TSN: Lecture 23
Introduction to
Traffic Engineering

Topics Covered

- Statistical Analysis
- Call Arrivals
- Objective of Traffic Engineering
- Blocking

Basic Concept

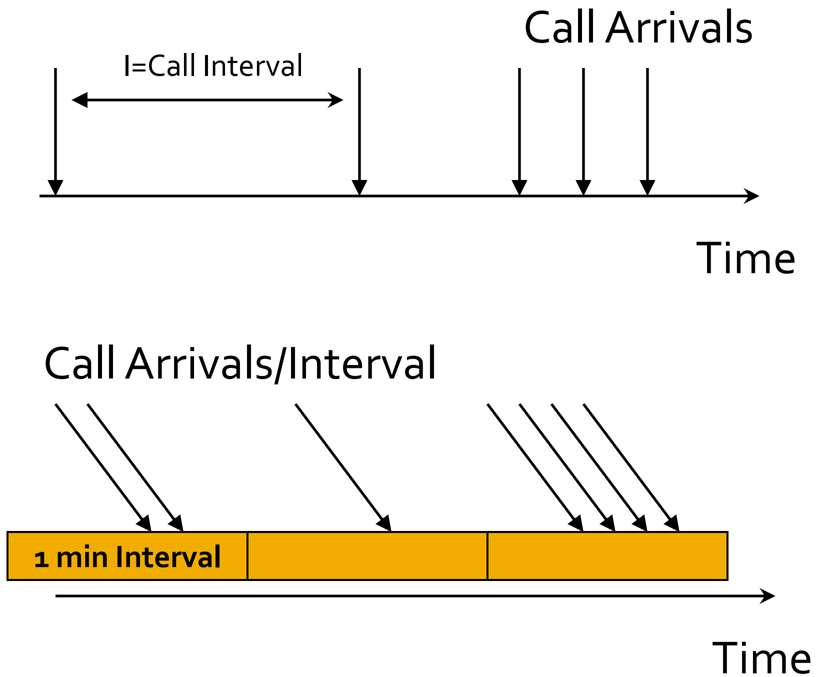
- **Performance analysis methods applied to telephony are usually referred to as traffic engineering**
- **Motivated by two factors**
  - **Unpredictable behavior of users**
    - **You never know when they call!**
  - **Users have to share resources**
    - **Users have to be happy!**

Statistical Analysis

- We cannot exactly predict what users do!
- We can statistically tell what users may do!
- Looking at the traffic pattern we can see
  - Number of callers arrived in one hour = 20/hr
  - Average length of calls = 3 min/call
- Statistics on voice and data communications are very different
  - Data tends to be bursty
  - Voice is continuous with known average length

Call Arrivals

- Calls arrive randomly!
  - But how?
- Looking at call arrivals
  - Average call interval (I=2sec/call)
  - Number of calls per unit interval (A=10call/min)
  - Note that I is inversely proportional to A



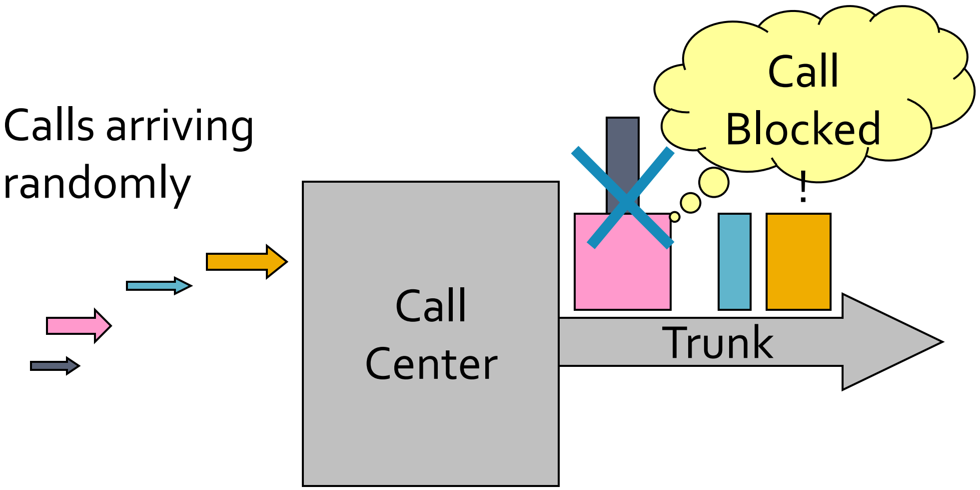
More Calls → Shorter time between successive calls

