

Abigail Davies - Socket Programming and Concurrency Assignment 1

by Abi Davies

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Socket Programming and Concurrency Report (ACCA6028)

Assignment 1

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Introduction

This report documents the research completed in reference to the transmission control protocol, maximum transmission unit, synchronous and asynchronous network communications, and interoperability. It studies articles and research papers produced by computer scientists, gaining an understanding of what each element is and their role in the transmission of data over a network. The effect each area has on the transmission and how it the best practises can be achieved are also covered. As with anything, there are also some problems that can be introduced as a result of some of the techniques and unfortunately, there is not always resolution. Lastly, there will be a discussion in the conclusion of the relationship between each of these elements, whilst referring to the advantages and disadvantages of implementing them in projects at the design stage or to any existing projects, addressed in the body of the report.

Transmission Control Protocol (TCP)

Transmission Control Protocol (TCP) allows data to be securely transmitted between devices [1]. It is generally one of the fundamental protocols that is implemented for applications like web browsing and peer-to-peer sharing, as well as many others [1]. It is likely that it is utilised in such applications as transmission of data in real time is not a requirement [2].

TCP works in conjunction with internet protocol (IP) where both have a valuable purpose and functions. Together, they create a reliable communication method between devices [3]. There are four layers involved in the transmission of data when using the TCP/IP method; Network access layer, internet layer, transport layer, application layer [1]. The data is split into smaller pieces, known as packets, from the device sending the data, which is submitted in specific order, through each layer of the communication line twice, so that the packets can be organised appropriately at the receiving device [3]. It has been said that the four-layer protocol is a compressed version of the Open Systems Interconnection (OSI) Model as illustrated in figure 1 [3] [4].

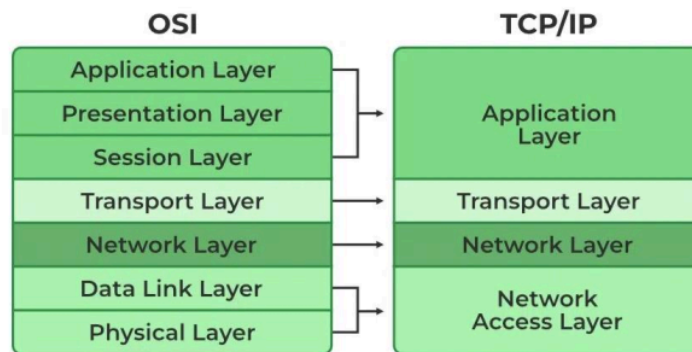


Figure 1 [3]

Four-layer Procedure

The first layer that the data will enter when utilising the TCP/IP protocol is the Network Access Layer. In general terms, individuals would state that this layer is what allows the communication to take place by managing the network infrastructure and is sometimes recognised as the data-link layer [1]. It generates the connection requests from the sender perception and manages the data arriving, from the receiving device perspective [3].

The next layer to be discussed is the Internet Layer. As you will see from figure 1, this can also be labelled as the network layer [3]. This layer exploits the IP suite as it operates a combination of protocols to handle the splitting of data into packets, as well as the addressing and routing [3] [1]. Each protocol within the IP suite has different responsibilities that work together to form a reliable and logical transmission of data over the network [3]. IP identifies the source and destination from the IP addresses found in the packet headers, Internet Control Message Protocol (ICMP) records and provides information on any network problems, whilst Address Resolution Protocol (ARP) recognises the hardware IP address using a number of ARP methods [3].

The Transport Layer follows, and it is responsible for exchanging acknowledging the data received and re-submitting any missing packets to guarantee the packets are received in order and successfully [3]. There are two types of this layer; TCP and User Datagram Protocol (UDP) [1]. To focus on TCP, it allows applications to make a connection that is similar those that are physically connected [3].

The final layer to be discussed is the Application Layer which manages the end-to-end communication of the data transfer and aims to complete without any errors [3]. A number of protocols can also be exploited in this process such as hypertext transfer protocol secure (HTTPS), secure shell (SSH), network time protocol (NTP) [3].

Three-way Handshake

The three-way handshake is an important algorithm used during an end-to-end connection that utilises TCP [5]. As shown in figure 2, the sender device or client will send a synchronised packet, where the receiver or server will respond with either a synchronised or acknowledge packet, followed by the sender or client responding with an acknowledge packet [5]. This process was introduced to initiate a connection between devices, ensuring their statuses are confirmed prior to sending data across the network [5].

