PAPER CODE NO.	EXAMINER : Leszek Gąsieniec
COMP526	DEPARTMENT : Computer Science Tel. No. 7954290

UNIVERSITY OF LIVERPOOL

MAY 2007 EXAMINATIONS

Master of Science: Year 1
No qualification aimed for: Year 1

Applied Algorithmics

TIME ALLOWED : Two Hours and a Half

INSTRUCTIONS TO CANDIDATES

Candidates will be assessed on their best four answers. If you attempt to answer more than the required number of questions, the marks awarded for the excess questions will be discarded (starting with your lowest mark).

If you attempt to answer more questions than the required number of questions (in any section), the marks awarded for the excess questions answered will be discarded (starting with your lowest mark).

Question 1

1.A Assume you have 5 symbols A, B, C, D and E forming an alphabet A, i.e., $A = \{A, B, C, D, E\}$. The distribution of probabilities in the alphabet A is as follows: $P(A) = 0.1, P(B) = 0.2, P(C) = 0.4, P(D) = 0.2$, and $P(E) = 0.1$. Construct, step by step, the Huffman tree for symbols in A, and comment on the time complexity of the construction. **[15 marks]**

1.B Recall the definition of $(k, k, n)-$*selectors*. Then consider the content of columns i, j and k in matrix $M[0..n-1, 0..x]$ and explain why M is not a $(3, 3, n)$-*selector*.

matrix M

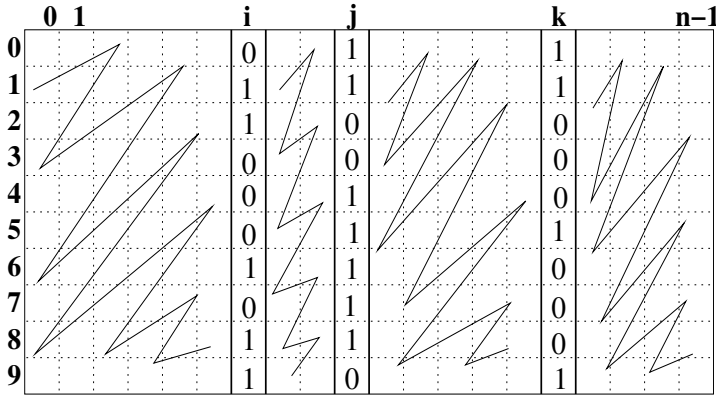

Figure 1: Binary matrix M

[7 marks]

1.C Explain the difference between the *exact* and the *relative* Hamming distance between two strings of the same length.

[3 marks]

Question 2

2.A Analyse graph G, shown in Figure 2, and remove 3 edges to create a subgraph of G which is a Gabriel graph. Then draw the route from node A to B that would be generated by the *Compass Routing* algorithm.

