Lecture 5: Network Analysis: Concepts

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Based on Slides by: Prof. Shervin Shirmohammadi
Requirements Analysis

- The act of gathering and deriving requirements in order to understand system and network behaviours.

- Ultimately we would like to develop threshold and limits for performance to distinguish between low and high performance services.
  
  - This will help us know whether best-effort, predictable, and guaranteed services may apply in the network.

- There is a subtle difference between requirements and features:
  
  - **Requirements** are description of network functions and performance that are needed for the network to successfully support its users.
  
  - A.k.a. Core or fundamental requirements
  
  - **Features** are functions and performance that are desired but not deemed necessary
    
    - e.g., think of some requirements and features on your current phone
Classification of Requirements

- **Informational requirements**: information rather than requirements, but will probably affect design:
  - E.g., a vendor telling you that a specific equipment has a given lifetime
  - E.g., the fact that an existing network is a 10 Mbps Ethernet LAN
IETF Requirement Classification

- **IETF RFC 2119**
  - Key Phrases used to classify importance of requirements.
  - *Must/Shall/Require* – Absolute requirement
  - *Must Not/Shall Not* – Absolute restricted requirements.
  - *Should/Recommend* – Implementation is not absolutely necessary.
  - *Should Not/Not Recommended* – Requirement may be prohibitive.
  - *May/Optional* – May become a future or discarded requirement.
Need for requirement Analysis

• It is fundamental for network design it is often overlooked or ignored.
  – Why is that the case?
  – It is in general a difficult task. Gathering requirements is time consuming and collating the results is rather challenging.
  – Network personnel are often distanced from the users and do not have an idea of what the user wants.
  – It appears to offer no immediate payoff.
  – You have to think about the architecture and design.
Requirements Technical Detail

- User
- Application
- Device
- Network

Highest Level, Least Technical

Lowest Level, Most Technical
User Requirements

User

Application

Device

Network

Timeliness
Interactivity
Reliability
Presentation Quality
Adaptability
Security
Affordability
Functionality
Supportability
Future Growth
User Requirement Definitions

- **Timeliness**: user must be able to access, transfer, or modify information within a tolerable time frame. e.g., Each file transfer shall take less than 10 minutes; video frames should come in every 30 msec.

- **Interactivity**: similar to timeliness, but focuses on response time from the system.
  - e.g., Web use, visualization (ftp not really “interactive”)

- **Reliability**: the level of service to the user must be consistent and reliable (RMA).

- **Presentation Quality**: quality must be presentable.
  - e.g., you can do video conferencing on the Internet today, but it often lacks quality (it is not sufficient to just throw more bandwidth at it)

- **Adaptability**: ability of the system to adapt to users’ changing needs;
  - e.g., mobility: users don’t care “where” the services are located, the logical services are decoupled from physical servers.

- **Security**: guarantee of confidentiality, integrity, and authenticity.

- **Affordability**: financial feasibility.

- **Functionality**: functional requirements
  - e.g., which application do users actually want and are planning to use.

- **Supportability**: how well the customer can keep the network operating at designated performance levels.

- **Future Growth**: if and when users are planning to deploy new apps/devices
Application Requirements

This is likely where the bulk of the requirements for the network are determined.
Application Types

• Mission Critical: need guaranteed, or at least predictable, high-performance RMA requirements
• Rate-critical: need guaranteed, or at least predictable, high-performance Capacity requirements
• Real-time and Interactive: need guaranteed, or at least predictable, high-performance Delay requirements
RMA Effect

• **Reliability, Maintainability, and Availability**
  – Reliability is a statistical measure of the frequency of failure of the network.
  – Maintainability is the statistical measure of the time to restore the system.
  – Availability is a measure of the relationship between the frequency of critical failures and the time to restore service.

• An application that handles a lot of transactions and money can lose revenue or customers.

• Telemetry and tele-conferencing applications can suffer from unrecoverable data.

• Sensitive data could be lost: customer ID or billing info

• Even life could be lost if a health care networking application fails.

• What type of application are the above?
Capacity Effect

• VoIP, video streaming and many other types of applications require predictable to guaranteed capacity
  – Why?

