Ollscoil *na* hÉireann, Gaillimh
National University of Ireland, Galway

SUMMER EXAMINATIONS 2001

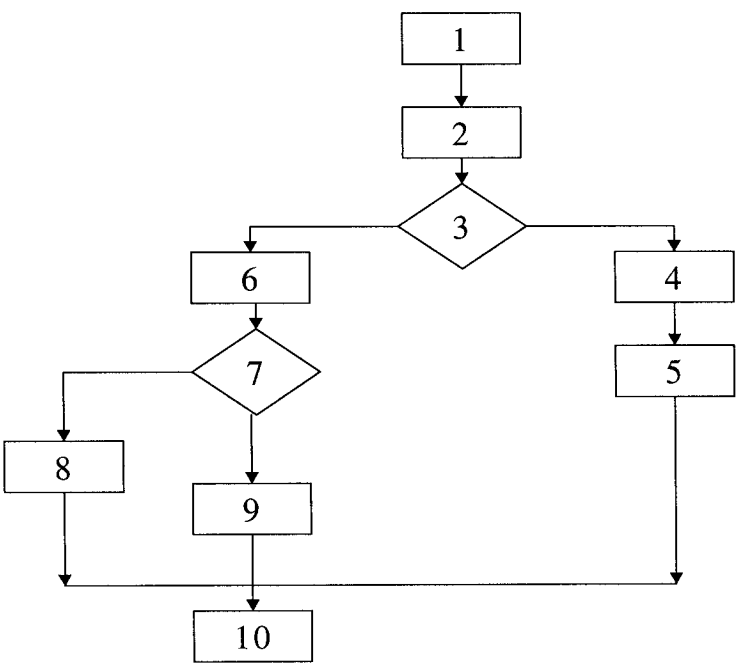
MASTERS OF INFORMATION TECHNOLOGY
and MASTERS OF ENGINEERING SCIENCE

CT503. SOFTWARE ENGINEERING

Prof. D. Bell
Prof. G. Lyons

(Time allowed: 3 hours)
Answer **four** questions in all.
All questions carry equal marks.

1. (a) A number of different Estimation methods are available for determining *effort* and *schedule* in large development projects. Describe the Basic COCOMO and Function Point Analysis (either Albrecht or FPII) techniques. Briefly compare the advantages and shortcomings of these methods.
   (b) Outline the significance of the V-model as a software testing strategy ? Illustrate how this maps testing effort against the development life-cycle and highlight the appropriate types of testing performed at each stage.
   (c) For the piece of procedural logic described in the following flow-chart:
   - Draw a flow graph;
   - Show the number of regions in the graph;
   - Calculate the Cyclomatic Complexity, V(G), using 3 separate methods;
   - List each independent path through the routine;
   - Estimate the upper bound number of tests required to ensure maximum branch coverage.



2. (a) Describe the application of Transaction and Transform Centre structures in architectural design. Illustrate, with appropriate diagrams, how both Transform Centres and Transaction Centres can be identified on DFD models of a system.

(b) For the Call Centre system described, construct a DFD and Structure Chart, and identify the type of architectural structure appropriate to this type of application.

The Cheap n' Cheerful PC Manufacturing Company has its global sales and servicing call centre in Ahascra, Co. Galway. The Call Centre has a fully automated call handling and routing system, allowing callers to be diverted to the service they require, based upon a numbered menu presented to each caller. The Call Centre provides the following services: Quotations, Sales, Technical Support, Warranty Claims. Customers can access the Call Centre in one of 2 ways: Telephone or WEB. Once connected, customers select their required service and the system routes them to the correct process and handling agents. Responses to customer enquiries can be dealt with in one of 3 ways: directly on the phone, by fax or e-mail.

(c) Convert the Data Flow diagram specified in the following table to a first-cut Structure Chart. State all assumptions clearly.