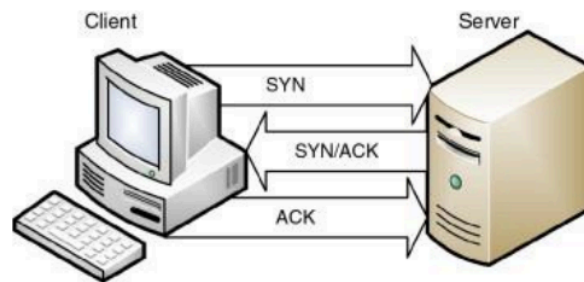


Figure 2 [5]

Two General's Problem

The three-way handshake previously discussed can also introduce problems. One of these problems is recognised as the two generals' problem [6]. Scott provides a clear representation of this on a YouTube video, whilst explaining an issue Scott experienced with an online delivery system [6]. To provide an overview of the two generals problem, it uses an army-based scenario to provide a visual representation of how there is no way to always guarantee that data, between two devices, has been exchanged successfully [7]. To use Figure 2 to explain further, based on the understanding learnt from Scott's video [6], when the client sends a synchronised packet to the server, the server responds to acknowledge that it received that message. However, in some cases a packet can get lost, e.g. the client's packet may not get to the server, or the server may have received the packet, but the acknowledgment packet is lost meaning the client is not aware that the server has received the packet [6]. Unfortunately, to quote Scott, there can be "no certainty" and no alternative method to resolve or get around this problem [6].

Maximum Transmission Unit (MTU)

The maximum transmission unit is the greatest number of bytes or octet that a packet or frame can be for any device that is transmitting and / or receiving data across a link [8]. The packet or frame is what the container is labelled as a representation of its role, depending on where the data is in the layer of the network. The containers are categorised as Protocol Data Unit (PDU) [9]. There are five different PDU names; data, segments, packets, frames, bits [9]. The PDU also holds management information about the protocols, which are added and removed as the data progresses through the different layers [9]. Figure 3 is a table that shows the connection between the OSI model, PDU names and TCP/IP model.

OSI Model	PDU	TCP/IP Stack
Application	Data	Application
Presentation		
Session		
Transport	Segment	Transport
Network	Packet	Internet
Data Link	Frame	Network Access/Link
Physical	Bits	

Figure 3 [10]

Wright states that MTU is commonly used when transmitting a packet using IP across an ethernet network [8]. As the packet is not just the data itself, and the header and payload are also included so these areas must be considered too [8]. In addition, as the MTU of both the sender and receiver are identified, prior to any transmission, an understanding of whether it will fail can be determined [8]. Therefore, in cases where the packet is greater than the MTU of a device or at a network layer, a technique called fragmentation can be utilised to split the packet into a number of smaller packets [8].

IP fragmentation involves the data being reconstructed at the receiving device, due to the original packets being divided into smaller packets at the sender device, in order to transmit data successfully [11]. The smaller packets hold header data that contribute to the success of reassembling the packet at the destination device [11]. Two advantages would be that it allows devices with lower MTU to receive data where they would have failed without this interception, and it is a simple concept as some layers do not need to be aware of the architecture [12]. That being said, fragmentation can result in lower performance levels on the network due to the resources being tied up to this process [11]. Other disadvantages that various researchers have discussed is that fragmentation does not always result in successful transmission as errors such as some of the smaller packets getting lost or corrupt prevent the data from being reconstructed at the destination, as well as there being no way to determine how many packets should be received, increasing the security risk too [13], [12]. Jain produced a research blog gathering an understanding of fragmentation and concluded that it is an important technique as it allows various packets to be transmitted between devices with various MTU sizes, although there are several problems associated with it [14].

MTU must be considered by developers when planning to introduce new elements to a system or when designing a new system which interacts with other devices. As discussed, it can have a number of effects on the performance of the system and the necessary techniques such as whether data will need to go through fragmentation to successfully complete the flow. Documenting and creating an understanding of what devices and network pathways are required for the system to perform as intended, allowing techniques or amendments to be considered prior to implementation.

