Top-Down Network Design

Chapter Four

Characterizing Network Traffic

Network Traffic Factors
- Traffic flow
  - unidirectional, bidirectional
  - symmetric, asymmetric
- Location of traffic sources and data stores
- Traffic load
- Traffic behavior
- Quality of Service (QoS) requirements
User Communities

<table>
<thead>
<tr>
<th>User Community Name</th>
<th>Size of Community (Number of Users)</th>
<th>Location(s) of Community</th>
<th>Application(s) Used by Community</th>
</tr>
</thead>
<tbody>
<tr>
<td>PC users in Computing Center</td>
<td>30, will grow to 60</td>
<td>Basement of library</td>
<td>Homework, e-mail, web research, library card catalog</td>
</tr>
<tr>
<td>Mac users in the Computing Center</td>
<td>15, will grow to 30</td>
<td>Basement of library</td>
<td>Homework, e-mail, web research, library card catalog</td>
</tr>
<tr>
<td>Library patrons</td>
<td>15, will grow to 30</td>
<td>Floors 1–3 of library</td>
<td>E-mail, web research, library card catalog</td>
</tr>
<tr>
<td>Business/Social Sciences PC users</td>
<td>15, will grow to 30</td>
<td>Business and Social Sciences building</td>
<td>Homework, e-mail, web research, library card catalog</td>
</tr>
</tbody>
</table>

A user community is a set of workers who use a particular application or set of applications.
## Data Stores

<table>
<thead>
<tr>
<th>Data Store</th>
<th>Location</th>
<th>Application(s)</th>
<th>Used by User Community (or Communities)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Library card catalog Windows server</td>
<td>Computing Center server farm</td>
<td>Library card catalog</td>
<td>All</td>
</tr>
<tr>
<td>AppleShare IP file/print server</td>
<td>Computing Center server farm</td>
<td>Homework</td>
<td>Mac users in the Computing Center and in Arts and Humanities building</td>
</tr>
<tr>
<td>Windows file/print server</td>
<td>Computing Center server farm</td>
<td>Homework</td>
<td>PC users in all buildings</td>
</tr>
<tr>
<td>Windows web server</td>
<td>Computing Center server farm</td>
<td>Hosts the WVCC website</td>
<td>All</td>
</tr>
</tbody>
</table>

A data store is an area in a network where application layer data resides.
A data store can be a server, a server farm, a Storage-Area Network, a mainframe, or any device of an internetwork where large quantities of data are stored.
The simplest method for characterizing the size of a flow is to measure the number of KBps or MBps between communicating entities.
Types of Traffic Flow

- **Terminal/host**: traffic is usually asymmetric. The terminal sends a few characters and the host sends many characters. (Telnet)

- **Client/server**: The flow is usually bidirectional and asymmetric. File Transfer Protocol (FTP), HTTP is probably the most widely used client/server protocol.

- **Thin client**: A special case of the client/server architecture. The bulk of data processing occurs on a server. User applications originate on a central server.

Types of Traffic Flow

- **Peer-to-peer**: the flow is usually bidirectional and symmetric. Each host acts as both a client and server (BitTorrent).

- **Server/server**: traffic includes transmissions between servers and transmissions between servers and management applications. The flow is generally bidirectional.

- **Distributed computing**: refers to applications that require multiple computing nodes working together to complete a job.
Traffic Flow for Voice over IP

- The flow associated with transmitting the audio voice is separate from the flows associated with call setup and teardown.
  - The flow for transmitting the digital voice is essentially peer-to-peer.
  - Call setup and teardown is a client/server flow
    - A phone needs to talk to a server or phone switch that understands phone numbers, IP addresses, capabilities negotiation, and so on.

Network Applications
Traffic Characteristics

<table>
<thead>
<tr>
<th>Name of Application</th>
<th>Type of Traffic Flow</th>
<th>Protocol(s) Used by Application</th>
<th>User Communities That Use the Application</th>
<th>Data Stores (Servers, Hosts, and So On)</th>
<th>Approximate Bandwidth Requirement for the Application</th>
<th>QoS Requirements</th>
</tr>
</thead>
</table>

Traffic flow for an application: Terminal/host, Client/server, Peer-to-peer, Server/server, Distributed computing
Traffic Load

- To calculate whether capacity is sufficient, you should know:
  - The number of stations
  - The average time that a station is idle between sending frames
  - The time required to transmit a message once medium access is gained
- That level of detailed information can be hard to gather, however