• Question: what about, for example, FTP, which can benefit from higher capacity?
  – FTP is not rate-critical: it can use whatever capacity is available from the network.
  – It can live with best-effort service: will function properly as capacity goes up and down dynamically in the network
Delay Effect

- Delay is a measure of the time differences in the transfer and processing of information.
- **What causes delay?**
- Historically this was resolved by the use of private networks, but more and more of these applications are moving to the Internet.
- **What does real-time mean then?** “As fast as possible”?
  - “real-time” is one of the most-abused terminologies in the industry!
  - *Real-time application* has strict timing relationship between source and destination.
  - From a system’s perspective, the system has an upper bound to responding to input.
  - Sometimes referred to as synchronous
  - If the data is not received in the right time frame then it is generally discarded.
  - Note that we usually talk about non-buffered streaming applications here.
Non-Real-time

• Non-real-time applications: have end-to-end delays but the destination will wait until the information is received.
  – e.g., Web applications, email
  – Also known as asynchronous

• “Interactive” burst applications are those where delay is predominantly from the network.
  – e.g., Telnet.
  – There are periods of no information transfer, and periods of information burst

• “Interactive” bulk applications are those where delay is predominantly from the processing.
  – e.g., FTP.
Application Delay Types

<table>
<thead>
<tr>
<th></th>
<th>Real Time</th>
<th>non-Real Time</th>
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</thead>
<tbody>
<tr>
<td>Interactive</td>
<td></td>
<td>Asynchronous</td>
</tr>
<tr>
<td>Burst</td>
<td>Telemetry</td>
<td>Time insensitive</td>
</tr>
<tr>
<td></td>
<td>processing</td>
<td>Telnet</td>
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<td></td>
<td></td>
<td>FTP</td>
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<td></td>
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<td>E-mail</td>
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</tbody>
</table>
Application Groups

- By grouping application with similar characteristics, often we can more quickly and easily determine general performance characteristics: one can extract requirements already developed.
- **Command and control/telemetry** applications
  - High-performance delay and reliability, mission-critical and/or real-time; e.g., aircraft control
- **Visualisation applications**
  - High performance capacity or delay, Real-time and/or controlled rate; e.g., weather modelling
- **Distributed computing applications**
  - High performance delay, possibly interactive; e.g., Parallel or Cluster Computing
- **Web access, development and use**
  - Delay sensitive but not high performance
- **Bulk data transport**
  - Not high performance; e.g., ftp, file sharing
- **Tele-service applications**
  - High performance capacity, delay, and/or reliability, might require multicast backbone (*mbone*); e.g., Teleconferencing, telemedicine, tele-seminars
- **Operations, administration and maintenance**
  - High reliability; e.g. network monitoring and management, network security
Application Locations

• It is often useful to determine where an application lies in your environment.
• This will help in mapping traffic flows during the flow analysis process.
Device Requirements

User

Application

Device

Network

Device Requirements

Device Types
Performance Characteristics
Device Locations
Device Types

- Why bother with device types?
- To avoid the last-foot problem: getting services and performance from the network to the user.
- Generic computing devices: difficult to list, describe, and graph each device; e.g., Desktop and laptops (portable)
- Servers: provide a service to one or more users; e.g., web server
- Specialized Devices: provide special capability; e.g., Surveillance Camera
  - Unlike servers and generic devices, these tend to be location-dependant
- Performance Characteristics to measure:
  - Storage performance
  - Processor (CPU) performance
  - Memory performance
  - Bus performance
  - OS performance
  - Device driver performance
Device Locations

- helps determine the relationships between components of the system.
- Coupled with types and performance requirements of devices and servers, it gives us an insight into the relative concentrations of users and devices, placement, and relative concentrations.
- This also helps us determine the traffic flow characteristics.
Network Requirements

Constraints from existing networks
Expected scaling of existing networks
Interoperability between networks
Existing network and support services
Existing architectural and design guidelines
Existing Networks and Migration

- Today, this is the most commonly applied case in Network Design.
- Sometime the design must accommodate dependencies and constraints imposed by the existing network:
  - **Scaling Dependencies**: how will the addition of a new network change the size and scope of the system? Is it dramatic (LAN to WAN) or within existing boundaries?
  - **Location Dependencies**: location of some or all components in the system are likely to change, and it will affect the flows.
  - **Performance Constraints**: performance affected by how the new network interacts with the existing one.
  - **Interoperability Dependencies**: occur at boundaries between the new and existing network, where different technologies or media are used.
  - **Network Obsolescence**: some parts of the existing network might need to be thrown away (devices, protocols, software).
Network Management and Security

- It is important at this stage to take into account some Network Management and Security requirements:
  - May want to capture any specific characteristics that the NM will impose on the network.
  - Hierarchical NM; Monitoring methods; NM protocols
  - Set of characteristics that will be monitored.
  - Centralized vs. distributed monitoring
  - NM performance requirements
  - Troubleshooting
  - Security (see next slide).
<table>
<thead>
<tr>
<th>Effect/Prob.</th>
<th>User Devices</th>
<th>Servers</th>
<th>Network Elements</th>
<th>Software</th>
<th>Services</th>
<th>Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unauthorized Access</td>
<td>B/A</td>
<td>B/B</td>
<td>C/B</td>
<td>A/B</td>
<td>B/C</td>
<td>A/B</td>
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<tr>
<td>Unauthorized Disclosure</td>
<td>B/C</td>
<td>B/B</td>
<td>C/C</td>
<td>A/B</td>
<td>B/C</td>
<td>A/B</td>
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<tr>
<td>Denial of Service</td>
<td>B/B</td>
<td>B/B</td>
<td>B/B</td>
<td>B/B</td>
<td>B/B</td>
<td>D/D</td>
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<td>Theft</td>
<td>A/D</td>
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<td>B/B</td>
<td>A/B</td>
<td>C/C</td>
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<td>Corruption</td>
<td>A/C</td>
<td>B/C</td>
<td>C/C</td>
<td>A/B</td>
<td>D/D</td>
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<tr>
<td>Viruses</td>
<td>B/B</td>
<td>B/B</td>
<td>B/B</td>
<td>B/B</td>
<td>B/C</td>
<td>D/D</td>
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<tr>
<td>Physical Damage</td>
<td>A/D</td>
<td>B/C</td>
<td>C/C</td>
<td>D/D</td>
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<td>D/D</td>
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</table>

