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by Andrew Cooper

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Networked Applications
Network Theory: Research into the
Transferal of Data between Networked
Devices

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Abstract

As the world becomes more data driven, having resources in place for the reliable delivery of data between devices is never more crucial. Therefore, protocols such as TCP/IP are becoming increasingly popular due to their ability for error checking and guaranteed delivery of data.

Contents

Abstract	i
Table of Figures & Tables	iii
1 Introduction	1
2 Transmission Control Protocol (TCP)	1
2.1 Operations	1
2.2 Guarantee Delivery of Data	2
2.3 Two Generals' Problem	3
2.4 The Three-way Handshake	3
3 Maximum Transmission Unit (MTU)	4
3.1 Protocol Data Unit (PDU)	4
4 Synchronicity & Asynchronicity in Network Protocols	4
5 Interoperability for Networked Applications	5
6 Conclusion	5
References	7

Table of Figures & Tables

Figure 1: Layers of TCP [3]	2
Figure 2: TCP Error Recovery after [4]	3
Table 1: MTU in Noteworthy Technologies after [5]	4
Table 2: Table showing PDU in OSI after [9]	4

1 Introduction

This research-driven report that contains core network theory discovered through the use of valid and credible sources. This report aims to give an insight into the importance of the transmission control protocol (TCP) for sending and retrieving data within a network, problems that TCP faces, techniques used to guarantee the successful delivery of data, the impact of maximum transmission unit has as packet sizes are increased and decreased, synchronicity and asynchronicity and interoperability with considerations to how these points affects professionals with the development of networked applications.

2 Transmission Control Protocol (TCP)

Transmission control protocol was first conceptualised by Vinton Cerf and Robert Kahn who wished to create a reliable protocol for sharing resources between devices that does not necessarily share the same network [1], as solutions to this problem had already been established [2]. They developed the understanding that for this to be an achievable goal, they would have to develop a standardisation between devices for communication to be achievable and effective.

“a set of agreed upon conventions”, (Cerf & Kahn) [1].

2.1 Operations

TCP is a group of protocols used to connect and interact with devices over networks such as the internet and private networks. TCP works on the transport layer of the OSI model and is responsible for the end-to-end communication between devices.

TCP adopts the end-to-end design principle, where application features are stored locally on host machines, which is used to govern how connection between devices should be established, how data should be formatted in packets, how the packets should be reassembled to ensure data does not become corrupted and the order in which the devices should attempt to communicate with each other. The TCP model is usually found combined with the internet protocol as client devices need these two protocol suites to access resources from the internet. Unlike TCP, which does all of the heavy lifting, IP is only responsible for attempting to route packets to ensure they end up in the desired location. The end-to-end principle means expensive operations, such as packet re-assembly is performed locally, an important feature as if these were performed within the internet protocol, networks would see an increase in latency, inactivity and congestion.

The transmission control protocol is divided into four layers of abstraction as seen in *figure 2*, which helps separate concerns which when joined together allows for data to be sent and received through networks with the use of applications.

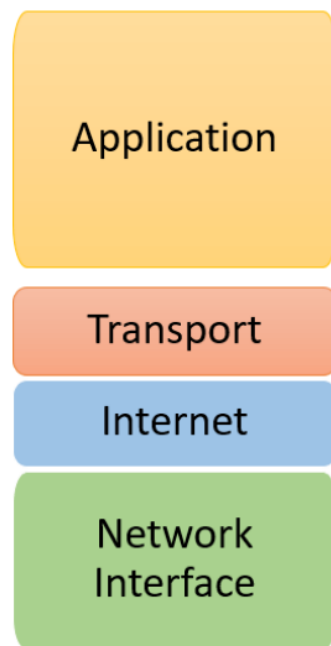


Figure 1: Layers of TCP [3]

Application Layer – The highest level of the TCP model and is used to provide applications for file transfer such as web browsers.

Transport layer – The main purposes of the transport layer are to send appropriate amounts of data and at speeds that are computable by the end node.

Internet Layer – The internet layer is used to move data from source to destination by obtaining information such as the address of origin and the address of end node.