Objective of Traffic Engineering

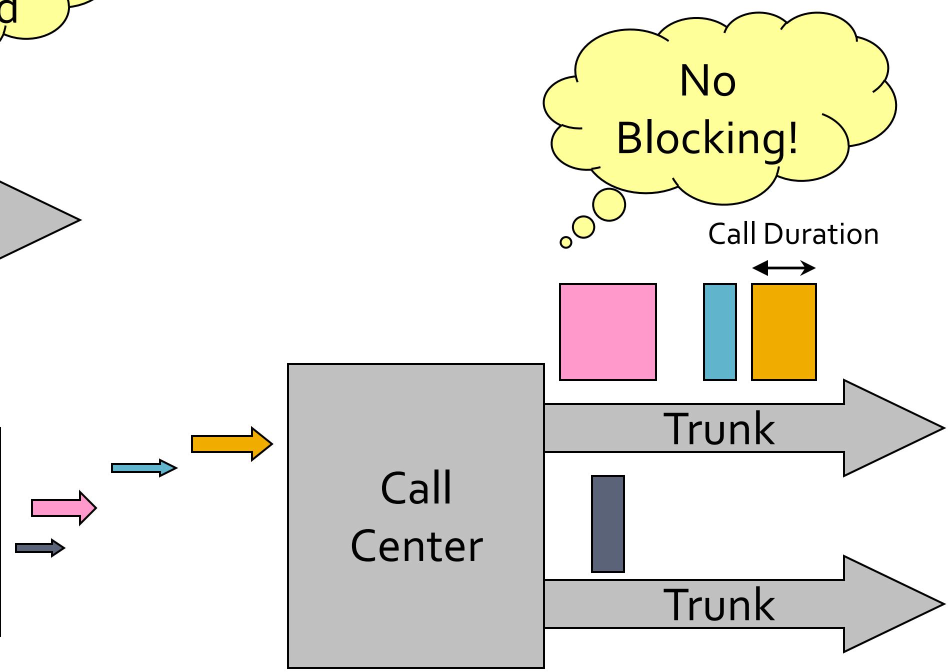
- **Given expected traffic (+ growth assumptions)…**
- **Provision resources (trunks, switches)…**
- **To minimize cost …**
- **Subject to minimum acceptable quality of service requirements.**

- **Available tools:**
  - Mathematical tools
    - Equations and formulas / Statistical tools
  - Simulation tools
    - OPNE; OMNET; etc.

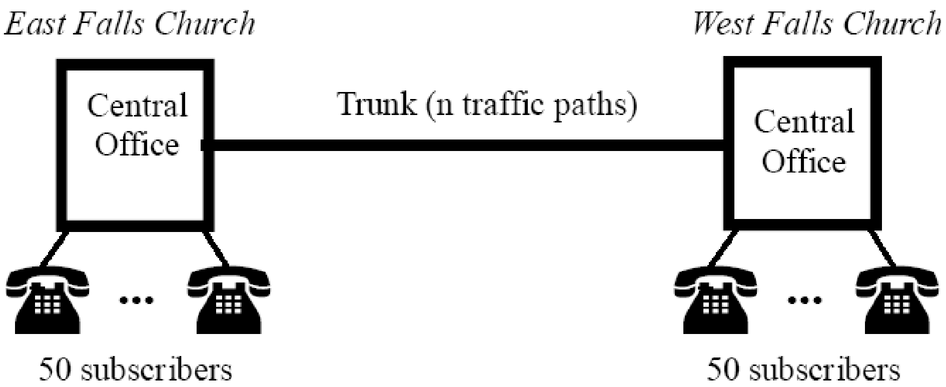
What is Blocking?



We need to figure out statistically what the probability of blocking is!
→ What is the grade of service!



The challenge



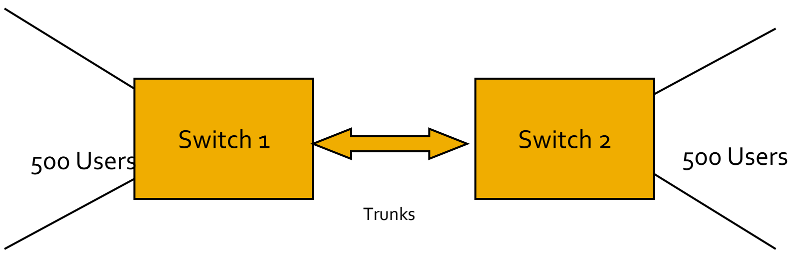
- Provisioning must be done by telephone companies
- In the example, consider connection between 2 COs
  - n = 50 channels ensures no blocking, but too costly
  - n = 1 channel good cost option, but subscribers will be unhappy (high blocking probability)
  - how do we determine the appropriate compromise?

