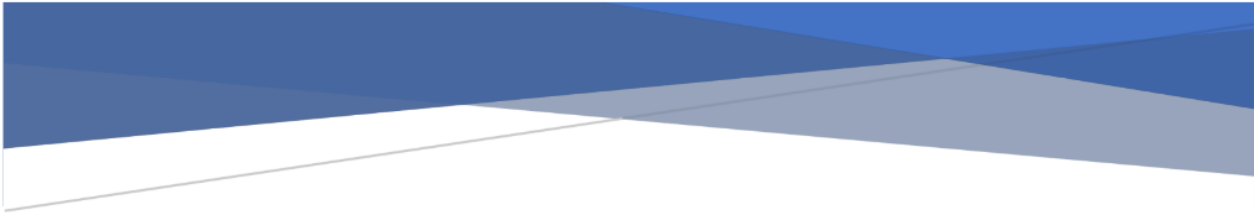


Networked Applications

by Callum Cross

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NETWORKED THEORY

Module: Networked Applications

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Abstract (1)

The use of the internet has become a requirement across the globe the more humanity advances, it allows the world to be digitally connected and information to be sent at speeds that would have never been imaginable more than 50 years ago. The data we send daily is inconceivable but with the current technologies available at this time allow this task that would be impossible by people is now possible with the protocols that have been put in place to make sure that we are guaranteed the data we requested with the machines and devices that we rely on a daily basis especially in this digitally connected globe.

Introduction (2)

Communication from and to local communities to even countries has been essential for centuries as we have relied on messages to be the foundation of getting and sending requests that would be needed to be shown and read by an organisation or person, examples of these could go back as far the Roman ages where they would send man on horseback to send messages across countries which could have taken weeks to even months, there was one main problem with that is that unless you ever seen that man on horseback again you would never know if that message had even gotten to the receiver of the message a good example of this scenario is called the two generals problem. [11]

These are problems that we as humans have had to overcome to make sure that the data we send is acknowledged. Secondly, in this report, we will discuss the current communications we use across the globe and what protocols and services are used to make sure that the data we send even in mass amounts have been received fully and is confirmed. Finally, this report will discuss how the current technologies affect current developers and how they design systems to make sure that all data that they have control of is not lost.

How does Transmission of Data Work? (3)

Data transmission is the definition of transmitting digital or analogue data over a network to one or more end-devices. It allows the transmission and communication between devices in multiple environments: point-to-point, point-to-multipoint or multipoint-to-multipoint

It works when a device creates a data object or file to then transmit to one or multiple recipient devices. The data being sent comes from the source device in forms of packets and within those packets are digital streams of digital bits. These data streams are sent over a communication medium for transmission to either a single destination or multiple destinations.

Aside from external communication, data transmission may be done internally within the host or recipient, between different parts of the same machine/device. This could be looked at data being sent to the computing processing unit and random-access memory, or even an external drive such as a hard drive. [12]

What is the Transmission Control Protocol? (4)

The transmission control protocol (TCP) provides a connected service to the upper layers. TCP is known for its very reliable services as quoted by Lydia Parziale “*TCP is to provide a reliable logical circuit or connection service between pairs of processes.*”. TCP was created for its guaranteed data acknowledgements, and therefore it’s one of the most standard methods of transferring data from end to end users between one or multiple devices. TCP controls how the packets are delivered to the recipient but also makes sure that the packets being sent are not too large so that the recipient will lose data this is formally known as congestion control. [1]

The transmission control protocol is mainly used for organising information in a way that is secure for transmission between the host and end-device. It guarantees the integrity of data sent over the network, no matter how large that data could be. Mainly, for this reason, it is used to transmit data from other high protocols that require all transmitted data to arrive in an efficient time. A figure of the TCP/IP Model is shown in figure 1.1.

