Trunking Theory

Instructor: M. A. Ingram

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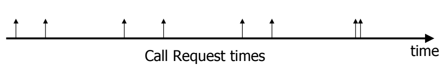
An Old Idea

- Trunking theory tells the size of a population that can be served by a limited number of servers with a specified grade-of-service (GOS)
- In the simple case, the GOS is the blocking probability
- Developed in the late 1800s by Erlang

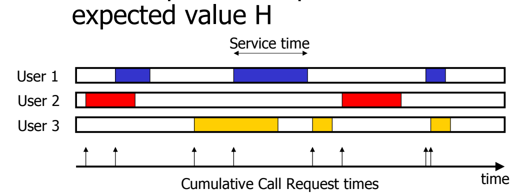
Request Model

- Assume that customers request service at random times at a certain cumulative average rate, λ
  - e.g. $\lambda = 13$ requests per hour
- Times between consecutive requests are independent exponential random variables (RVs) with parameter λ



Server Model

- The durations of service (i.e. the lengths of the calls or "holding times") are independent exponential RVs with expected value H



Measuring Traffic Intensity

- An "Erlang" is the average fraction of time that a channel is occupied
- One continuous call is an example of traffic intensity of 1 Erlang
- A channel that carries traffic only half the time carries 0.5 Erlangs of traffic
- For the request and server models in previous slides, the traffic intensity is λH

Single User vs. Total

- Suppose each user generates a traffic intensity of A_u Erlangs
- Suppose there are U users
- Then the total traffic intensity in Erlangs is

$$A = A_u U$$

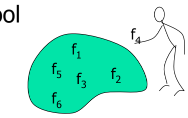
Channels

- Each call requires a channel
- One approach is to dedicate a channel to each user
  - A user's call request is never denied
  - A channel sits idle when its user is not making a call

Not an efficient use of resources!

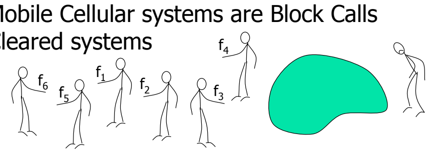
Trunked System

- Channels are "pooled"
- No user has a fixed channel
- A new user is assigned some channel from the pool
- When a call is finished, the channel is released back into the pool



"Block Calls Cleared"

- In a Block Calls Cleared type of system, a call request is simply denied if all channels in the pool are in use
- The blocked caller is free to make a new request
- Mobile Cellular systems are Block Calls Cleared systems



Probability of Blocking

- The GOS measure for Block Calls Cleared systems is the probability that a user's call request is blocked
- The Erlang B formula determines the blocking probability, p, given a certain total offered traffic intensity, A, and a certain number of channels C in the pool

$$p = B(A,C)$$

Erlang B Formula

- A is the total *offered* traffic
- Because some calls are blocked, A is not the traffic carried by the system

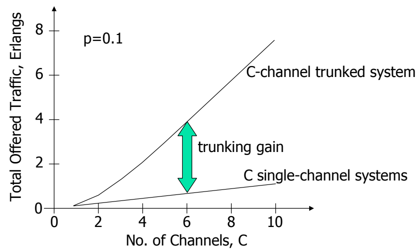
$$p = B(A,C) = \frac{\dfrac{A^C}{C!}}{\displaystyle\sum_{k=0}^{C} \frac{A^k}{k!}}$$

Trunking Gain

- Trunking gain is the improvement in offered traffic intensity that is obtained when sets of channels are merged into trunk pools
- In the next slide, the offered traffic intensities for a 10% blocking probability are compared for a C-channel trunked system and C fixed, single-channel systems

Graphical Comparison

- Sketched from [Hernando and Pérez-Fontán,`99]



Summary

- In a trunked system, channels are pooled for common use on an as-needed basis
- In a Block Calls Cleared system, a new request is simply denied if all channels are busy
- The more channels in the pool, the higher the offered traffic can be for a given probability of blocking

References

- J. M. Hernando and F. Pérez-Fontán, *Introduction to Mobile Communications Engineering*, Artech House, 1999
- T.S. Rappaport, *Wireless Communications*, Prentice Hall, 1996