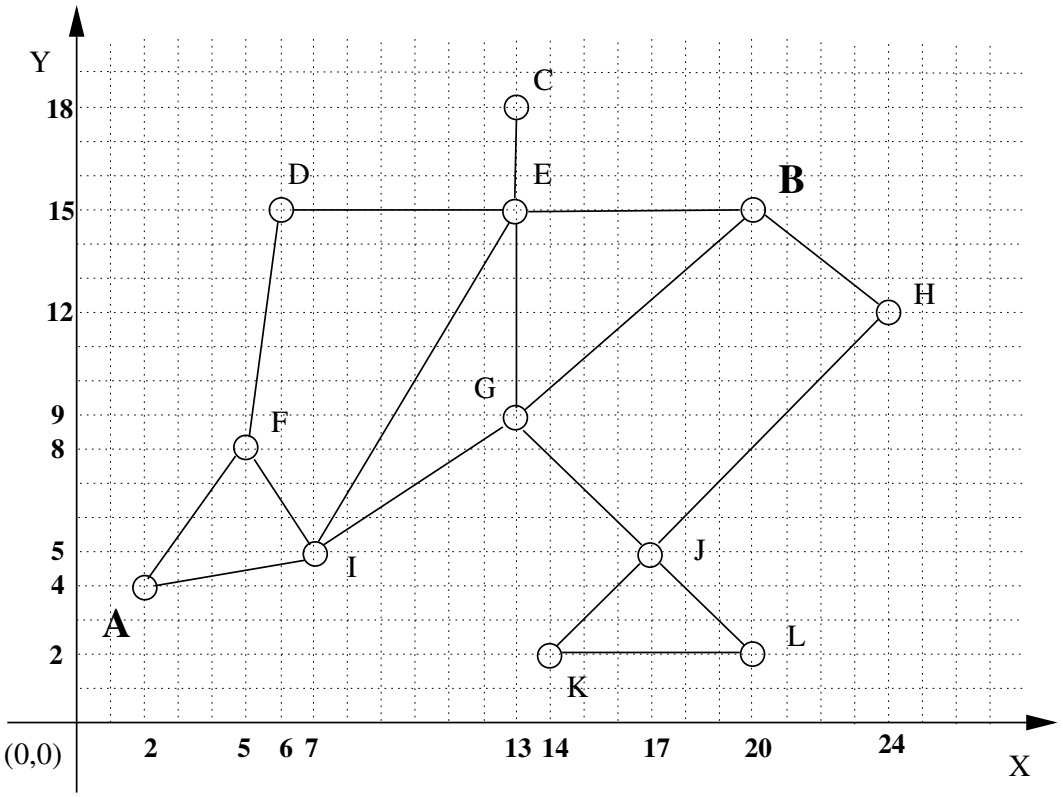

Figure 2: Graph G

[15 marks]

2.B Given word $w = babaaaba \in \{a, b\}^*$. Construct, step by step, the *LZW* (Lempel-Ziv-Welch) factorisation of w and provide the compressed representation of w.

[7 marks]

2.C State the definition of the *LCA* property in trees and discuss briefly one of its applications. **[3 marks]**

Question 3

3.A Draw a *suffix tree* and create a *suffix array* for an input string $abbabbaa$. Comment briefly on sizes of *compact suffix trees* and *suffix arrays* for strings built over constant size alphabets. **[15 marks]**

3.B Let $S = (20, 30, 30, 20, 40, 30, 20, 20, 20)$ be an input sequence of numbers whose values are initially stored in the list $Q = [20, 30, 40]$. Build an output sequence and trace the content of Q throughout the execution of *MTF (Move-to-Front) algorithm.*

[7 marks]

3.C Comment briefly on the *physical layer* in OSI-ISO 7-layer reference model of network communication.

[3 marks]

Question 4

4.A Explain briefly the mechanism used in the Burrows-Wheeler Transform (BWT) and show the result of applying the BWT on the string $S = baabab$.
[15 marks]

4.B Explain the difference between two important models in distributed algorithm design: the *synchronous model* and the *asynchronous model.* **[7 marks]**

4.C Comment briefly on use of the *loop invariant* method. **[3 marks]**

Question 5

5.A Consider a sequence of bits $D = D_3D_2D_1D_0 = 1001$ that is to be sent across a noisy communication channel.

- Compute parity bits P_2, P_1 and P_0 and interleave them with the bits of the sequence D according to the rules *error detection* (via parity of subsets of bits) mechanism.
- Explain also how one can discover that one bit of D, e.g., D_2, flipped from 0 to 1 during traversal through the communication channel.

[15 marks]

5.B The *Adanacci Language* AL is constructed as follows:

1. $A_0 = ad$,
2. $A_1 = da$, and
3. $A_i = A_{i-1} \cdot A_{i-2}$, for all integers $i \geq 2$, where symbol $\cdot$ stands for concatenation operation.

State the definition of a witness against periodicity and list a witness against non-period 3 in Adanacci string A_4. **[7 marks]**

5.C Explain the difference between two basic communication primitives: *broadcasting* and *gossiping*. **[3 marks]**