ADELAIDE UNIVERSITY AUSTRALIA

Examination in the School of Mathematical Sciences

Semester 1, 2005

3098	Communications Network Design
	APP MATH 4012

Official Reading Time: 10 mins
Writing Time: 180 mins
Total Duration: 190 mins

ANSWER ALL QUESTIONS
NUMBER OF QUESTIONS: 4 TOTAL MARKS: 100

Instructions

- **Answer all 4 questions**
- Begin each answer on a new page.
- Examination materials must not be removed from the examination room.

Materials

- 1 Blue book is provided.
- Calculators are not permitted.

DO NOT COMMENCE WRITING UNTIL INSTRUCTED TO DO SO.

1. Internet architectural principles:
   (a) Answer each of the following True or False
      (i) IP is a data-link layer protocol.
      (ii) The Internet Protocol limits the type of topology on which it can be applied.
      (iii) In a layered model functionality is always placed exclusively at one layer.
      (iv) a linear cost model is an ideal model for real network costs.
      (v) a linear cost model can incorporate distance, and bandwidth related costs.
   (b) Answer each of the following in a sentence or two:
      (i) What is the difference between the data-link layer and the physical layer of the OSI protocol stack?
      (ii) Why is a distributed network often considered superior to a centralized network?
      (iii) State the "robustness principle" which is often used in network design.
      (iv) What is the key difference between packet switching and circuit switching.
      (v) What type of measurements are needed for most network design algorithms (I do not consider cost to be a measurement).
   (c) Write a paragraph (no more than half a page) on **one** of the following topics
      (i) The end-to-end principle
      (ii) The impact of Moore's law (and related laws) on the development of communications network design.

      These will be assessed 50% on clarity of presentation, and 50% on content.

[25 marks]

2. Routing:

   (a) Perform Dijkstra's algorithm on the graph shown in Figure 1 to find the shortest paths from node 1 to all other nodes. **Show your working.**

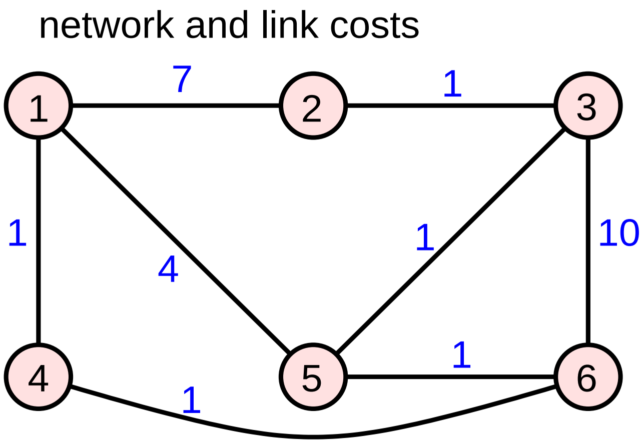

Figure 1: A network, and link costs.

   (b) Answer the following.

      (i) State the mathematical formulation of the routing problem, with linear, separable costs. Define all of the terms used in your formulation.

      (ii) Why does this formulation result in shortest-path routing?

      (iii) How is Dijkstra's algorithm applied in real network settings in order to compute shortest paths?

   (c) Name at least 5 ways in which the routing protocol BGP differs from a protocol like OSPF. Describe each of your 5 points with a couple of sentences.

[25 marks]

3. Network design

   (a) Suggest three optimization *strategies* used for designing a minimum cost network. **Note:**

   - I don't want an individual method, I want the underlying principle of the methods.
   - I don't want a problem description either.

   For each approach, provide an example of a method that applies the strategy. Very briefly outline the advantages and disadvantages of each strategy and thereby compare the three.