Traffic Model Tool

- Calls arrive randomly
- All calls are independent
- Traffic models
  - Idea: telephone usage and sizing the network
  - Difference: What to do when blocking happens
  - Objective: calculate the Grade of Service (GOS)
    - If GOS is 0.01 (P.01)→ 1 call will be blocked out of 100 attempted calls!
    - Defined formally as the number of lost calls over offered calls
- Two common models
  - Erlang C
    - Call arrival behavior follows a Poisson distribution
    - blocked calls may be retried at anytime
  - Erlang B Model
    - When a call is blocked it is cleared and will only be tried later
    - The load does not consider blocked calls

Traffic Characteristics

- It is all about sharing effectively:
  - Telephone traffic is the aggregate of telephone calls over a group of circuits or trunks with regard of the number and duration of calls.
- Units:
  - Call arrival rate / hour (A)
  - Average service time or hold time (tm) / hour
    - Duration of the call
  - An *Erlang* (E) is a unit of telecommunications traffic measurement.
    - Strictly speaking, an Erlang represents the continuous use of one voice path.
    - In practice, it is used to describe the total traffic volume of one hour
    - Expresses the traffic intensity (dimensionless)
    - E = A x tm (in Erlang)



Traffic Characteristics

- Common units used in North America:
  - CS : calls-second per second
  - CCS : hundred (centrum) calls-second per hour
  - 1 Erlang = (60)(60)/100 = 36 CCS = 3600 CS
- Capacity of a single channel is one Erlang
  - Interpretation: a telephone that is busy 10% of the time represents a load of 0.1 Erlang on that particular line
- Example: 1000 calls/hour each has an average length of 5 min: 1000x(5/60)=83.33 Erlang; note the total capacity is 100!
  - What is CS and CCS?

Using Erlang B Formula

- **Assumptions:**
  - **Poisson arrivals (infinite # of sources)**
  - **equal traffic density per source**
  - **lost calls cleared**
- **Probability of blockage at the switch due to congestion or "all trunks busy":**
  - **E is the mean of the offered traffic [Erlangs]**, s **is the number of trunks**

$$P_{Blocking} = \frac{\frac{E^s}{s!}}{\sum_{k=0}^{s} \frac{E^k}{k!}}$$

Using Erlang B Formula

Example: Suppose our expected traffic in the busy hour is 10 erlangs
and we require blocking probability of 1 call in 200 (or better).

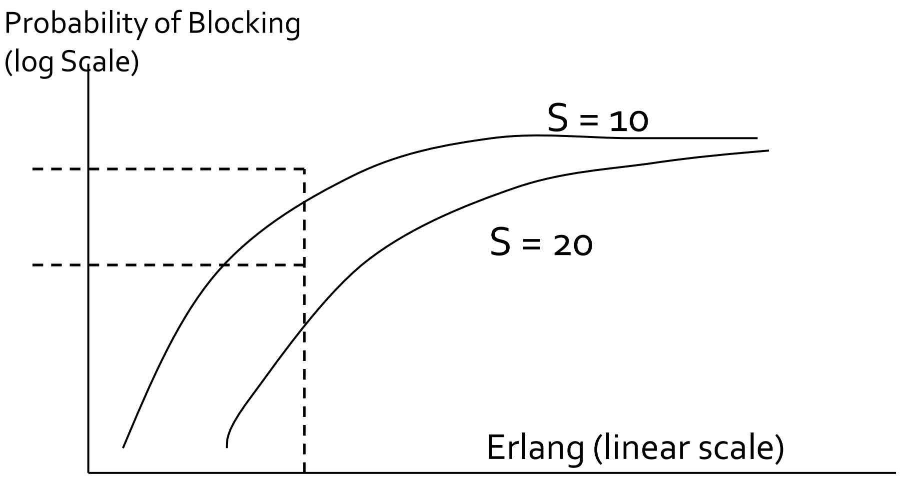
- What is the grade of service?
- How many trunks should we use?
- What is the efficiency of the system?

Trunks	P=0.001	P=0.005	P=0.01	P=0.05
1	.001	.005	.01	.05
5	.76	1.13	1.36	2.22
10	3.09	3.96	4.46	6.22
15	6.08	7.38	8.11	10.63
20	9.41	11.09	12.03	15.25
25	12.97	15	16.12	19.99

→1/200 = P0.005 = GOS
→20 Trunks
→Efficiency =
Erlang/Number of Tunks (x100) = 10/20 (x100) = 50%

Erlang B Behavior

- The Y axis is typically expressed in log scale
- S is the number of trunks
- Blocking is between 0-1
- Note that eventually blocking will approach 1
- Larges S (more trunks result in lower blocking)
- As the load increases (higher Erlang) more blocking is expected
- Higher load can be due to longer hold time or more call arrivals



References

- http://www.cisco.com/univercd/cc/td/doc/cisintwk/intsolns/voipsol/ta_isd.htm on traffic analysis
- http://www.tarrani.net/mike/docs/TrafficEngineering.pdf good information on traffic engineering and statistical calculations
- Tools to calcualte Erlang B
  - http://personal.telefonica.terra.es/web/vr/erlang/eng/mcerlb.htm
  - http://www.erlang.com/calculator/erlb/ (this one may be simpler to use!)