Assignment #1 Solutions

1. Problem 1 – Modeling delay in a communications network:

(a) Identify and describe in ONE sentence the main components of delay in a communications network.

(b) Develop an equation for the end-to-end delay along a communications path including various routers. The only constant that you may assume is that the speed of light in the given transmission medium is 2*10^8 m/sec. Identify each of the variables in your equation.

(c) If the distances between nodes were constant (D) and each node (end systems and routers are nodes) can transmit R bits per second, what would the equation in (b) look like?

(d) In the Internet, which of these would you expect to remain constant and which of these would you expect to change. Explain (one sentence).

Don’t look for an obscure answer – choose the most obvious answer.

- The number of routers in the Internet
- The distance between a ground station and a satellite in geosynchronous orbit.
- The size of IP packets transmitted in any given HTTP session (i.e., Web browser connected to Web server).
- The average round-trip time in any Internet based client server application (round-trip time is the interval between the time you send a request and the time that you receive a response).

Answer:

a) The four components of delay in a communication delay are:

- Nodal processing: This is the delay that occurs at nodes due to the processing for bit errors and determining the output link.
- Queuing: This is the delay due to the packet waiting at output link for transmission.
- Transmission delay: This is the delay caused by the data rate of the link.
- Propagation delay: This delay is the amount of time it takes for the head of the signal to travel from the sender to the receiver over a medium.
b) The equation would be:
\[
\text{delay} = n \times (d_{\text{proc}}+d_{\text{queue}}+\frac{l}{r}) + \frac{d}{s})
\]
where \( n \) is the number of routers, \( d_{\text{proc}} \) is the processing delay, \( d_{\text{queue}} \) is the queuing delay, \( l \) is the packet length, \( r \) is the link bandwidth, \( d \) is length of physical link and \( s \) is the propagation speed (\( 2 \times 10^8 \) m/s).

c) The equation would be:
\[
\text{delay} = n \times (d_{\text{proc}}+d_{\text{queue}} + \frac{l}{R}) + \frac{L}{s})
\]

d)
- The number of router in the internet: I would expect this to change as more links are created we would require more routers.
- Distance between a ground station and a satellite in geosynchronous orbit: I would expect this to remain constant as the distance for a satellite to be in geosynchronous orbit is fixed which is 42,164 km.
- The size of IP packet transmitted in any given HTTP session: I would expect this to change as we change from IPv4 to IPv6.
- The average roundtrip in any Internet based client server application: I would expect this to change because as technology advances I believe the delay in communication will decrease.

2. Problem 2 – Network Models:

(a) The OSI model was developed before the Internet and was developed by agreement by the US and European nations (CCITT), yet the Internet and its protocols is by far the dominant network technology on our planet. Why?

(b) List the major disadvantages with the layered approach to protocols

Answer:

The OSI model was developed before the Internet and was developed by agreement by the US and European nations (CCITT), yet the Internet and its protocols is by far the dominant network technology on our planet. Why?

Solution:

The reason behind TCP/IP’s dominance over OSI can be summarized as a result of technical, political and economic reasons:

The reasons for the popularity of TCP/IP over the OSI are:

- TCP/IP answers an immediate, almost desperate need - data communications in heterogeneous networks - very well.
- It is relatively simple and robust compared to other alternatives.
- TCP/IP is bundled into the Berkeley Software Distribution (BSD) Unix. Hence, TCP/IP became the minimum networking capability for any vendor entering the market for scientific and engineering graphics workstations.
- Its available on virtually every hardware and operating system platform (often free, as its open source).
- Thus, it’s the lingua franca of the Internet.
- It’s more credible than OSI, making greater utilization of bandwidth at a lower cost.
- It supports multiplexing and being connectionless, supports more communication devices.
- Existence of Internet layer reduces error handling overhead on the transport layer with the help of intelligent hosts, thus increasing throughput and efficiency at the transport layer.

**Problem 3 – Segmentation:**

(a) What is segmentation?

(b) Why do we need it?

(c) Is segmentation restricted to the network layer, or might it be required at other layers? Why? Include the application layer in your answer.

(d) What effect do you think segmentation has on the following:

1. **Reliability**
2. **Throughput**
3. Time to resend damaged transmission.
4. Flexibility (ease with which we can adapt to new lower layers)

**Answer:**

(a) What is segmentation?