Network Protocols

A network protocol is a set of rules agreed between networks that allow communication to take place [15]. Robert et al states that without this agreement in place, it would be like two individuals attempting to communicate in different languages where each do not understand the other [15]. Furthermore, there are now standards in place which allow there to be a common ground [15].

Synchronous and Asynchronous

Protocols can be synchronous, asynchronous or have a combination of both for the communication line [16]. Synchronous communication is instantaneous and uses a common clock to synchronise [17]. Lindsey et al advises that there are two techniques used to control the signal; the master slave synchronisation and mutual synchronisation [18].

Asynchronous communication is usually applied for communications that are sporadic [17]. Bick and Field state that power grids have some elements that are asynchronously managed, while the main concept of a power grid is synchronous [19]. This is an example of where both types of networks can be taken advantage of efficiently for one system.

There are many differences between the two including the structure in which the data is transmitted; synchronous transfers data in blocks or frames, whereas asynchronous transfers data in bytes or characters [17]. Additionally, there are also some advantages with both, such as synchronous communication allows errors to be resolved in real time and asynchronous communication has a lower cost [17]. Due to there being a number of advantages and disadvantages of both communication styles, it enables them to be relevant and effective for different tasks [17]. A basic example of an application where synchronous communication would be implemented and exploited would be video conferencing [20]. Just like a phone call, that also operates using synchronous communication, video conferencing allows individuals to work from home affectively whilst being able to collaborate with their work colleagues [20]. On the other hand, an example of an asynchronous communication line would be emails [21]. Emails do not require an immediate response [21], allowing the communication style to be asynchronous instead.

Additionally, the data flow whether it be synchronous or asynchronous, transmits through an operation called I/O [22]. I/O stands for input / output [23]. Generally, this operation can differ between blocked or non-blocked, e.g. synchronous messages are non-blocking as they should return a response immediately and asynchronous messages are blocked [22]. A dispatch I/O model can be broken down into three categories; forecasting, planning and operating [24]. Glowacki states that in general terms, the aim of a dispatch model is to reduce the delivery cost to meet systems demand, whilst complying with security conditions, through balancing the management of blockages and reserving operation simultaneously [25].

Whilst considering the points stated by other researchers, it is clear that synchronous and asynchronous networks work well when they are utilised to their advantages. Similarly to MTU, this decision will also affect the performance of the network and therefore should also be considered when designing systems. Diagrams have been heavily used throughout the blogs, documents and papers discussed, suggesting that it would be useful to do when designing as allows each area to be investigated individually. This also allows each element to focus on what is required so that the pros and cons can be analysed to achieve the aim and objectives of a development project.

Interoperability

To quote the Cambridge Dictionary, interoperability is “the ability to work together with other systems or pieces of equipment” [26]. In terms of networking, when a network is interoperable, it means that the devices, created with different or the same technologies, can communicate without any incapability errors [27]. Azad et al investigated interoperability networks, specifically focusing on internet of things (IoT), documenting that it is vital for a network to be interoperable [28]. It was further stated that without this attribute, devices on the network would not have the ability to have a consistent, smooth communication line [28].

In many public organisations interoperability within systems is becoming more important and there are many advantages that are recognised when systems have this attribute [29]. One of the benefits would be that it increases collaboration between systems in an organisation, by allowing different departments to exchange data between their systems [29]. Further on this point, it also creates diversity by allowing different devices to communicate affectively [27]. Some departments may work using a computer and other departments may relay more heavily on smart phones / tablets for remote working [27]. Another advantage of having interoperable systems would be that it reduces cost [29]. Cost reduction could be viewed in many different lights, e.g. IBM state that interoperable systems prevent the requirement of purchasing new software that can process data for exchange and / or human resources where they would no longer be required to manually prepare data for systems that were not compatible [29]. Additionally, Howard refers to the reduction of being locked in with certain vendors [27]. This can also add to the cost reduction as it allows organisations to choose their vendor, focusing on weighing up the cost, reliability, performance, etc. and not limiting to which vendor is compatible.

On the other hand, Azad et al documented their research that studied two basic protocols that could be exploited to allow systems to be interoperable that are not primarily [28]. Bluetooth and Wi-Fi were the two chosen protocols, and the aim was to improve the capability and flexibility of systems, whilst tackling the latency and bandwidth constraints that are usually introduced [28].

