Comparison of approximate transient queueing network models *

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Three approximate finite capacity queueing network models—Filipiak's model [Fil88], Tipper & Sundareshan's model [TS90] and a new model—are compared in terms of their accuracy and their computation for a small packet-switched communication network. The aim of the paper it to find the approximate model that yields a good compromise between accuracy and computation.

The packet-switched communication network is modelled by a queueing network. Consider a packet-switched communication network consisting of M transmission links. Each transmission link is modelled by a finite capacity single server queue with index i where $1 \leq i \leq M$. The queues have exponentially distributed service times with mean $1/\mu_i$. Let n_i denote the number of customers either being served or waiting for service at queue i and let the network state descriptor be given by $\mathbf{n} = (n_1, n_2, \ldots, n_M)$. External customers entering the network via queue i form a nonstationary Poisson process with parameter $\nu_i(t)$. Let $\alpha_{i,j}(t)$ denote the probability that a customer, upon completing service at queue i, proceeds directly to queue j. Transit times between service centres are zero. Any customer that is blocked at a queue is rejected from the network.

Filipiak's *dynamic flow model* is a fluid approximation model for transient queueing systems. Tipper & Sundareshan's model consists of Kolmogorov's system of differential equations for each queue in the network and uses a fluid approximation to model the flow of customers between queues. The new model is developed from Filipiak's dynamic flow model and is called the AQ-model (approximate queue model). All three models consist of differential equations and their solutions are obtained using numerical integration techniques.

The accuracy for the approximate models are calculated as follows. First, a *modelling error* is defined in terms of the performance measures for both the approximate model and an accurate model (Kolmogorov's system of differential equations). Second, the modelling error is calculated for a small packet-switched communication network under various transient conditions and finally, the modelling error for the approximate models are compared.

The paper shows that the models listed in order of decreasing accuracy are: Tipper & Sundareshan's model, the AQ-model and Filipiak's model. On the other hand, in

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terms of computation, Filipiak's model and the AQ-model have similar requirements while Tipper & Sundareshan's model has significantly greater requirements. Therefore the AQ-model provides a good compromise between accuracy and computation for transient networks.

References

[Fil88] Janusz Filipiak. *Modelling and Control of Dynamic Flows in Communication Networks*. Springer-Verlag, 1988. ISBN 3-540-18292-6.

[TS90] David Tipper and Malur K. Sundareshan. Numerical methods for modeling computer networks under nonstationary conditions. *Proceedings of the IEEE*, 8(9):1682–1695, December 1990.