

NAME

Fmdn() – Virtual waiting time distribution function

IntFmdn() – Virtual waiting time distribution function for integral values of x

Mdn() – Calculates the state probabilities of a queue (queue length)

Fekdn() – Virtual waiting time distribution function

SYNOPSIS

```
#include <queue.h>
```

```
double Fmdn(double x, double rho, int n);
```

```
double IntFmdn(int N, double rho, int n);
```

```
double *Mdn(double x, double rho, int n);
```

```
double Fekdn(double x, double rho, int k, int n);
```

DESCRIPTION

delim \$\$ These functions return the state probabilities or the virtual waiting time distribution of a $M/D/n$ queue. (And the virtual waiting time distribution of a $E_k/D/n$ queue.)

Fmdn() is a model for the $M/D/n$ queueing 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 and n is the number of servers.

Fekdn() is a model for the $E_k/D/n$ queueing system with Erlang- k 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 and n is the number of servers.

ALGORITHM

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

$$P\{SW \leq t\} = \sum_{i=0}^{n-1} \sum_{j=0}^i P(j) \sum_{\nu=0}^{\{T\} - \{A(\nu)-t\}} \{ \{A(\nu)-t\} \sup \{ \nu + \nu - 1 - i \} \text{ over } \{ \{ \nu + n - 1 - i \} ! \} \} e^{\sup \{ A(\nu)-t \}} ,$$

where $P(j)$ is a state probability.

For integral values of the waiting time we have

$$P\{SW \leq t\} = \sum_{\nu=0}^{\{n(t+1)-1\}} P(\nu).$$

The state probabilities are calculated using the following procedure

– first we make an initial guess $(M/M/n)$:

$$\{P \sup \{(1)\}(0) = (\sum_{i=0}^{n-1} \{(\lambda h) \sup i \text{ over } \{i!\} + \{(\lambda h) \sup n \text{ over } \{n!\} \} \{1 \text{ over } \{1 - \lambda h \text{ over } \{n\} \} \}) \sup \{-1\}\}$$

$$\{P \sup \{(1)\}(i) = P(i-1) \{ \lambda h \text{ over } i, \text{ } i=1,2,\dots,n-1\}$$

$$\{P \sup \{(1)\}(i) = P(i-1) \{ \lambda h \text{ over } n, \text{ } i=n,n+1,\dots,I \text{ (until } P(i) < \{\epsilon\})\}$$

$$\{P \sup \{(1)\}(i) = P(i-1) \{ \lambda h \text{ over } n, \text{ } i=I+1,\dots,I+n\}$$

– then we iterate until $\{ \max_{i \leq I} |P \sup \{(k)\}(i) - P \sup \{(k-1)\}(i)| \} < \{\epsilon\}$:

$$P \sup \{(k)\}(i) = \{ \sum_{\nu=0}^{\{n\}} P \sup \{(k-1)\}(\nu) \} P(i, h) + \sum_{\nu=n+1}^{\{n+i\}} P \sup \{(k-1)\}(\nu) P(n+i-\nu, h), \text{ } i=0,1,\dots,I$$

$$P \sup \{(k)\}(i) = P \sup \{(k)\}(i-1) \{ \lambda h \text{ over } n \}, \text{ } i=I+1,\dots,I+n$$

$$S \sup \{(k)\} = \sum_{i=0}^{\{I+n\}} P \sup \{(k)\}(i)$$

$$P \sup \{(k)\}(i) = \{ P \sup \{(k)\}(i) \text{ over } \{ S \sup \{(k)\} \} \}, \text{ } i=0,1,\dots,I+n$$

$$P(i, h) = \{ \{(\lambda h) \sup i \text{ over } \{i!\} \} e^{\sup \{ -(\lambda h) \}} \}$$

$E_k/D/n$ waiting time distribution is calculated using the $M/D/n$ algorithm:

$E_k/D/r$ (FIFO) is equivalent to $M/D/r*k$ (FIFO).

ERRORS

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

SEE ALSO

COST 224: Performance evaluation and design of multiservice networks