How the Transmission Control Protocol Operates (5)

The transmission control protocol is a standard as quoted by Danny Briere “*Transmission Control Protocol/Internet Protocol (TCP/IP) is the most common protocol for transmitting packets around a network*” that describes how the devices will establish and maintain a connection through which applications and services can exchange data with each other. The transmission control protocol works with the Internet Protocol, which defines how computers will send the data to the recipient. [4]

An example of this could be when a web server would send a file to the end-user, such as an HTML webpage, it will use the hypertext transfer protocol (HTTP). The hypertext transfer protocol will ask the TCP layer to set up a connection to the end-device and will set up for the transmission of the data which was requested. The TCP model will divide the data being sent and fill them into packets and will number them accordingly with each packet having their own unique number for that piece of data being sent, once complete it will forward the packets to the IP layer for delivery. Even though each packet has the same source and destination IP address packets could possibly be sent on multiple routes for the most efficient speed, this could happen because of a high load on the current network routes that were first calculated and may not be quicker than taking longer routes.

The TCP layer in the client computer waits until all packets have arrived, then acknowledges those it receives, once the TCP layer has completed all packets it will then look for packets it may be missing or have been lost during the transmission if this has happened the TCP layer will ask for a retransmission of packets it hasn’t received which are identified by the numbers the packets have been received in. Finally, the TCP layer assembles the packets into one file or multiple and delivers them to the recipient.

A model of the TCP/IP protocols can be seen in *Figure 1.2*



TCP/IP Model (6)

Link Layer / Physical Layer (6.1)

The physical and link layer in computer networking is the first and lowest layer in the TCP/IP Model. The physical part is the actual hardware and wires used to connect the device physically to the network either this can be wireless or wired depending on the device. The logical layer is the group of methods and communication standards that operate on the physical network hardware. This consists of dealing with the encapsulation of IP packets and the flow control of those packets being sent.

Although it may not be required, a network interface is usually connected with a network adapter. An instance of this could be that a loopback interface has no network adapter associated with it. A machine or device must have one network adapter card for each network it would like to connect to simultaneously. However, a device requires only one replica of the network interface software for each network adapter it uses. For example, if a host attaches to two token-ring networks at the same time. It must have two network adapters. However, only one copy of the software from the token-ring network interface is needed, and one copy of the token-ring driver is required. [10]

Transport Layer (6.2)

In the networking world, the transport layer is how the data will be transferred from one device such as the host to the end-device leading to many features in this layer an example of these are orientated communication, flow control, error control and multiplexing. The standard services and protocols of this do provide host-to-host communication for applications. [10]

1. The transmission control protocol is a connection-oriented protocol that provides reliability whilst transmitting data from a source to a destination end-device without any error. The transport control protocol divides the incoming byte streams into smaller segments and assigns each segment with their own unique number in the byte stream. At the receiving host, TCP will order the segments again and send an acknowledgement back to the host so it knows what packets have been received and which packets may have to be retransmitted. Finally, the TCP controls the flow control of the packets to make sure it does not exceed the maximum transmission unit and does not overwhelm or slow the receiving recipient's network.
2. User Datagram Protocol (UDP) is a message-oriented protocol that provides a connectionless and unacknowledged service. This is because UDP is used for sending small amounts of data as large amounts become very unreliable due to it not using TCP's sequencing or error control.



3. Stream Control Transmission Protocol (SCTP) combines features from both TCP and UDP. The protocol is a message-oriented service which is like UDP but takes features from TCP such as reliability and connection-oriented service that TCP has. SCTP is more commonly used for telephone communication over the internet

Internet Layer (6.3)

The Internet layer takes the role of transferring data between the host and client devices. The internet layer accepts data from the previously talked about layer, which is the Transport Layer and passes the data onto the Network Interface Layer. The following are part of the functions of the Internet Layer [10]:

- The Internet Layer will take care of sending data through the shortest route if there are multiple routes leading to the same destination. In addition, if a route has problems with connectivity issues, then an alternate path will be found and re-adjusted through the chosen route.