Dividing of the datagram/packet into smaller fragments is called Segmentation.

(b) Why do we need it?

So that packets may be formed that can pass through a link with a smaller maximum transmission unit (MTU) than the original datagram size.

(c) Is segmentation restricted to the network layer, or might it be required at other layers? Why? Include the application layer in your answer.

At present, segmentation is restricted to the network layer. Application layer cannot determine the packet size which can be sent on network. Therefore, it should restrict itself to the message passing.

(d) What effect do you think segmentation has on the following:

1. **Reliability** - If the IP fragments are out of order, a firewall may block the non-initial fragments because they do not carry the information that would match the packet filter. This would mean that the original IP datagram could not be reassembled by the receiving host, thus endangering reliability.
2. **Throughput** - decreases overall speed because of associated overhead. Reassembly is very inefficient on a router whose primary job is to forward packets as quickly as possible.
3. **Time to resend damaged transmission** - If one fragment of an IP datagram is dropped, then the entire original IP datagram must be resent, and it will also be fragmented, therefore takes considerably longer time to resend damaged transmission.

4. **Flexibility (ease with which we can adapt to new lower layers)** - It increases flexibility as it provides a solution to the use of different maximum packet sizes by splitting the datagrams that originally did not fit into the packet size of the lower layer to be traversed, and to coalesce the pieces at the receiving node.

**Problem 4 – IETF Standards:**

Go to [www.ietf.org/rfc.html](http://www.ietf.org/rfc.html) and look up RFC 2026 and read it. Answer these questions:

(a) **What is an Internet Draft?**

(b) **What are the differences between a Proposed Standard, Draft Standard, and Standard?**

(c) **Was HTML standardized by IETF? Why or why not?**

**Answer:**

(a) **What is an Internet Draft?**

Internet Draft is a series of working documents published by the IETF. Typically, they are drafts for RFCs, but may be other works in progress not intended for publication as RFCs. During the development of a specification, draft versions of the document are made available for informal review and comment by placing them in the IETF's Internet-Drafts directory. This makes an evolving working document readily available to a wide audience, facilitating the process of review and revision.

Internet-Drafts have no formal status, and are subject to change or removal at any time; therefore they should not be cited or quoted in any formal document.

(b) **What are the differences between a Proposed Standard, Draft Standard, and Standard?**

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<th>Proposed Standard</th>
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<td>1)</td>
<td>The entry-level maturity for the standards track is &quot;Proposed Standard&quot;. A specific action by the IESG is required to move a specification onto the standards track at the &quot;Proposed Standard&quot; level.</td>
<td>A specification from which at least two independent and interoperable implementations from different code bases have been developed, and for which sufficient successful operational experience has been obtained, may be elevated to the Internet Standard level.</td>
<td>A specification for which significant implementation and successful operational experience has been obtained may be elevated to the Internet Standard level.</td>
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<td>2)</td>
<td>A Proposed Standard specification is generally stable, has resolved known design choices, is believed to be well-understood, has received significant community review, and appears to enjoy enough community interest to be considered valuable.</td>
<td>A Draft Standard must be well-understood and known to be quite stable, both in its semantics and as a basis for developing an implementation.</td>
<td>An Internet Standard (which may simply be referred to as a Standard) is characterized by a high degree of technical maturity and by a generally held belief that the specified protocol or service provides significant benefit to the Internet community.</td>
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<td>3)</td>
<td>Further experience might result in a change or even retraction of the specification before it advances.</td>
<td>A Draft Standard is normally considered to be a final specification, and changes are likely to be made only to solve specific problems encountered.</td>
<td>All specifications unconditionally accepted.</td>
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<td>4)</td>
<td>Usually, neither implementation nor operational experience is required for the designation of a specification as a Proposed Standard. However, such experience is highly desirable, and will usually represent a strong argument in favour of a Proposed Standard designation.</td>
<td>The requirement for at least two independent and interoperable implementations applies to all of the options and features of the specification. In cases in which one or more options or features have not been demonstrated in at least two interoperable implementations, the specification may advance to the Draft Standard level only if those options or features are removed.</td>
<td>Has cleared requirements of both Proposed and Draft and beyond.</td>
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<td>5)</td>
<td>It is desirable to implement them in order to gain experience and to validate, test, and clarify the specification. However, since the content of Proposed Standards may be changed if problems are found or better solutions are identified, deploying implementations of such standards into a disruption-sensitive environment is reasonable.</td>
<td>In most circumstances, it is reasonable for vendors to deploy implementations of Draft Standards into a disruption-sensitive environment.</td>
<td>Completely acceptable to run in a disruption sensitive environment.</td>
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6) A Proposed Standard should have no known technical omissions with respect to the requirements placed upon it. However, the IESG may waive this requirement in order to allow a specification to advance to the Proposed Standard state when it is considered to be useful and necessary (and timely) even with known technical omissions.

