Mobile Communications

TCS 455

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Lecture 7

Office Hours:
BKD 3601-7
Tuesday 14:00-16:00
Thursday 9:30-11:30

Announcements

- Read
  - Chapter 3: 3.1 – 3.2, 3.5.1, 3.6, 3.7.2
    - Posted on the web
  - Appendix A.1 (Erlang B)
- Due date for HW2: Nov 27
- All ***graduate*** **students** should send an email to me (prapun@siit.tu.ac.th). I need to somehow add ***your id*** into the SIIT online lecture note system. In the case that there is some delay to this, I might need to send the files to you via ***email***.

Estimating the number of users

- Trunking
- Allow a large number of users to share the relatively small number of channels in a cell by providing access to each user, on demand, from a pool of available channels.
- Exploit the statistical behavior of users
- Each user is allocated a channel on a per call basis, and upon termination of the call, the previously occupied channel is immediately returned to the pool of available channels.

Common Terms

- **Traffic Intensity**: Measure of channel time utilization, which is the average channel occupancy measured in Erlangs.
  - This is a dimensionless quantity and may be used to measure the time utilization of single or multiple channels.
  - Denoted by ***A***.
- **Holding Time**: Average duration of a typical call. Denoted by $H = 1/\mu$.
- **Blocked Call**: Call which cannot be completed at time of request, due to congestion. Also referred to as a **lost call**.
- **Grade of Service (GOS)**: A measure of congestion which is specified as the probability of a call being blocked (for Erlang B).
  - The AMPS cellular system is designed for a GOS of 2% blocking. This implies that the channel allocations for cell sites are designed so that 2 out of 100 calls will be blocked due to channel occupancy during the busiest hour.
- **Request Rate**: The average number of call requests per unit time. Denoted by λ.

M/M/m/m Queue Assumption

- **Blocked calls cleared**
  - Offers no queuing for call requests.
  - For every user who requests service, it is assumed there is no setup time and the user is given immediate access to a channel if one is available.
  - If no channels are available, the requesting user is blocked without access and is free to try again later.
- Calls arrive as determined by a *Poisson process*.
- There are memoryless arrivals of requests, implying that all users, including blocked users, may request a channel at any time.
- There are an infinite number of users (with finite overall request rate).
  - The finite user results always predict a smaller likelihood of blocking. So, assuming infinite number of users provides a conservative estimate.
- The duration of the time that a user occupies a channel is exponentially distributed, so that longer calls are less likely to occur.
- There are m channels available in the trunking pool.
  - For us, m = the number of channels for a cell (C) or for a sector