Process	Input	Output
A	X1	X4
B	X2	X5
C	X3	X6
D	X4,X5,X6	X7
E	X7	X8,X9
F	X9	X10
G	X8,X10	X11
H	X11	X12
I	X12	X13

3. The following narrative is part of a specification for a new Student Record System for universities. Based upon this description (and using your own imagination and assumptions, where appropriate), develop an object-oriented analysis of the system using UML conventions, including:
   (a) Use Case diagrams to illustrate the interaction of Students, Professors and Records Office staff with the system.
   (b) A Class Model, identifying all relevant classes, associations (including inheritance), attributes and operations;
   (c) A Sequence Diagram to illustrate the object interactions involved in the Course Selection/Registration process.

Student Transactions and Records Administration System (STARS)

The system provides for the administration of student admissions, course selections & registrations, allocation of professors to courses, entry of exam scores, calculation of exam results, reporting of these results to Examinations Boards and maintenance of all appropriate records relating to students, courses and examinations.

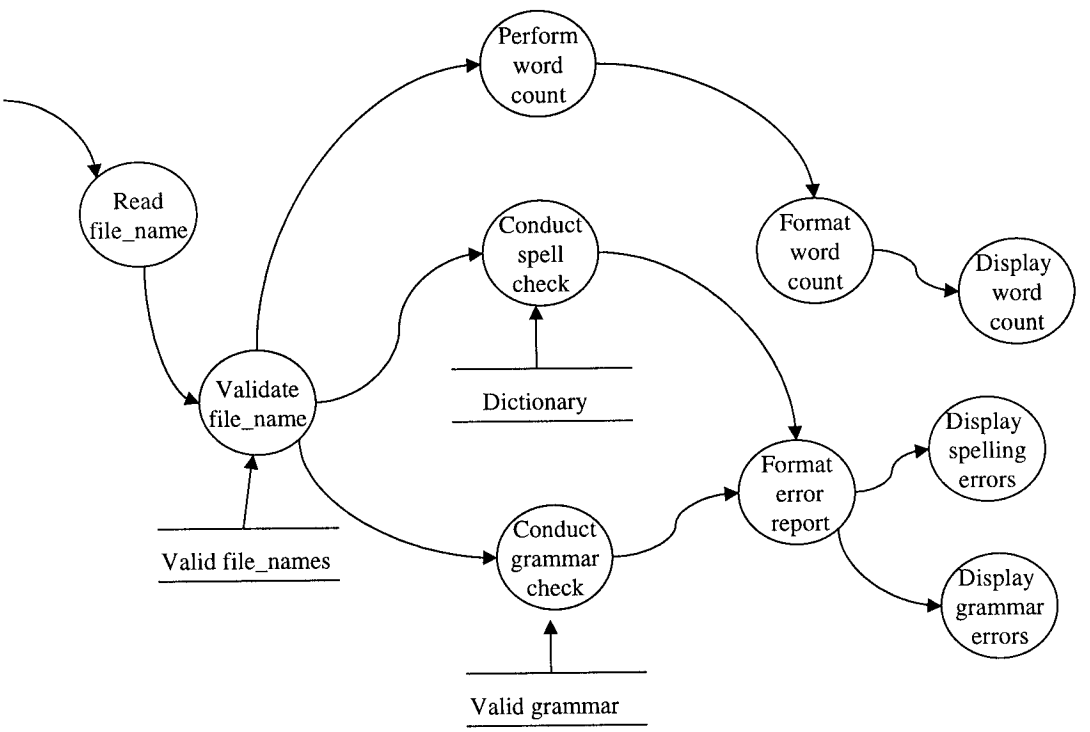
Students use the system to complete their annual degree admission/registration, after which they are then allowed to select optional courses from a menu of available courses, in the first week of each semester. At this time, students are also expected to formally sign-up for examinations. Professors use the system to select courses to teach, request course teaching rosters, request class lists, and enter (or view) exam scores. The Records Office staff use the system to create class lists, lecture theatre schedules, examination lists, marks & standards templates; they also use the system to compile exam results, generate student transcripts and graduation lists.

