

NAME

Fmd1() – Virtual waiting time distribution function
 IntFmd1() – Virtual waiting time distribution function for integral values of x
 SumMd1() – Calculates the state probabilities of a M/D/1 queue
 RecMd1() – Calculates the state probabilities of a M/D/1 queue using a recursive algorithm

SYNOPSIS

```
#include <queuel.h>

double Fmd1(double x, double rho);
double IntFmd1(int N, double rho);
double *SumMd1(double x, double rho);
double *RecMd1(int x, double rho);
```

DESCRIPTION

delim \$\$ These functions return the state probabilities or the virtual waiting time distribution of a M/D/1 queue.

Fmd1() is a model for the M/D/1 queuing system with Poisson arrivals and deterministic (constant) service time. Parameter x is the amount of unfinished work in the system. ρ is the load level of the system.

ALGORITHM

M/D/1 waiting time distribution is calculated using the following algorithm (Iversen):

$$P\{W \leq T + \tau\} = e^{-\lambda \tau} \sum_{0 \leq n \leq T} \frac{(-\lambda \tau)^n}{n!} P\{W \leq T - n\},$$

where $P\{W \leq T - n\}$ is the waiting time for integral values of x :

$$P\{W \leq t\} = P\{0\} + P\{1\} + \dots + P\{t\}.$$

The state probabilities can be calculated by using a general or a recursive algorithm (Fmd1() uses the recursive algorithm, because it is more accurate):

$$\begin{aligned} P(0) &= 1 - A \\ P(1) &= (1 - A)(e^A - 1) \\ P(2) &= (1 - A)(-e^A(1 + A) + e^{2A}) \\ A &= \lambda h \text{ (If } h=1, A=\lambda \text{).} \end{aligned}$$

General algorithm:

$$P(i) = (1 - A) \sum_{1 \leq n \leq i} \frac{(-1)^{i-n} e^{nA}}{(nA)^{i-n}} \frac{(nA)^{i-n}}{(i-n)!} + \frac{(nA)^{i-1}}{(i-1)!}, \quad i=2,3,\dots$$

(The last term always equals e^{iA} .)

Recursive algorithm:

$$\begin{aligned} P(i+1) &= \frac{1}{P(0,h)} \left(P(i) - \frac{P(0) + P(1)}{P(i,h)} P(i,h) - \sum_{2 \leq n \leq i} P(n) P(i-n+1,h) \right), \quad i=3,4,\dots \\ P(i,h) &= \frac{(\lambda h)^i}{i!} e^{-\lambda h} \end{aligned}$$

ERRORS

When ρ is close to 1, these functions might give inaccurate results.

SEE ALSO

COST 224: Performance evaluation and design of multiservice networks