There are number of practices that be used to achieve interoperability within a network. Desourdis et al states that there are eight disciplines that create these best practices for designing, implementing and maintaining the infrastructure developed [30]. Figure 4 has been extracted from Desourdis et al research paper explaining the connections between the eight disciplines [30].

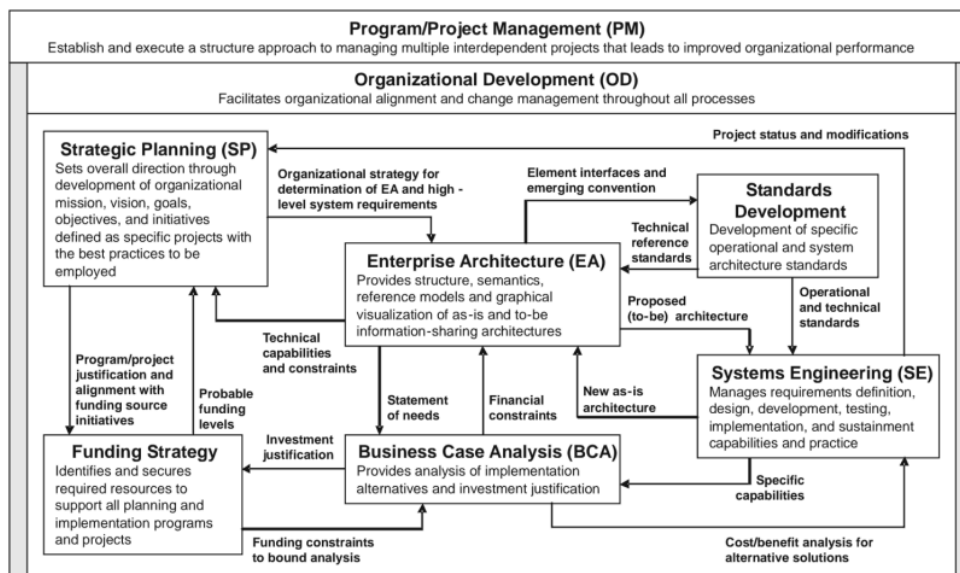


Figure 4 [30]

Desourdis et al's research looks at the standards that should be followed in order to achieve interoperability for new systems and therefore, the disciplines should be followed from the design stage, all the way to the maintenance of the system [30]. Further on this, Vasseur and Dunkels studied smart objects, finding that it can be problematic to implement interoperability at a later stage so is always recommended to be introduced in development as a primary concern [31].

On the whole, interoperability is becoming progressively more important in networking. Companies creating products to sell will need to have this as a top priority to ensure that the product reaches its full potential, as well as organisations that are developing systems in-house. As seen from the research, without this element being considered during the design and planning stages, it can prove very difficult, although not impossible in some cases, to introduce at a later stage. That being said, the methods used if introduced later on may be more limited.

Conclusion

To conclude, there are many concepts that should be considered when developing applications that communicate over network, whether this be when new applications or improving and adding elements to existing systems. Altogether the concepts discussed work hand-in-hand with each other to achieve the end goal of a smooth efficient communication line and for this reason, it is vital to consider all at the development stages, whilst assessing how each can have an impact on the systems performance. As documented throughout, the research suggests that considering which protocols, and the type of data exchange required are extremely important to the design stages, whilst understanding whether the systems will be interoperable with each other. The research suggests that synchronous and asynchronous data flows can be utilised best in differing ways so it is important to consider which method would be best for the task at hand. Furthermore, developers confirmed that systems can use a combination of the two for a variety of tasks, creating an enhanced performance on the system by focusing on the requirements. Compatibility between devices is also an increasing demand due to the advantages that comes with it. Inoperability between devices within a workspace can make a significant difference to the ways of working by reducing manual intervention on those that are incompatible. To further iterate the research, although not impossible, it can prove problematic to introduce these changes at a later stage in the development cycle, so it is important to consider at the design stage if developing a new system.

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Abigail Davies - Socket Programming and Concurrency

Assignment 1

GRADEMARK REPORT

FINAL GRADE

72/100

GENERAL COMMENTS

A fairly good report though use of sources needs a little work. You have used a very good number of sources, though are maybe a little too dependent on non-authoritative web resources. I would suggest starting your search from journal/library indexers, rather than web searches.

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