Network Interfaces – The network interface layer is at the lowest level of the TCP model and describes how data should be sent over the network.

2.2 Guarantee Delivery of Data

Secondly, TCP is employed as a reliable source of delivery, a method in which this is achieved is by labelling packets with initial sequence numbers. This method requires all segments of data to be given a sequence number that is of that time unique, which means packets can be reconstructed in correct order. However, the practicality of identifying packets comes into play with the positive acknowledgement technique, as when a client receives data, an acknowledgement of the delivery of data is sent back to the host to confirm that the segment had indeed been received. TCP also stores a retransmission timer, this is used as a counter to know whether the client device has received the data, if the timer reaches zero before an acknowledgement has been received, the host device can resend that particular packet.

Figure 1 displays how the acknowledgement technique works when a segment has not been received.

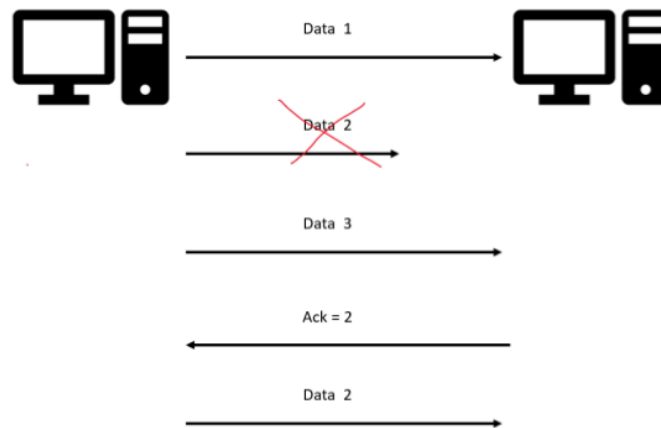


Figure 2: TCP Error Recovery after [4]

Figure 2 is a simple depiction of how TCP uses error recovery to ensure the client has received all packets. As shown, the second data packet has failed during transition but data packet three successfully made it. However, an acknowledgement has been sent from the client requesting data packet two be sent, this is how TCP guarantees delivery of data.

2.3 Two Generals' Problem

The two generals' problem is used to describe the lack of common knowledge between two systems simultaneously. To help understand the problem the analogy of two generals was created. Two armies either side of a fortified castle needs to synchronise their attack on the castle to win, if either army attempts to attack without the other, they will lose. To unify their attack, general (a) will need to send a message to general (b) giving instructions when they should strike. If the message makes it to general (b) successfully, general (b) will have to send a message of acknowledgement to general (a) confirming that they indeed got the message. However, if the acknowledgement does reach general (a), he will then have to send a new acknowledgement to general (b) confirming so. This becomes a looping effect where each general will continue to acknowledge each other's acknowledgements.

2.4 The Three-way Handshake

TCP is connection-oriented protocol which means that a connection must be established and agreements are made between two devices before data can be sent between the two.

The three-way handshake is a three-step method used for the establishment of a connection between two clients. For devices to communicate over a network. The method works by client sending a synchronization segment to a host with an available open port, asking to connect. For a connection to be established, the host will need to send a synchronization segment to the client asking for a connection to be opened as well as an acknowledgement to the

synchronization segment sent originally. Lastly, the client device can send an acknowledgement back to the host and a connection is created between devices.

3 Maximum Transmission Unit (MTU)

The maximum transmission unit defines the largest packet size, namely the protocol data unit (PDU), can be transmitted across a network link [5]. Different technologies govern the maximum transmission unit, as seen in *table 1*.

Maximum Transmission Unit	Technology/ interface (in Bytes)
Maximum MTU	65,535
Ethernet	1500
IEEE 802.3	1492
Minimum MTU	68

Table 1: MTU in Noteworthy Technologies after [5]

Should the PDU exceed the maximum size of the interface, IP fragmentation can be performed to reduce the size of the data by splitting resources into smaller segments [6] able to pass through the interface. However, some state that IP fragmentation should be used as little as possible [5] [7] [8] due to the increased overhead that comes with increasing the number of segments needed to be sent causing inefficiency of the network. The more traffic on a network, the more congested the network becomes, this problem is only worsened should segments become corrupted or dropped in transmission, causing retransmission and a higher level of congestion.