Erlang B

$$P_b = \frac{\frac{A^C}{C!}}{\sum_{k=0}^{C} \frac{A^k}{k!}}.$$

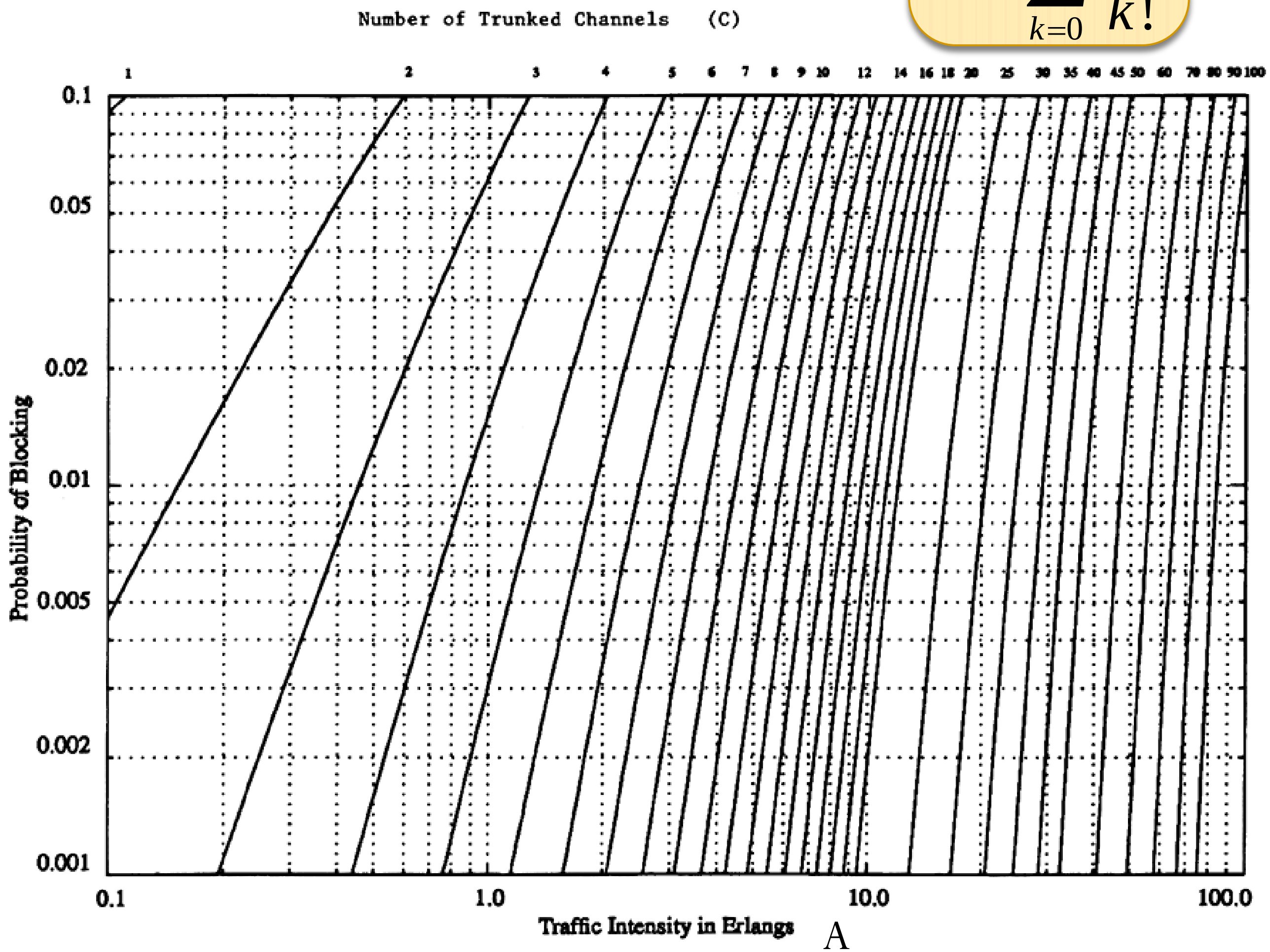


Figure 3.6 The Erlang B chart showing the probability of blocking as functions of the number of channels and traffic intensity in Erlangs.

Erlang B Trunking GOS

Table 3.4 Capacity of an Erlang B System

Number of Channels *C*	Capacity (Erlangs) for GOS = 0.01	= 0.005	= 0.002	= 0.001
2	0.153	0.105	0.065	0.046
4	0.869	0.701	0.535	0.439
5	1.36	1.13	0.900	0.762
10	4.46	3.96	3.43	3.09
20	12.0	11.1	10.1	9.41
24	15.3	14.2	13.0	12.2
40	29.0	27.3	25.7	24.5
70	56.1	53.7	51.0	49.2
100	84.1	80.9	77.4	75.2

Example

- How many users can be supported for 0.5% blocking probability for the following number of trunked channels in a blocked calls cleared system?
  (a) 5
  (b) 10
- Assume each user generates 0.1 Erlangs of traffic.

