

## Bulk Arrivals

This Hypercard stack was prepared by:  
Dennis L. Bricker,  
Dept. of Industrial Engineering,  
University of Iowa,  
Iowa City, Iowa 52242  
e-mail: [dennis-bricker@uiowa.edu](mailto:dennis-bricker@uiowa.edu)



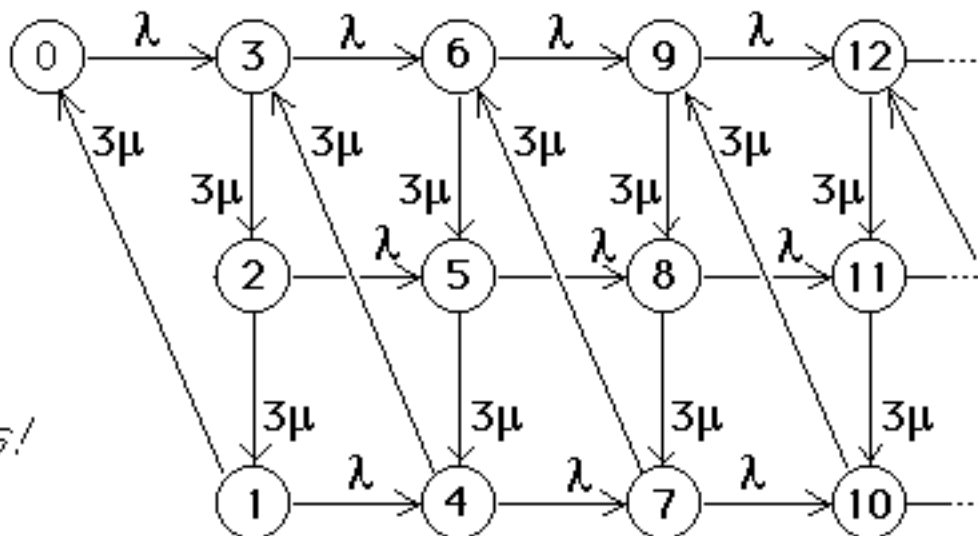
## Bulk Arrivals

"Customers" arrive in batches of size  $K$ ,  
with batch arrivals forming a Poisson  
process with rate  $\lambda$

Service time for each customer has  
exponential distribution with mean  $1/K\mu$   
i.e., time to process the batch has mean  $1/\mu$