Application Layer (6.4)

Within the TCP/IP Model, the application layer is the highest abstraction layer that provides the interfaces and protocols needed by end-users. It combines the functionality of the presentation layer, session layer and the application layer of the OSI model. [10]

The application layer does contain many high-level protocols, and these are just a few:

- Domain Naming System (DNS)
- Hypertext Transfer Protocol (HTTP)
- Telnet
- Secure Shell (SSH)
- File Transfer Protocol (FTP)
- Trivial File Transfer Protocol (TFTP)
- Dynamic Host Configuration Protocol (DHCP)

How does the TCP/IP Model help Developers? (7)

The TCP/IP Model is an industry-standard model that can be effectively deployed in practical networking software and network problems. The model is built for cross-platform communication allowing developers not having to worry about the device they are sending data to or receiving from. Removing these types of problems allows developers to focus more on the software development side instead of worrying about network problems that could possibly be interrupted due to a device not being able to accept the data being sent.

It also allows developers from worrying about the device's hardware knowing that the transfer control protocol will manage the packets being from and to the end-user device as the transfer control protocol will use both error control and flow control to manage the packets. A chart of the TCP/IP model is shown in *Figure 1.1*

What is a Maximum Transmission Unit? (8)

A maximum transmission unit (MTU) is the largest size of packet that can be sent at one time through a network, specified in octets (eight-bit bytes), these rather large packets can be sent through a network such as the Internet. The Internet's Transmission Control Protocol (TCP) uses the MTU as a standard measurement of the maximum size of each pack in any transmission. Larger than the normal MTU size packet may mean in retransmissions if the associated packet encounters a end-host or router that can't handle the packet size. On the other hand a too small of an MTU packet means relatively more overhead and more acknowledgements must be sent and handled. Most operating systems provide a default a MTU value that is suitable to most receiving end hosts. Generally, Internet users should follow advice from their ISP (Internet Service Provider) about whether to change the default value of the MTU but most will not be needed as quoted by Lydia Parziale "*the maximum transmission unit (MTU) at the network layer should not exceed 1500*".[2] [3]

The Impact of Max Transmission Unit (9)

Packet size affects the performance of a network a lot. Every medium of transmission specifies MTU. If a packet is more than MTU, it will be dropped. The reason behind this is something called bandwidth which is the maximum number of bits per second in order to guarantee a reasonable level of reliability. A larger packet will take longer to transfer which in turn results in more collisions at the physical level, and larger packets would mean larger memory allocations at intermediate boxes as well as end hosts. If your packet size is large in probability, it will get dropped at the queue, or worst-case scenario could get fragmented this can be backed by the quote from Peter Dordal "*When TCP sends a packet containing user data (this excludes ACK-only packets), it sets a timeout. If that timeout expires before the packet data is acknowledged, it is retransmitted.*"[5]

Fragmentation of packets or more formally known as IP Fragmentation is an Internet Protocol (IP) process that breaks packets down into smaller chunks of packets so it can pass through a link with a smaller MTU than the original packet size. Once the receiving host has collected all packets, they will be reassembled into their original size.

Fragmentation can create excessive retransmissions when packets have lost data or have not been received at all. The transmission control protocol as it's reliable must retransmit all the fragments needed in order to recover data from the loss of a single fragment. Therefore, the host sending data normally uses two approaches to decide the size of packets to send over the network. The foremost is for sending the host an Internet Protocol (IP) packet of size equal to the MTU of the first hop of the source-destination pair. The subsequent is to ask the MTU Discovery algorithm to determine a new path between the two hosts so that fragmentation can be avoided.

How does MTU Affect Design Decisions? (10)

The maximum transmission unit is clearly something that developers would have to think about if they are creating large applications that will be dealing with a multitude of data. If this is designed incorrectly this can lead to performance problems on the network and including both the host and end-user as too much data that the server or end-user can not handle will lead to fragmentation within the network leading to loss of time and possible loss of cash-flow.