Size of Objects on Networks

<table>
<thead>
<tr>
<th>Type of Object</th>
<th>Size in Kbytes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Terminal screen</td>
<td>4</td>
</tr>
<tr>
<td>E-mail message</td>
<td>10</td>
</tr>
<tr>
<td>Web page (including simple GIF and JPEG graphics)</td>
<td>50</td>
</tr>
<tr>
<td>Spreadsheet</td>
<td>100</td>
</tr>
<tr>
<td>Word processing document</td>
<td>200</td>
</tr>
<tr>
<td>Graphical computer screen</td>
<td>500</td>
</tr>
<tr>
<td>Presentation document</td>
<td>2000</td>
</tr>
<tr>
<td>High-resolution (print-quality) Image</td>
<td>50,000</td>
</tr>
<tr>
<td>Multimedia object</td>
<td>100,000</td>
</tr>
<tr>
<td>Database (backup)</td>
<td>1,000,000</td>
</tr>
</tbody>
</table>
Traffic Behavior

- **Broadcasts**
  - All ones data-link layer destination address
    - FF: FF: FF: FF: FF: FF
  - Doesn’t necessarily use huge amounts of bandwidth
  - But does disturb every CPU in the broadcast domain

- **Multicasts**
  - First bit sent is a one
    - 01:00:0C:CC:CC:CC (Cisco Discovery Protocol)
  - Should just disturb NICs that have registered to receive it
  - Requires multicast routing protocol on internetworks

- A router does not forward broadcasts or multicasts. All devices on one side of a router are considered part of a single broadcast domain.

Network Efficiency

- **Frame size**: using a frame size that is the maximum supported for the medium in use has a positive impact on network performance for bulk applications. Avoid fragmentation and reassembly of frames → performance degrades.

- **Protocol interaction**: Inefficiency is also caused by the interaction of protocols and the misconfiguration of acknowledgment timers and other parameters.
Network Efficiency

- **Windowing and flow control**
  - A station's send window is based on the recipient's receive window.
  - The recipient states in every TCP packet how much data it is ready to receive.
  - The recipient's receive window is based on how much memory the receiver has and how quickly it can process received data.

- **Error-recovery mechanisms**
  - Connectionless protocols usually do not implement error recovery.
  - Most data link layer & network layer protocols are connectionless.
  - Some transport layer protocols, such as UDP, are connectionless.
  - Error-recovery mechanisms for connection-oriented protocols vary.

QoS Requirements

- **Terminologies that ATM engineers use for classifying and specifying QoS requirements for classes of traffic.**

- **ATM service specifications**
  - Constant bit rate (CBR): a source end system reserves network resources in advance and asks for a guarantee that the negotiated QoS be assured to all cells
  - Realtime variable bit rate (rt-VBR)
  - Non-realtime variable bit rate (nrt-VBR)
  - Unspecified bit rate (UBR)
  - Available bit rate (ABR)
  - Guaranteed frame rate (GFR)

- Map applications and protocols to the correct service category in order to meet network performance objectives.
QoS Requirements per IETF

- Terminologies that IETF engineers use for classifying and specifying QoS requirements for classes of traffic.
- IETF integrated services working group specifications
  - Controlled load service
    - Provides client data flow with a QoS closely approximating the QoS that same flow would receive on an unloaded network
  - Guaranteed service
    - Provides firm bounds on end-to-end packet-queuing delays

QoS Requirements per IETF

- IETF differentiated services working group specifications - RFC 2475
  - IP packets can be marked with a differentiated services codepoint (DSCP) to influence queuing and packet-dropping decisions for IP datagrams on an output interface of a router

<table>
<thead>
<tr>
<th>Version</th>
<th>IHL</th>
<th>Type of Service</th>
<th>Total Length</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Identification</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Flags</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Fragment Offset</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Time to Live</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Protocol</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Header Checksum</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Source IP Address</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Destination IP Address</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Options</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Padding</td>
<td></td>
</tr>
</tbody>
</table>
Network Traffic Checklist

✓ I have identified major traffic sources and stores and documented traffic flow between them.
✓ I have categorized the traffic flow for each application as being terminal/host, client/server, peer-to-peer, server/server, or distributed computing.
✓ I have estimated the bandwidth requirements for each appl.
✓ I have estimated bandwidth requirements for routing protocols.
✓ I have characterized network traffic in terms of broadcast/multicast rates, efficiency, frame sizes, windowing and flow control, and error-recovery mechanisms.
✓ I have categorized the QoS requirements of each application.
✓ I have discussed the challenges associated with implementing end-to-end QoS and the need for devices across the network to do their part in implementing QoS strategies.

Summary

• Continue to use a systematic, top-down approach
• Don’t select products until you understand network traffic in terms of:
  ◦ Flow
  ◦ Load
  ◦ Behavior
  ◦ QoS requirements
Review Questions

- List and describe six different types of traffic flows.
- What makes traffic flow in voice over IP networks challenging to characterize and plan for?
- Why should you be concerned about broadcast traffic?
- How do ATM and IETF specifications for QoS differ?