At the beginning of each semester students log-on to the system to view a menu of optional courses for their respective degree/year. The log-on procedure uses a secure WEB based degree_registration form which validates the student ID and password. Once accepted, the student can then access the menu of courses by first entering the current semester number (i.e. S1 or S2), after which the student_schedule of compulsory courses is displayed. At this stage, the menu of available optional courses is called from the

student_schedule. After selecting the correct number of optional courses, the timetable information for these is automatically entered into the student_schedule. The system has an in-built check to ensure that only a pre-determined number of optional courses is selected; this pre-determined number is kept as part of the student's degree_registration information.

A degree consists of up to 4 degree years, each comprising a number of compulsory and optional courses. At registration time, students apply for a specific degree/year and select optional courses. Course information includes: code, title, number of lectures, schedule, number of credits. All courses are taught and examined by professors, for whom Staff_ID, Department, Faculty and Specialisation is stored. Examinations normally take place at the end of each semester and exam results are entered remotely by professors. These are later compiled and aggregated according the Marks & Standards templates, entered into the system by the Records Office. A class can have many students, and represents a collection of students possibly drawn from different degree programmes. Class lists present details of the number of students taking a course, the Student_ID, name and degree for all those taking the course. Student information maintained in the system includes: Student_ID, Name, Term & Home Address, exam performance in each subject and for each year completed.

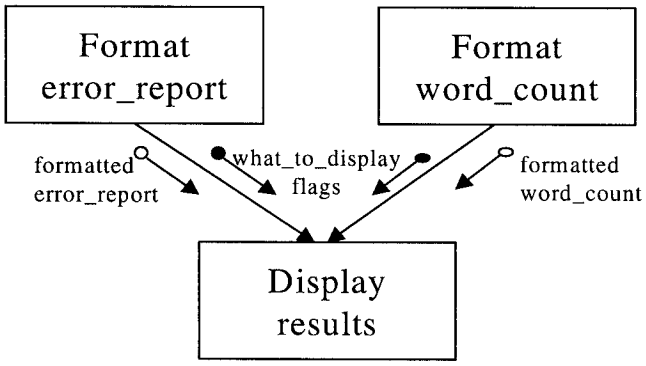
4. The DFD below describes part of the functionality of a text editing package.



(a) Create a fully annotated first-cut structure chart and comment upon the quality of the software architecture, in particular referring to the types of Coupling and Cohesion evident in this initial design.

(b) Re-design the structure chart so as to improve Cohesion and Coupling, explaining each of your design decisions.

(c) For the modules show below, comment on the use of fan-in and identify the types of Coupling and Cohesion. How could this segment of the design be improved?



5. (a) The following table presents a work breakdown summary and experienced-based time estimates for the tasks involved in developing a core software module for a Satellite Navigation System.

Activity Description	**Task**	**Must Follow**	**Expected Time** *Min., Aver., Max. (Days)*
Identify all risks	A	None	19,36,40
Conduct risk analysis	B	A	19,26,34
Develop risk management plan	C	A,B,D	55,60,68
Develop behavioural model	D	None	50,60,68
Construct STD for module	E	None	19,22,24
Validate STD for module	F	E	10,12,15
Specify module architecture	G	E,F	20,24,28
Develop module p-spec.	H	C,G	35,40,42
Prepare test plan	I	H	45,50,55

(i) Draw a Gantt chart for the module development phase shown.
(ii) Draw a PERT chart for the development phase and determine the critical path.

(b) During the Cost-Benefit study for the system, the following stream of cash-flows was identified:

Year	**Type of cost**	**Costs incurred (£)**	**Revenues expected (£)**
2001 (t=0)	Capital cost	20,500,000	
	Operating cost	150,000	
2002	Capital cost	300,000	1,500,000
	Operating cost	140,000	
2003	Operating cost	200,000	2,750,000
2004	Operating cost	200,000	5,500,000
2005	Operating cost	200,000	7,000,000
2006	Operating cost	200,000	8,800,000
2007	Capital cost	5,500,000	10,500,000
	Operating cost	300,000	
2008	Operating cost	200,000	12,500,000

Using non-discounted break-even analysis, determine the year in which the Proposed Satellite Navigation System would break even. Using the discounted cash-flow technique, with a financing rate of return of 12%, evaluate the financial viability of the project (You can assume that all cash-flows are end-of period payments.) Identify any assumptions and/or formulae used in your analysis.