On the other hand, if developers are working with small applications that may not have to send or receive large amounts of data, then the TCP would be suitable enough without any optimisations as this transmission control protocol will take care of each packet going through the network.[8]

Synchronicity Communications (11)

Synchronous communication can be defined as communication between two people in real-time. Examples of this could include face-to-face or mobile phone communication. A communication term between two or multiple individuals that can take place simultaneously. This means that individuals could be communication at the same time, though not necessarily at the same location. Examples of synchronous communication can include instant messaging and telephone calls.

Data flows in full-duplex mode in the form of blocks. The synchronization between the host and client is a necessity so that the host knows where the new block starts (since there is no gap between data when being sent and received). Each block of characters is named with the synchronization characters, and the recipient acknowledges and acquires the data until a special character that tells the flow it has reached the end of the blocks.

The way the transmission is sent is both efficient and reliable and is mostly used for transferring large amounts of data. It can also provide real-time communication allowing conference calls and even chat rooms to be possible without a huge lag in between. [6]

An image of synchronous communication is shown in *Figure 1.4*

Asynchronicity Communications (12)

Asynchronicity communication data flows in a half-duplex mode; this means it streams one byte or a character at a time. It streams data continually, the data size of a character is 8 bits to which a parity bit is added, which will create a start and stop bit, meaning the final data would be 10 bits.

Unlike synchronous communications where the clock needs to be synchronized, it doesn't need to be synced for asynchronous communication; rather, it uses the parity bit to control the transfer flow of bits being transferred. It, in fact, uses character-based synchronization so that the receiving device synchronizes itself with the receipt of data on a character. It's simple, economical and fast, which allows it to do many types of communication for different features ranging from forums, television, emails and radios. [6]

An image of asynchronous communication is shown in *Figure 1.3*

Factors of Synchronous and Asynchronous in Design (13)

When designing an application thinking about the transmission flow of the data is a big impact because if you get it wrong, the application will not be able to operate at an optimum network transmission. Knowing what type of software or application you'll be creating from the beginning and the goals you'd like to achieve as end goal will make this task a lot easier as you would know what type of transmission you would need with the examples as talked about in each example of communication.

The Need for Interoperability (14)

Network interoperability has become an important part of the telecommunications industry, as, for this reason, new technologies have been developed alike network functions virtualization (NFV). These types of technologies have created freedom for users and their devices from vendor lock-in by replacing hardware with open source software, allowing major telecom organisations to create a more malleable communications network.

What is Interoperability (15)

But what exactly is interoperability? While definitions vary, the basic idea behind this technology is the ability for two or multiple networks, devices or components to transfer data to each other. With respect to the telecommunications industry, interoperability references to the interwind of telecommunication services over multi-vendor connections as quoted by Mahmoud Elkhodr "*This standard will provide seamless interoperability among smart things without the need of complex local installations, and gives back the freedom to the users, developers, and businesses*". As networks continue to grow and expand with the likes of the up and coming mobile network 5G and the Internet of Things (IoT) era, it is important that we can keep a cross-platform protocol to enable end-to-end communication.[7]

There are a host of benefits attached to interoperability. By achieving network interoperability, users can communicate with various devices through an individual terminal on the fly. Moreover, without being locked into a single vendor, network operators can

choose equipment from various manufacturers based upon price and performance. By the same token, manufacturers can sell the same equipment to a range of operators with interoperable networks.

Uses of Interoperability (16)

Healthcare is essential in making sure that we stay healthy. Interoperability is used to optimize and create a standard quality of medical care. This industry relies on information from multiple sources such as laboratories, hospitals, clinics, pharmacies and primary care providers. These sources use a wide range of systems to record this large amount of information. Therefore, technology in the health systems should be interoperable to allow the relevant exchange of records and more advanced healthcare to the patient in need.

Telecommunications is heavily used daily and used by many different devices which is an advantage for Interoperability as it used to operate effectively with different types of services and systems. Main components of telecommunication compatibility are normally used in scale of the networks, signal availability and equipment coverage. An example of this is interoperability is needed for communication with two-way radios.