3.1 Protocol Data Unit (PDU)

The PDU is the packet of data that is sent over the network and is commonly used to describe the data segments that are sent from each layer of the OSI model.

Layer	PDU
Transport Layer	Segments
Network Layer	Packets
Data Link	Frame
Physical Layer	Binary Bits

Table 2: Table showing PDU in OSI after [9]

Table 2 displays the PDU at the first four layers of the OSI model.

4 Synchronicity & Asynchronicity in Network Protocols

Synchronicity in network protocols rely on two devices synchronising their transmission signals with the use of an external clock to regulate transmission into fixed intervals. Synchronous transmission is usually used when large amounts of data needs to be sent

through to a client quickly as this method sends packets of data at fixed intervals. Synchronous transfer of data is particularly useful in applications that require real-time interaction [10] such as VoIP, video streaming services and instant messaging apps. However, synchronous protocols send data a lot quicker, they're also more expensive than other methods such as asynchronicity.

Asynchronicity in networked protocols do not require clock synchronisation with other devices meaning they can send data at any time and only synchronised during transmission, which is achieved by inserting a start and end bit at the beginning and end of the packet, which is usually sent a byte at a time. Asynchronous transmission is usually used when sending small amounts of data and is slower than synchronous due to the extra binary bits added to the start and end, also lack in strength when compared to synchronicity in sending large amounts of data.

Applications with best use of asynchronicity are those of which do not require both host and client to be available at the same time such as email.

5 Interoperability for Networked Applications

Interoperability is ability to share information between two or more systems or applications with ease, which allows for the new proprietor of the information to be able to use it [11]. This is a topic of high interest in the IoT field of study, as interoperability has the ability to increase the benefits of IoT massively [12]

In terms of networked applications, such as web services, interoperability can be achieved by using the Simple Object Access Protocol (SOAP) [13], a messaging protocol that adopts XML.

However, interoperability can either be classified as syntactic interoperability or semantic interoperability [14].

6 Conclusion

Within the contents of this research paper, the author has developed an understanding of the importance of TCP and efforts made to make it a reliable protocol and efforts implemented to ensure guaranteed transfer of data. As the internet is ever growing and latest innovations rely heavily on the successful transfer of constant data, TCP will lead the way in communication between devices.

Secondly, the maximum transmission unit is an important consideration for data transfer as PDUs too large for the network MTU will need to be reduced in size, this not only causing overhead, but increase on traffic within the network.

Thirdly, synchronicity is a method of synchronisation between two or more devices that require the synchronisation of a clock to govern when data is allowed to be sent across a network. Synchronous transmissions are more apt at sending large amounts of data in short amount of times and is best used in transmission that is deemed more "expensive".

Andrew Cooper

Asynchronicity is the method of transmission that does not require the synchronisation between two devices with the use of clocks and is not ruled by appropriate times to send packets. However, packets sent asynchronously tend to have more overhead due to the parity bits needed to be added to state the start and end of the packet.

Lastly, interoperability in networked applications is the ability to share information, an important concept as interoperability aims to pass useful information between services regardless of vendor.

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Andrew Cooper

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FINAL GRADE

44/100

GENERAL COMMENTS

Instructor

The sources you've used are, overall, quite weak. Wordpress blogs are completely unacceptable, but several of the others are barely better. You must make an effort to use journal articles as much as possible at level 6.

The report overall is reasonable, though a little lacking in detail. You're a modest way shy of the word count - which isn't necessarily a problem, but has resulted in a proportional lack of depth here.

The report is reasonably well-presented, I like the use of figures.

Engagement with Literature Skills (20): 4

Knowledge and Understanding Skills (30): 12

Cognitive and Intellectual Skills (30): 15

Transferable Skills for Life and Professional Practice (20): 13

PAGE 1

PAGE 2

PAGE 3

PAGE 4

PAGE 5

PAGE 6

PAGE 7

PAGE 8

PAGE 9

PAGE 10

PAGE 11

PAGE 12