6. Based on the order management and production planning activities of the PC manufacturing company described below:
   (a) Develop:
      - An environmental model (context diagram & event list)
      - A completed behavioural model using DFDs.

   Customers place orders for computers. If they have already done business with the company, they are asked for their unique CUSTOMER-NUMBER. If they are a new customer, their details will be recorded, including: NAME, ADDRESS, PHONE-NUMBER, and a unique CUSTOMER-NUMBER will be assigned to them. Once they have a CUSTOMER-NUMBER, details of their order are recorded. These include the PRODUCT-ID and QUANTITY. The PRODUCT-ID is cross-checked against the PRODUCTS data store to ensure that it exists. The customer order is then stored, and the ORDER-STATUS is set to "Pending."

   At the end of each working day, a BUILD-PLAN is generated and sent to the Production Control System. The BUILD-PLAN is a list of all those orders whose status is "Pending." When an order is added to the BUILD-PLAN, it's ORDER-STATUS is modified to "Released."

   Frequently, the PRODUCTS data store is updated with new information from the Materials Planning System, which modifies or adds information on the company's products.

   At the end of each working day, the Production Control System provides updates as to the status of each order. The status can be one of "Queuing", "40% Complete", "70% Complete", "Finished" or "Sent."

   At the end of each month, Management request a STATUS-REPORT which is based on information from the ORDERS and the PRODUCTS.

   (b) The firms ERP database stores information about Customers (Customer_ID, name, address), Raw Material Parts (Part_No., Part_name, Part_class, Part_description, Part_suppliers, Part_warehouse_code). Customers can be identified by ID. The Part_warehouse_code is dependent upon the Part_ID and Part_class, while the Part_supplier can be either identified through either the Part_No. or Part_class.

   Based upon this information, create a set of normal form relations from the data, identifying any offending functional dependencies at each stage of the normalisation process.

7. For the Traffic Light Control System described in the following narrative and diagram:
   (a) Construct a Context Model, showing eternal events, and a fully annotated State-transition Diagram (STD) to describe its operation.
   (b) Use a Decision Table to specify the detailed logic controlling the light sequence for either of the North-South or East-West branches.

   Traffic Light Controller

   A software based traffic light controller regulates the lights for a busy traffic intersection. The intersection is a 4-road, 90° cross-road, laid-out on a North-South/East-West alignment, as shown. The controller receives periodic (1-second) inputs from traffic detectors embedded in the 4 approach road pavements at 50m from

the junction. These indicators check for the presence of traffic build-up on the respective branch road. Aperiodic interrupts are also received from pedestrian request buttons at each of the crossings shown. The lights operate 24-hours per day, for 365 days per year, apart from occasional service intervals when service engineers can switch-off the controller.

In the normal operating sequence, light changes occur at timed intervals of 3 minutes, giving equal priority to the N-S and E-W directions. The initial "safe" mode is assumed to be "all-on-red", from which changes to green are switched in alternate branches, always returning to the "all-on-red" mode for 5 seconds, via Orange (i.e. Green-Orange-Red), before switching the alternate route. The timed 3-minute change is only switched if there is traffic present on the alternate branch (i.e. E-W is changed from Green to Red after 3 minutes only if there is traffic present on the N-S route). If the pedestrian request button is pressed on a Green route, the controller switches a 1-minute pedestrian interval (i.e. "all-on-red") before switching the alternate route to Green.

The controller has the following operations: sense traffic detectors, sense pedestrian buttons, clock, change lights, pedestrian over-ride, service over-ride.