**Effect:** A=Destructive B=Disabling C=Disruptive D=No Impact

**Probability:** A=Certain B=Unlikely C=Likely D=Impossible
Requirement Specification vs. Map

- **Requirement Specification**: lists all requirements, where and how they were gathered, reason why each is considered core, feature, future, informational, or rejected, and their priority level.

<table>
<thead>
<tr>
<th>ID/Name</th>
<th>Date</th>
<th>Type</th>
<th>Description</th>
<th>Gathered/Derived</th>
<th>Locations</th>
<th>Status</th>
<th>Priority</th>
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<tbody>
<tr>
<td>Hussein Al Osman</td>
<td>CEG4190</td>
<td>5-25</td>
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- **Requirement Map**: shows the location dependencies between applications and devices

```
Unused   Lounge Wireless Access   Equipment Room (Internet Connection)   R&D 50 Users
```
### Requirements Analysis for a Company LAN

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<table>
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<tbody>
<tr>
<td>1</td>
<td>150 users (60 engineers, 15 HR and Finance, 30 Manufacturing, 10 Management, 30 Sales/Marketing, 5 Other).</td>
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<tr>
<td>2</td>
<td>Each area in the building must support Fast Ethernet connections to the backbone.</td>
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<tr>
<td>3</td>
<td>Database, Visualization, Manufacturing, and Payroll applications are considered mission-critical for this company.</td>
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<tr>
<td>4</td>
<td>Inventory application (INV1) for manufacturing requirements not determined at this time.</td>
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<tr>
<td>5</td>
<td>Database application (DB1) requires a minimum of 150 Kb/s, per session.</td>
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<td>6</td>
<td>Engineering users have workstations with GigE NICs.</td>
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<td>7</td>
<td>Visualization application (VIS1) for finance requires up to 40 Mb/s capacity and 100 ms round-trip delay.</td>
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<tr>
<td>8</td>
<td>Payroll application (PAY1) requires 100% uptime (while in operation) between finance and outside payroll company.</td>
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<td>9</td>
<td>Company must be kept secure from Internet attacks.</td>
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<tr>
<td>10</td>
<td>Company requires a minimum of T1 access to Internet.</td>
</tr>
<tr>
<td>11</td>
<td>Current network will be completely replaced, so there are no requirements from existing network.</td>
</tr>
<tr>
<td>12</td>
<td>Other general applications: mail, word processing, internal and external Web access.</td>
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<tr>
<td>ID/Name</td>
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<td>11</td>
<td>02Feb13</td>
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<tr>
<td>12</td>
<td>20Jan13</td>
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</table>
Exercise 1

Which of the following customer requirements could be categorized as mission critical? As rate-critical? As real-time? As none of these?

– Processing telemetry data live from a space shuttle launch and providing that data to mission control during launch (Customer: NASA).

– This fulfills all three requirements as defined above. Telemetry information is (literally) mission critical since it is being collected and disseminated real-time during the launch versus being analyzed post-launch. The information is rate critical because the activity is happening in real time and the need is to monitor conditions as they occur during the launch. And finally it is real time since the action related to the data (Shuttle launch) is intrinsically required as the launch occurs.

– Processing requests from automated teller machines throughout a city (Customer: Bank)

– The data is mission-critical to the Bank because it is core to their business needs during the day. The network needs to be very reliable and not provide a single point of failure path – normally ATM networks for Banks use a network topology where the ATM machines in a small geographical area are spread out on different circuits taking different physical routes so that any one network failure will not incapacitate all the ATM’s.

– Processing required for typical Web page browsing from your servers.

– None of the above
Exercise 2

- Categorize each of the following requirements as user, application, device, or network.
  - Database servers must run Brand XYZ software
  - This is a straightforward User requirement.
  - Teleconferencing requires at least 350kb/s capacity
  - This can be a combination of application.
  - Users must be able to submit print jobs up to 25MB in size
  - This is an application requirement
  - Each access network should be able to serve up to 200 users
  - This is a networking requirement
Thank You!