



# Traffic Engineering

Part 1: Introduction

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# outline

- Queue theory
- Multiple access networks
- Routing enhancement
- Congestion control
- Traffic shaping

# Evaluation

- Homework (15%)
- Midterm exam (15%)
  - 1398/1/29
- Final exam (55%)
- Research (15%)

# References

- Data Networks,
  - D. P. Bertsekas, R. G. Gallagar,
  - 2<sup>nd</sup> edition, 1992
- Traffic Engineering and QoS Optimization of Integrated Voice & Data Networks,
  - G. R. Ash,
  - Morgan Kaufman Publication,
  - 2006
- Data Communication and Networking,
  - Behrouz Forouzan,
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  - 5th edition (July 1, 2012)

# What is Traffic Engineering (TE)?

- Traffic engineering is a method of
  - optimizing the performance of data communications network by **dynamically analyzing, predicting and regulating** the behavior of data transmitted over that network.

# TE

1. Static, off-line, planning activity that is used to dimension capacity planning within a transport network.
  2. Dynamic mechanism for placing traffic within a network.
- to optimize the use of the network resources so that maximum revenue is derived from minimum expenditure.

# TE is met by:

- avoiding congestion,
- placing existing traffic
  - so that capacity is available to meet further services,
- Providing adequate QoS
  - so that differentiated services can be sold to the customers,
- Planning capacity
  - so that resources will be available in good time to meet the demands.

# Internet TE

➤ is concerned with the **performance optimization** of operational networks.

➤ Includes

- the measurement,
- modeling,
- characterization,
- and control

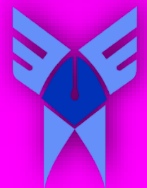
of Internet traffic and the application of techniques

- to achieve specific performance objectives, including
- the reliable and expeditious movement of traffic through the network,
  - the efficient utilization of network resources, and the planning of network capacity.



# TE leads to

- Reduced congestion
- Improved bandwidth utilization



# TE Approaches

## ➤ Preplanned:

- OSPF
  - smart link weight setting
- MPLS
  - optimal general routing

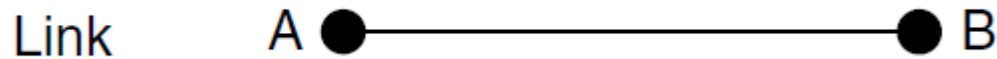
## ➤ On demand

- MPLS
  - Constraint-Based Routing

# Basic Definitions (Link, Path):

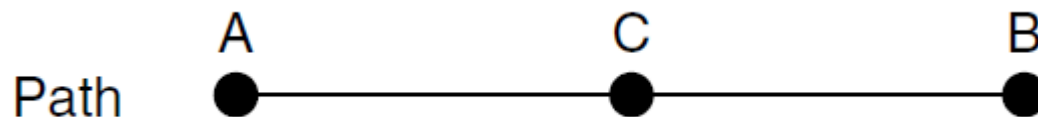
## ➤ Link:

- A bandwidth transmission medium between nodes that is engineered as a unit.



## ➤ Path:

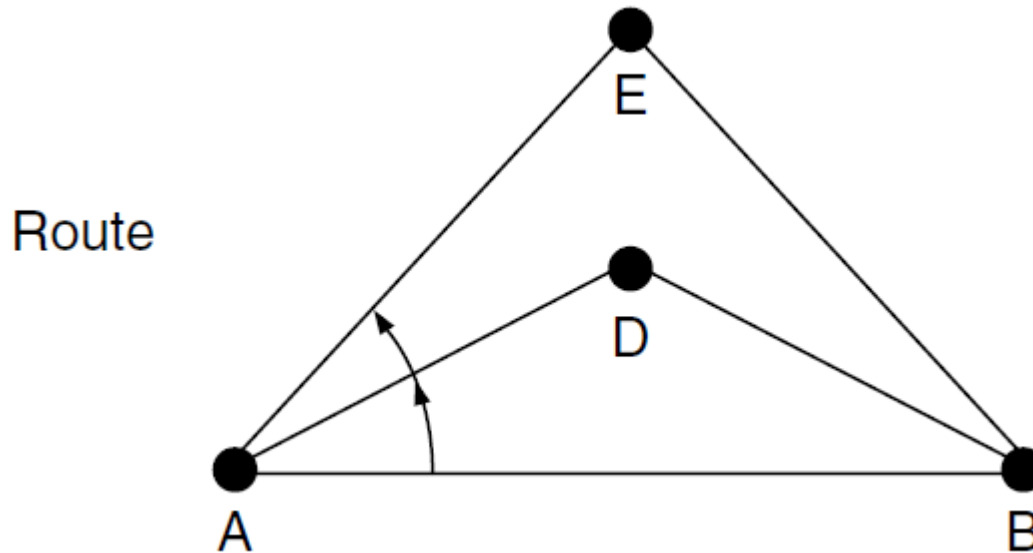
- A concatenation of links providing a connection/bandwidth-allocation between an O-D pair.
  - O-D pair:
    - An originating node to destination node pair for a given connection/bandwidth-allocation request.



# Basic Definitions (Route):

## ➤ Route:

- A set of paths connecting the same originating node destination node pair



# Basic Definitions (Peak rate):

## ➤ Peak rate:

- The highest rate at which a source can generate traffic.
- is limited by the speed of the hardware devices.
  - For example, we cannot generate packets faster than 10 Mbits/sec over a 10 Mbits/sec Ethernet.
- In some cases traffic is deliberately shaped to reduce the peak rate from the source;
- the peak rate can be calculated from the packet size and the spacing between consecutive packets.

# Basic Definitions (Average rate):

## ➤ Average rate:

- The average transmission rate over a time interval.
- can be calculated in many ways, and the results can be quite different.
  - It is important to know the exact method and the time interval used in the calculation.
- Typically the average rate is calculated with a moving time window so that the averaging time interval can start from any point in time.

# Basic Definitions (Burst size):

## ➤ Burst size:

- The maximum amount of data that can be injected into the network at the peak rate.
- reflects the burstiness of the traffic source.
- **To avoid packet losses**, the first hop router may have to allocate a buffer for the source larger than its burst size.

# Quality of Service (QoS)

- The capability to provide resource assurance and service differentiation in a network is often referred to as QoS.



# Resource Allocation

- packets get dropped or delayed
  - because the resources in the network cannot meet all the traffic demands.
- A network, in its simplest form, consists of shared resources such as:
  - bandwidth and buffers,
  - serving traffic from competing users.
- A network that supports QoS needs to take an active role in the resource allocation process and