Erlang B

$$P_b = \frac{\frac{A^C}{C!}}{\sum_{k=0}^{C} \frac{A^k}{k!}}.$$

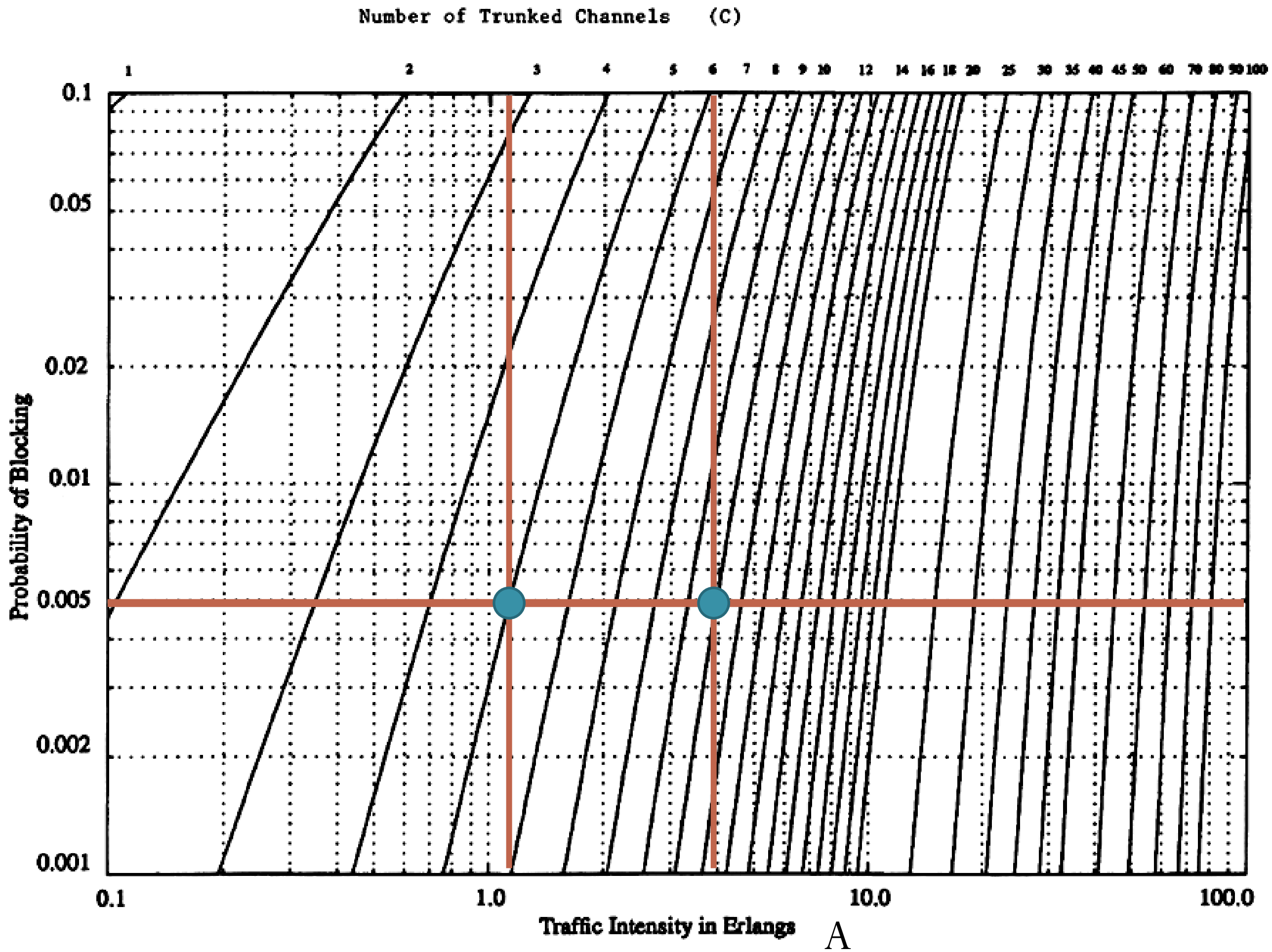


Figure 3.6 The Erlang B chart showing the probability of blocking as functions of the number of channels and traffic intensity in Erlangs.

Example

- Consider a cellular system in which
  - an average call lasts two minutes
  - the probability of blocking is to be no more than 1%.
- If there are a total of 395 traffic channels for a seven-cell reuse system, there will be about 57 traffic channels per cell.
- From the Erlang B formula, the may handle 44.2 Erlangs or **1326 calls per hour**.

