References

1. MARKOV PROCESSES AND REVERSIBILITY

For a fuller introduction to Markov processes see Feller (1968) and Cox and Miller (1965); a thorough account of the general theory is given by Chung (1967). Time-reversed Markov chains were first considered by Kolmogorov (1936); this paper contains his criteria for reversibility, which were later extended by Reich (1957) and Kendall (1960). For a discussion of reversible diffusion processes see Kent (1978). Good introductions to queueing theory are Cox and Smith (1961), Cooper (1972), Gross and Harris (1974), Kleinrock (1975), and Koenig and Stoyan (1976); Little's result is proved in Ross (1970). For a further discussion of the Ehrenfest model see Kac (1959), Bartlett (1962), and Ruben (1964). Theorem 1.6 is taken from Moran (1961); the result is used by Rényi (1970) and Penrose (1970) to establish the convergence to a limiting distribution of a Markov chain. The electrical network described in Section 1.4 is used by Keilson (1965) in his review of the transient behaviour of reversible processes. Exercise 1.2.6 and the concept of dynamic reversibility are due to Whittle (1975). For uses of dynamic reversibility in spectral analysis see Anderson and Kailath (1979). Reversible null recurrent Markov processes are discussed by Kendall (1975); in this setting Exercises 1.2.7 and 1.7.8 take a more natural form.

2. MIGRATION PROCESSES

Theorem 2.1 was originally proved by Burke (1956). The proof given here based on reversibility is due to Reich (1957). The queue considered in Exercise 2.1.1 was described by Boes (1969); the method used in part (i) of this exercise and in the telephone exchange model of Section 2.1 is due to Daley (1976). A series of simple queues was first considered by Jackson (1954). Theorem 2.2 was originally proved by Reich (1957, 1963, 1965); the proof given here is due to Burke (1972), who also established the results contained in Exercises 2.2.4, 2.2.5, and 2.2.6. For the solution to Exercise 2.2.4 see Burke (1968). Theorems 2.3 and 2.4 come from the important paper of Jackson (1963). The phenomenon of partial balance was observed by Whittle (1967, 1968). The examples in Section 2.3 are based on work by Taylor and Jackson (1954) and Koenigsberg (1958). Exercise 2.3.5 is a development of Gordon and Newell (1967). The reader interested in the computational methods touched on in Exercises 2.3.6, 2.3.7, and 2.3.8

should see Reiser (1977). Corollary 2.6 is due to Muntz (1972) and Theorem 2.5 to Kelly (1975a). The family size process is described by Kendall (1975) and the optimal allocation result is due to Kleinrock (1964). The converse to Exercise 2.4.3 has been established by Melamed (1979) for the case where each colony is a single-server queue; see also Brémaud (1978). Exercise 2.4.5 comes from Whittle (1968).

3. QUEUEING NETWORKS

The important paper of Muntz (1972) established the link between Poisson preserving queues and product form solutions for networks. This link is the basis of the treatment of queueing networks given in this chapter. Baskett, Chandy, Muntz, and Palacios (1975) exhibited the equilibrium distribution for networks in which the queues take certain forms, these forms including most of the special cases discussed in Sections 3.1 and 3.3. The presentation given in Sections 3.1 and 3.3 is based on Kelly (1976b). The means whereby an arbitrary distribution is approximated by a mixture of gamma distributions is known as the method of stages (Cox and Miller, 1965). The method is particularly useful in Section 3.3 because of the insensitivity of the results to the form of the distributions, and hence to the complexity of the approximation. Barbour (1976) establishes the validity of the limiting procedure used in Section 3.3 whereby systems involving arbitrary distributions are approximated by systems involving mixtures of gamma distributions. Results for systems involving arbitrary distributions can be obtained directly: see Takács (1969), Shanbhag and Tambouratzis (1973), and Kelly (1976d). The insensitivity of symmetric queues can be deduced from the results of Koenig, Matthes, and Nawrotzki (1967); see also Chandy, Howard, and Towsley (1977). The phenomenon described in part (iii) of Theorem 3.12 was observed in a class of teletraffic models by Cohen (1957) and Descloux (1967). The expression of the virtual waiting time in an $M/G/1$ queue as a geometric mixture was first given by Beneš (1957); Exercise 3.3.7 supplies an explanation of the fact. Exercise 3.3.10 is taken from Kelly (1975a). The results contained in Exercise 3.3.11 were obtained by Shanbhag and Tambouratzis (1973), Mecke (1975), and Oakes (1976). Exercise 3.4.6 is due to Cohen (1977) and Schassberger (1978b). Exercise 3.4.8 is based on a result of Mar'yanovitch discussed by Gnedenko and Kovalenko (1968). The functional form (3.26) is suggested by the work of Kovalenko (1962). Exercise 3.5.8 is based on an example of Koenig and Jansen (1974).

Recent reviews of work on queueing networks are Disney (1975), Gelenbe and Muntz (1976), and Lemoine (1977). Sections on queueing networks are included in the textbook of Kleinrock (1975) and the monograph of Curtois (1977).