**Continuous-Time Markov Chain**

$K=3$

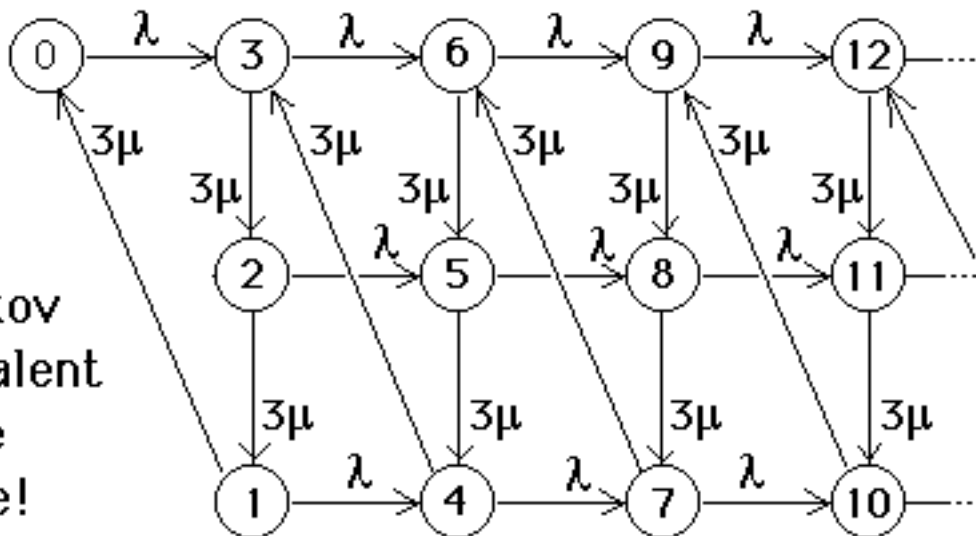


*Not a birth-death process!*

©D. Bricker, U. of Iowa, 1997

**Continuous-Time Markov Chain**

$K=3$

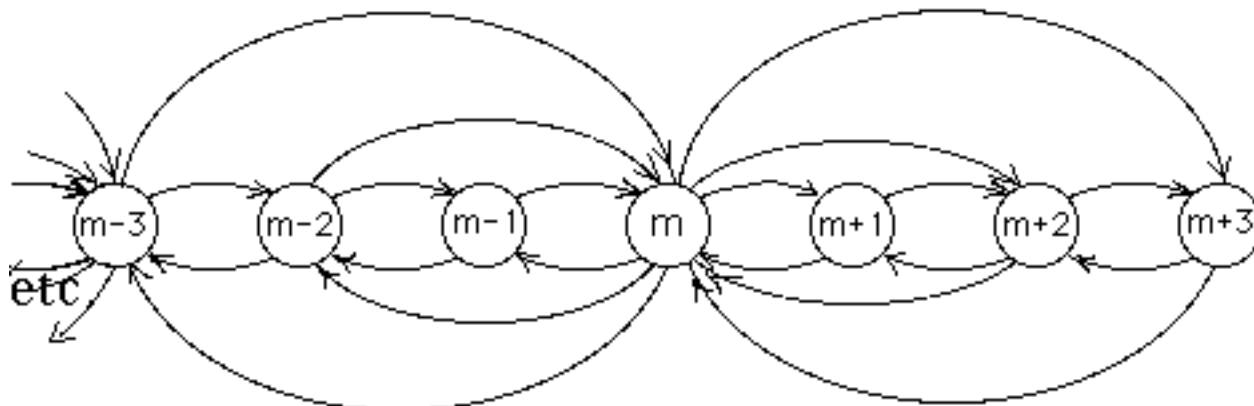


This C-T Markov chain is equivalent to that for the  $M/E_k/1$  queue!

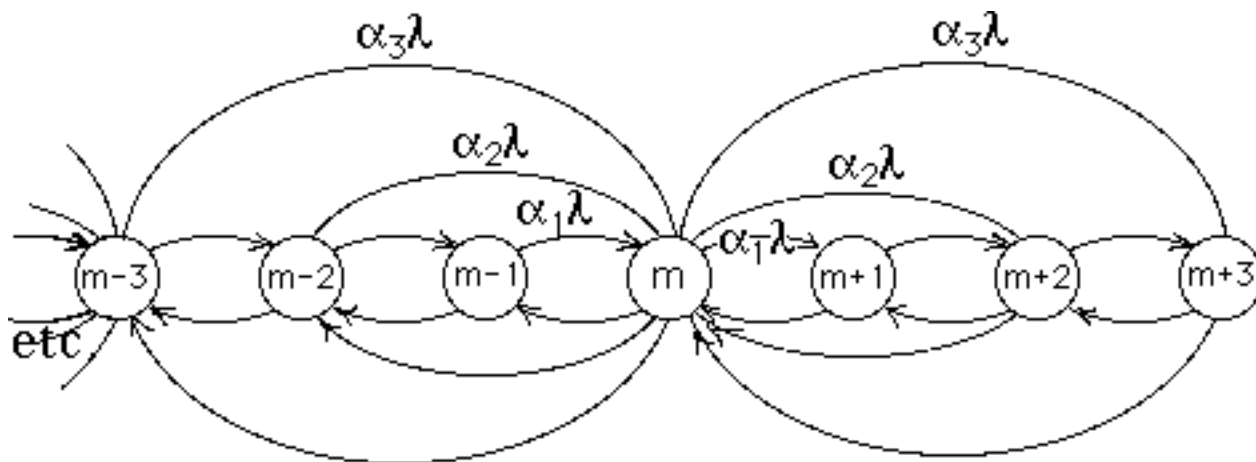
©D. Bricker, U. of Iowa, 1997

# Bulk Arrivals, with Random-Sized Batches

Let  $\lambda$  = arrival rate of batches  
 $\alpha_k$  = probability that batch contains  $k$  customers,  $k=1,2,3,\dots,K$   
 $\mu$  = service rate for each customer



©D. Bricker, U. of Iowa, 1997



**Balance Equations**

$$\lambda \pi_0 = \mu \pi_1$$

$$\vdots$$

$$[(\alpha_1 + \alpha_2 + \dots) \lambda + \mu] \pi_m = \mu \pi_{m+1} + \sum_{k=1}^{m-1} \alpha_k \lambda \pi_{m-k}$$

©D. Bricker, U. of Iowa, 1997