Erlang B

$$P_b = \frac{\frac{A^C}{C!}}{\sum_{k=0}^{C} \frac{A^k}{k!}}.$$

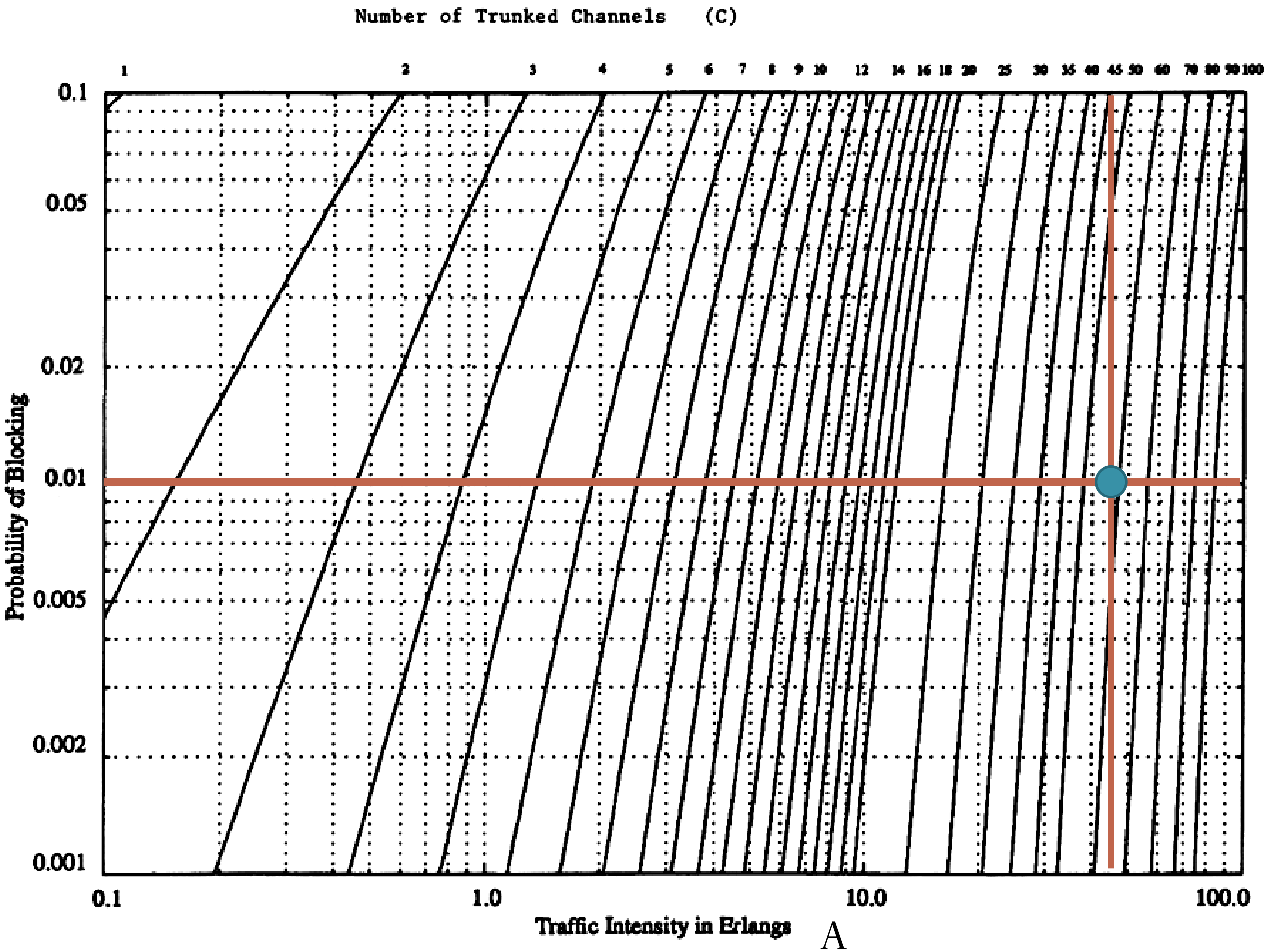


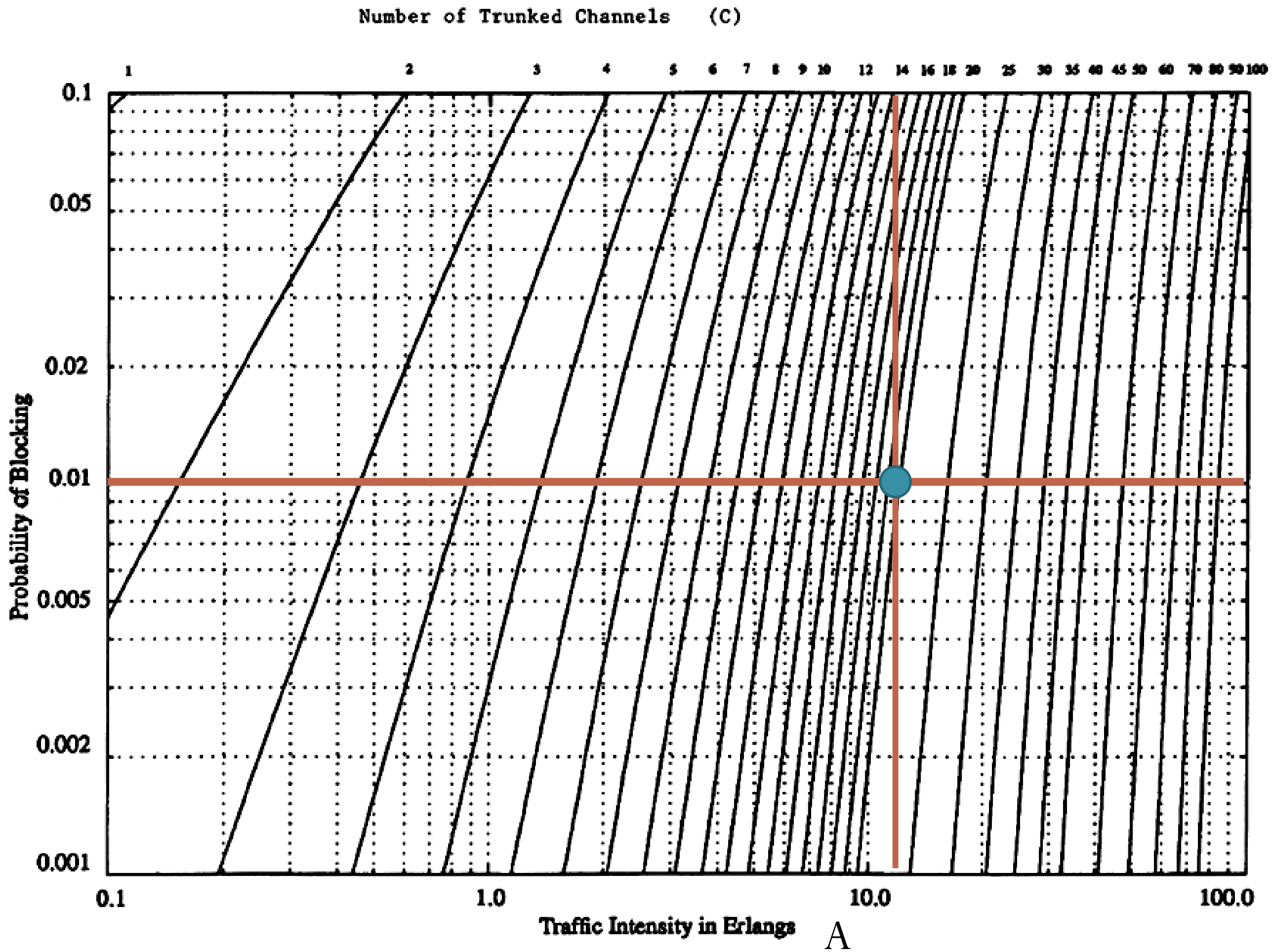
Figure 3.6 The Erlang B chart showing the probability of blocking as functions of the number of channels and traffic intensity in Erlangs.

Example

- Now employing **120° sectoring**, there are only 19 channels per antenna sector (57/3 antennas).
- For the same probability of blocking and average call length, each sector can handle 11.2 Erlangs or 336 calls per hour.
- Since each cell consists of three sectors, this provides a cell capacity of $3 \times 336 =$ **1008 calls per hour**, which amounts to a 24% decrease when compared to the unsectored case.
- Thus, sectoring decreases the trunking efficiency while improving the S/I for each user in the system.

Erlang B

$$P_b = \frac{\frac{A^C}{C!}}{\sum_{k=0}^{C} \frac{A^k}{k!}}.$$



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