4. EXAMPLES OF QUEUEING NETWORKS

The approach to communication networks described in Section 4.1 was pioneered by Kleinrock (1964, 1976). For an introduction to the area of machine interference see Cox and Smith (1961). Muntz (1975) reviews queueing models of computer systems. Exercises 4.2.5 and 4.3.4 are based on an idea of Schassberger. Syski (1960), Beněs (1965), and Cooper (1972) discuss many interesting teletraffic models. The model of a telephone exchange with unreliable lines generalizes work by Mar'yanovitch discussed in Gnedenko and Kovalenko (1968). The model of a switching system extends a result of Buchner and Neal (1971). Exercise 4.4.9 describes a result of Cohen (1957) and Exercise 4.4.10 a result of Koenig (1965). Cooper (1972) gives some of the background to the interesting phenomenon mentioned in Exercise 4.4.11. Matis and Hartley (1971) discuss compartmental models in biology, Chiang (1968) birth–illness–death models, and Bartholomew (1973) manpower systems. Theorem 4.2 and Exercise 4.5.4 are taken from Kingman (1969). The transient analysis of compartmental models in which the arrival rate depends on the number in the system is difficult (see Milch, 1968). Takács (1962) discusses the transient behaviour of certain queues. Exercise 4.5.6 (and its solution) come from Oakes (1977). The problem with viewing road traffic flow as a series of queues is that the queues may coalesce: see Miller (1961) and Gipps (1977). The generalization of a type I counter is mentioned in Oakes (1976). For the more usual approach to electronic counters, via renewal theory, see Cox (1962). The result for a repair shop is due to Yaroshenko and is discussed in Gnedenko and Kovalenko (1968). Exercise 4.6.9 is based on Wolff and Wrightson (1976). The applications mentioned in Exercises 4.6.11 and 4.6.12 are discussed by Maher and Cabrera (1975) and Koenigsberg and Lam (1976).

5. ELECTRICAL ANALOGUES

The connection between reversible random walks and electrical networks described in Section 5.1 has been discussed by Nash-Williams (1959) and Kemeny, Snell, and Knapp (1976). The flow model of Section 5.2 was introduced by Kingman (1969) and the invasion model of Section 5.3 by Clifford and Sudbury (1973); both of these models were considered further by Kelly (1976c).

6. REVERSIBLE MIGRATION PROCESSES

The reversible migration processes introduced in Section 6.1 come from the important paper of Kingman (1969). The models of social grouping behaviour discussed in Section 6.2 are taken from Cohen (1972); see also

Cohen (1971). The closed flow model leading to the equilibrium distribution (6.14) is due to Spitzer (1970). Exercise 6.3.2 is based on an idea of White (1970).

7. POPULATION GENETICS MODELS

The neutral allele model discussed is just one of the many stochastic models of use in population genetics; others are described by Ewens (1969) and Crow and Kimura (1970). For an account of the varying emphasis in current theories of evolution see Crow (1972), Lewontin (1974), and Kimura (1976). The model introduced in Section 7.1 is based on the work of Moran (1958); its equilibrium distribution was obtained by Trajstman (1974). Theorem 7.1 comes from Kelly (1977); Ewens (1972) and Watterson (1974) had previously established the result for samples from large populations. The results contained in Exercises 7.1.4, 7.1.8, and 7.1.11 are due to Ewens (1972). Exercises 7.1.6 and 7.1.7 are based on Kingman (1978) and Exercise 7.1.10 on Kelly (1976a). It was Watterson (1976) who first realized that reversibility could help answer questions about the age of an allele. Section 7.2 is taken mainly from Watterson and Guess (1977) and Kelly (1977). Fixation times are discussed by Guess and Ewens (1972); the results of Section 7.3 come from Kelly (1977). Exercise 7.3.2 is due to Watterson (1961); the extension contained in Exercise 7.3.3 is a variant of a result of Kimura and Ohta (1969). For a fuller discussion of the topic touched on in Exercise 7.3.5 see Watterson (1975). Another application of time reversed processes in genetics is described by Seneta (1965).

8. CLUSTERING PROCESSES

Early attempts to model social grouping behaviour were made by Coleman and James (1961), White (1962), and Goodman (1964). The basic model of Section 8.2 is due to Whittle (1965a). Morgan (1976) established Lemma 8.3 and discussed some of the examples given in Section 8.3. Expression (8.21) was first obtained through the classic approach to polymer statistics of Flory (1953) and Stockmayer (1943). Watson (1958), Gordon (1962), and Good (1963) developed the branching process approach touched on in Exercise 8.4.7. The development presented in Section 8.4 is a special case of the powerful and elegant treatment of polymerization processes due to Whittle (1965a, 1965b, 1972).

9. SPATIAL PROCESSES

Theorem 9.2 was first established by Brook (1964); Grimmett (1973) obtained the explicit representation given in Exercise 9.1.1. See Moussouris

(1974) for the counterexamples referred to in Exercise 9.2.2. Methods for the statistical analysis of data arising from Markov fields have been developed by Besag (1974a); see also Kingman (1975), Ripley (1977), Bartlett (1978), and the papers in Tweedie (1978). Theorem 9.3 is due to Spitzer (1971) and Besag (1974b). Much of the work on Markov fields is motivated by applications in statistical mechanics; expositions from this point of view are Preston (1974) and Spitzer (1974). Section 9.3 is based on Kelly (1975b). The step from gamma distributions to arbitrary distributions is made possible by the work of Barbour (1976). The reader interested in the model developed in Exercise 9.3.6 should see Preston (1975), Kelly and Ripley (1976), and Ripley and Kelly (1977). Matthes and Koenig have done important work on the phenomenon of insensitivity and have shown that for a certain fairly general class of systems insensitivity is characterized by a form of partial balance (see the appendix to Gnedenko and Kowalenko, 1971, written by Koenig, Matthes, and Nawrotzki, or the introduction to this work written by Schassberger, 1977). Theorems 9.9 and 9.10 are inspired by this work. It is possible to describe a network of symmetric queues as a spatial process (cf. Schassberger, 1978a). Exercise 9.4.3 is taken from Whittle (1975).

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