3

(i) Consider multi-level baseband signalling. Comment upon the extent to which it is possible to achieve both vertical and horizontal opening of the eye diagram, comparing this with the situation for binary signalling.

[25%]

(ii) Multilevel signalling may be used to increase the data rate achievable over a given bandwidth channel. For a given channel bandwidth and noise environment what are the implications for transmitted power of employing 4-level polar signalling rather than binary polar signalling as a means of doubling the information rate if the symbol error rate is not to be compromised.

[25%]

(iii) For a given information rate, it is possible to reduce the bandwidth requirement by adopting multi-level rather than binary signalling. This reduces the noise level but the implications for transmit power must also be taken into account. Show that for baseband systems in an additive white Gaussian noise environment binary signalling provides the overall best power efficiency for a given symbol rate.

[25%]

(iv) In the light of your answer to the above, comment upon the merits of the 2B1Q linecoding arrangement commonly employed for basic rate ISDN access.

[25%]

Question 4.

(i) Optical fibre is generally indicated as the `transmission technology of choice'. Explain why you feel this is the case.

[25%]

(ii) Indicate circumstances for which a telecommunications operator might choose to deploy digital radio links rather than optical fibre cables.

[25%]

(iii) Distinguish clearly between an optical transmission link being:

(a) loss limited;
(b) dispersion limited.

[25%]

(iv) Consider a monomode optical fibre system operating at 1550nm over standard monomode fibre, for which the dispersion is l6ps/(nm.km). Fibre loss is 0.25dB/km. The laser source linewidth is 2nm, launch power is OdBm, the transmission rate is 1GBit/s and the receiver sensitivity is -40dBm. Estimate the maximum attainable unrepeatered link length and indicate whether the system is loss limited or dispersion limited.

[25%]

TURN OVER

Question 5.

(I) Outline the principle of operation of an erbium doped fibre amplifier (EDFA) and indicate alternative pumping arrangements and their attributes.

[25%]

(ii) Outline the nature and importance of `Q' in relation to the performance of optically ampflfied transmission systems.

[25%]

(iii) In what way does amplified spontaneous emission influence the performance of optically amplified (OA) systems.

[25%]

(iv) We commonly identify four key noise sources for OA systems. What are these? Which amongst these is ultimately the limiting noise source.

[25%]

END OF PAPER