Software can be quite useful for Interoperability as it allows functionality of different programs to exchange data, share files and use the same standards and protocols. A software language that can be shown using interoperability is Java. It's often considered a highly interoperable programming language as it can run and execute on any program with a downloaded or built-in Java Virtual Machine (JVM). [9]

Conclusion (17)

In conclusion, we looked at how the TCP/IP model is used and how each module of its stack was extremely useful to telecommunications and software developers, we also looked at how effective the maximum transmission unit can be if designed correctly and the consequences it can have on both large and small applications.

Thirdly we looked at the differences of both synchronous and asynchronous transmission flow and how they both differ from each other. We looked at the applications that would be most useful to both transmissions and the reasons why they would be best suited for those applications.

Finally, we looked at what Interoperability was and how it fundamentally operated, but we took a look into the reasons you would use it and what devices could possibly use the technology. Next, we looked at the current industries that would use Interoperability and why they would use the technology to their advantage.

There can be no doubt that the technologies being used in the current industry help greatly in the development process of software as it allows developers to design and focus more on how the software will work rather than how low-level networks will. It allows developers to be more productive and allows organisations from educations to small startups to run as effectively as possible with little to no delays.

List of Tables and Figures (18)

Figure 1.1 Model Packet Transmission

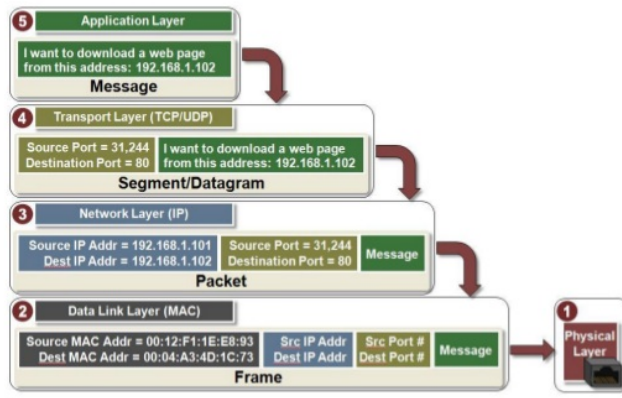


Figure 1.2 Layers Terminology

Layer #	Layer Name	Protocol	Protocol Data Unit	Addressing
5	Application	HTTP, SMTP, etc...	Messages	n/a
4	Transport	TCP/UDP	Segments/ Datagrams	Port #s
3	Network or Internet	IP	Packets	IP Address
2	Data Link	Ethernet, Wi-Fi	Frames	MAC Address
1	Physical	10 Base T, 802.11	Bits	n/a

Figure 1.3 Asynchronous Transmission

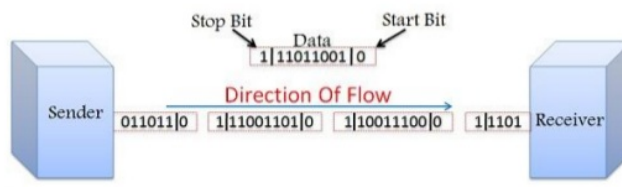
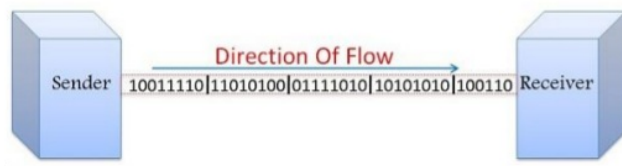


Figure 1.4 Synchronous Transmission



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Networked Applications

GRADEMARK REPORT

FINAL GRADE

67 / 100

GENERAL COMMENTS

Instructor

The sources you've used are mixed in quality. WordPress blogs are completely unacceptable and other, unverified websites are barely better - however, this isn't ubiquitous and some of your sources are perfectly fine. You must make an effort to use journal articles as much as possible at level 6.

A good display of knowledge and understanding, with a nicely-written and presented report. The diagrams are a nice addition, though they would be better-placed closer to their figure reference.

Engagement with Literature Skills (20): 7

Knowledge and Understanding Skills (30): 22

Cognitive and Intellectual Skills (30): 24

Transferable Skills for Life and Professional Practice (20): 14

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