In cases in which one or more options or features have not been demonstrated in at least two interoperable implementations, the specification may advance to the Draft Standard level only if those options or features are removed.

All features have been time tested.

(c) HTML was not standardized by IETF. Several draft relating to HTML expired but IETF established HTML working group, which published RFC 1866 – HTML 2.0 as a standard. HTML received international standard in 2000 when it was maintained by W3C.

Problem 5 – Packet vs. Circuit-Switched Communications:

(a) You are about to receive the world’s first telemetry controlled electronic heart. Since you don’t want to be encumbered by wires, you choose the WiFi9000 model over the ONOaWiRe1000 model. You will notice in the brochure that both models can be configured for circuit-switched or packet switched communications – which do you specify? Why?

What kinds of service guarantees would you hope to have?

(b) Consider an application that transmits data at a steady rate (e.g., the sender generates an N-bit unit of data every k time units, where k is small and fixed). Also, when such an application starts, it will continue running for a relatively long period of time. Would a packet-switched network or a circuit-switched network be more appropriate for this application? Why?

Answer:

You are about to receive the world’s first telemetry controlled electronic heart. Since you don’t want to be encumbered by wires, you choose the WiFi9000 model over the ONOaWiRe1000 model. You notice in the brochure that both models can be configured for circuit switched and packet switched communications – which do you specify? Why?

What kinds of service guarantees would you hope to have?

Specify circuit switched communication:

The reason is that it establishes a dedicated end-to-end connection and once a link is established, it is solely used by the single connection, in this case the link to the telemetry controlled electronic heart which guarantees consistent performance. This is unlike Packet Switching where the resources are not reserved but accessed on demand, and as a consequence the transmission may have to wait. This is unacceptable for a device like the electronic heart which needs to run non-stop.
The service guarantees that I hope to have are as follows:

- Once established, continuous network availability.
- Increased performance as there is no delay or waiting.
- Reliability due to reserved resources.
- No loss of packets as there is no delay.

**Problem 6 - Protocols:**

(a) You and Luke Sky Walker are commanders in the rebel army preparing to attack Darth Vader and his Death Star. By yourselves, neither you nor Luke possesses enough fire power to defeat Darth Vader, but together you can destroy the Death Star. However, you must come to agreement on the precise moment to attack, but you cannot communicate using the normal communications else your presence and location will be detected by Darth Vader. But you each possess an unlimited number of R2D2 messenger droids that you can use to send messages to each other. But, the droids may be destroyed by the enemy’s PatrolBots, so you have no way of knowing if your message gets through unless Luke sends a droid back to you with a confirmation message. Suppose your droid gets through to Luke and Luke sends a droid back to you with a confirmation message agreeing to the time to attack, but it is destroyed by a PatrolBot? Should he attack? You haven’t received a confirmation, so what will you do? Is there a protocol that you and Luke can use to avoid defeat? If not, explain why not. If there is a protocol that would work, please explain it.

(b) Two blue armies are each poised on opposite hills preparing to attack a single red army in the valley. The red army can defeat either of the blue armies separately but will fail to defeat both blue armies if they attack simultaneously. The blue armies communicate via an unreliable communications system (i.e., a foot soldier). The commander of one of the blue armies would like to attack at noon. However, if he sends a message to the other blue army ordering the attack, he cannot be sure that the message will get through. He could ask for acknowledgement but that might not get through either. Is there a protocol that the two blue armies can use to avoid defeat?