   (b) Given a standard linear separable cost function $C(\mathbf{f}) = \sum_{e \in E} \alpha_e f_e + \beta_e$, and costs shown in Figure 2, apply Minoux's method to try to find a minimum cost network. **Show your working.**

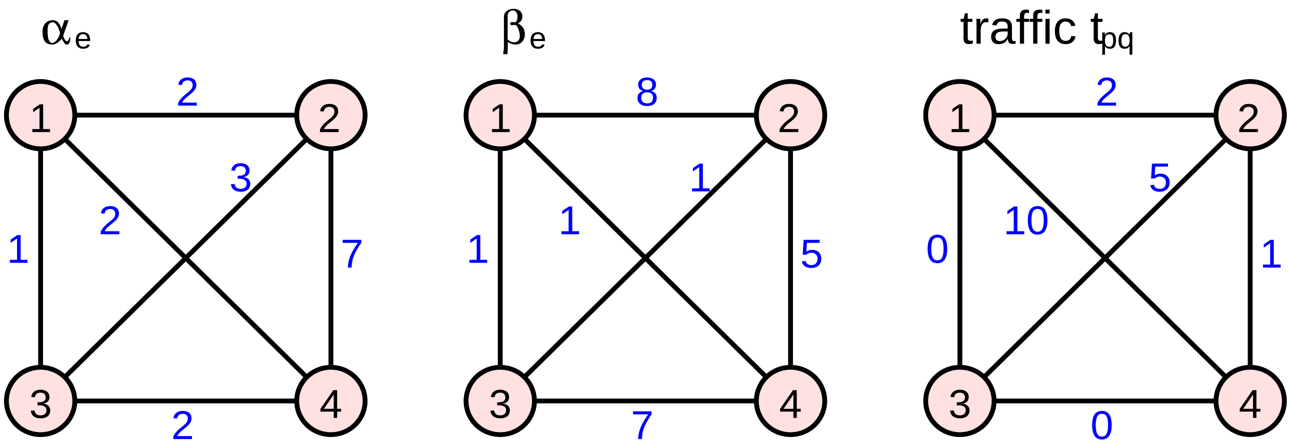

Figure 2: A network, with link costs, and offered traffic.

[25 marks]

4. Tree-like networks:

(a) (i) Given a network, with costs $\alpha_e = 0$ and β_e given by the link attributes in Figure 3, find a minimum weight spanning tree using Prim's algorithm. **Show your working.**

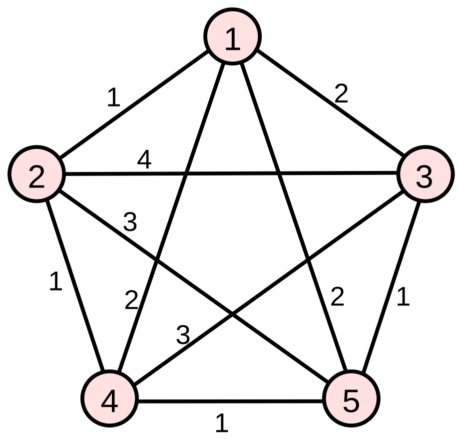

Figure 3: A network of five nodes.

(ii) Using your minimum weight spanning tree, solve the Travelling Salesman Problem for the network to find a tour. Is it always posible to use the same approach to solving the Travelling Salesman Problem?

(b) Provide a precise definition of

(i) a cutset;

(ii) a pair of non-crossing cutsets;

(iii) a fundamental cutset.

(c) Imagine a slightly different tree-like network design problem, where the $\alpha_e = 1$, and $\beta_e = 0$ for the network, and the attributes on the links in Figure 3 instead show the offered traffic between nodes (e.g. the offered traffic between nodes 2 and 3 is 4).

(i) Given the following minimal cutsets for the first 3 iterations of Gusfield's algorithm, show the network at each step.

iteration	X for the minimal cutset
step 1	$\{2, 3, 4, 5\}$
step 2	$\{3, 1, 4, 5\}$
step 3	$\{4\}$

(ii) Perform the complete **last step** of Gusfield's algorithm to find the minimum spanning tree for the network. **Show your working.**

(iii) Compare your result above with the result from a minimal star design (given the same cost function). Note this is different from a minimum distance star.

[25 marks]