

Sneaky Packets: Packet Switching Concepts for the Technologically Disinterested

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ABSTRACT

This paper proposes an in-class exercise that makes the arcane and abstract concepts associated with packet switching, more interesting, relevant, and generally fun. Using self-efficacy enhancing activities students are exposed to fundamental Internet concepts like encapsulation, packet switching, DNS, addressing, etc. through an in-class variation on the old activity of passing notes. Students have found the exercise fun. They also generally retained a better conceptual understanding of how packet switching systems work than those just reviewing the concepts, based on their performance in course assessment.

Keywords: Internet, packet switching, encapsulation, teaching, in-class exercise, fun, game

INTRODUCTION

Almost everyone is now using the Internet and its associated technologies daily through smartphones, tablets, computers, and even televisions. They send and receive e-mail, surf websites, download information, upload assignments and engage in a vast array of other activities. However, for those non-technically oriented business students in an introduction to information systems course the how's behind this digital magic are often difficult to understand, especially when faced with theoretical and logical models. This resistance is further fueled by apprehension and occasional fear about difficult technological concepts. While some among this group may argue that they do not need to understand technology concepts, it is hard to argue that technology and business are not more linked than separate.

To help in overcoming this disconnect and improve learning some have looked at simulations (Cronan, Léger, Robert, Babin, & Charland 2012) and games (Boyle, et. al. 2016), but these often require a technical competence and system interaction which actually reinforces the students' resistance to the topic. In response we have developed an in-class activity that requires the students to not just be actively involved in the learning process, but to experience the Internet and networking communications process first hand in a fun and interesting way. This proposes a classroom activity to demonstrate in a fun and entertaining way the foundational concepts behind the packet switching methodology used by networks and the Internet.

THEORETICAL BACKGROUND

For many years in-class activities have attempted to capture business students' attention and encourage them to think about topics and systems in a different more interactive way. One classic example is the paper plane exercise to cover business production and management concepts as students build paper airplanes (Valle 2010). This does not, however, address the students' resistance or anxiety regarding technology related topics. In relation to teaching foundational information technology concepts to unengaged business students, the construct of self-efficacy is a major determinant of performance (Gist, Schwoerer, & Rosen, 1989; Compeau & Higgins, 1995; Smith-Jentsch et al., 1996), and engagement (Chen, 2017) and is negatively associated with the major negative aspect of anxiety (Bandalos, Yates, & Christ, 1995; Compeau & Higgins, 1995), especially among women (Lee & Huang, 2014). Business students often fail to see or actively avoid seeing the relevance of technology concepts. Self-efficacy has been related to both the acquisition and transfer of skill (Smith-Jentsch et al. 1996). Social cognitive theory and the role of self-efficacy, as being positively related to learning, have generally been supported (Pajares & Miller, 1994; Compeau & Higgins, 1995).

In a study of learning computers and systems Gist et al.'s (1989) study of computer learning and self-efficacy, found those high in self-efficacy at the beginning did better, in all training conditions, than those lower in self-efficacy. While externally imposed strategies can expedite the learning process - internally provided strategies are more

effective (Singer & Chen, 1994). A task which is seen as too difficult, either through independent appraisal or through experience and feedback, will lead the individual to avoid it or fail to commit to it due to a fear of failure (Bandura, 1991; Wood & Bandura, 1991; Martocchio & Webster, 1992). Non-computer-oriented business students facing required information system and technology courses are filled with this fear and thus show immediate resistance. If someone does not want to learn, then they will not succeed.

The focus of this paper is on a specific form of self-efficacy termed, “computer self-efficacy”, which has been defined as a “judgment of one’s capability to use a computer” (Compeau & Higgins, 1995) or as applied to our situation the student’s capacity to understand a computer concept. Computer self-efficacy affects the individual’s computer usage, anxiety levels, perceived ease of use, and usefulness (Igarria & Iivari, 1995). Computer self-efficacy is also malleable. Research shows that mastery experiences, modeling (Bandura, 1977; Wood & Bandura, 1989), and actual usage (Compeau & Higgins, 1995; Igarria & Iivari, 1995) can positively affect a person’s computer self-efficacy. Alternatively, other research has shown that self-efficacy may be either negatively (Compeau & Higgins, 1995) or positively (Igarria & Iivari, 1995) affected by expert support. Thus, computer self-efficacy appears to be a critical key to the learning which results from a learning experience. Increasing computer self-efficacy appears to provide the individual learner with additional tools which can maximize the benefits of any training condition or material.

How computer instruction is presented has been shown to have a strong effect on both ultimate learning and levels of self-efficacy. A pretraining intervention which simply defined the computer material to be taught as being “acquirable” resulted in self-efficacy gains over a “fixed” or limited acquirability definition (Martocchio, 1994). In other research, identifying the training as an “opportunity” resulted in higher levels of computer self-efficacy and learning (Martocchio 1992). Labeling training as “play” was also found to result in higher motivation to learn and better performance among younger workers (Webster & Martocchio, 1993). If the individual is provided the opportunity to learn about the computer in a positive, playful manner, computer self-efficacy should be increased, and training should result in increased learning.

It is proposed that a positive and playful manner of computer interaction could be achieved using a fun classroom activity. Humor (Marques 2012) in learning has been found to result in better attention, greater retention, and better understanding, and overall a more pleasant environment. Playfulness has been found to be correlated with involvement in a task (Webster & Martocchio, 1992), which can lead to increased positive computer experience and higher computer self-efficacy beliefs. Thus, it is our contention that the use of a fun and often humorous classroom activity, which uses simple activities to demonstrate more complex computer concepts, could allow for increased computer concepts mastery experiences and thus high computer self-efficacy.

By drawing the individual into a more involved and positive experience with information technology concepts, it is believed that anxiety and fear will decrease. Decreasing anxiety should result in higher computer self-efficacy beliefs (Compeau & Higgins, 1995; Bandalos et al., 1995). This coupled with some fun and a little humor, should lead to an increase in the amount of learning which can occur during subsequent instructional sessions. By decreasing the apprehension and anxiety associated with general technology concepts, the learner can focus on the specific material and ideas being provided and not on the preconceived technology and application specific fears.

THE ACTIVITY

The activity is designed to demonstrate, in a fun and interactive manner, an array of the fundamental concepts behind packet switching and routing in networking and the Internet. There is substantial abstraction of the concepts, but the primary focus is not absolute technical accuracy, but rather a more entertaining and fun macro-conceptual understanding of the process. Specific traffic details and concepts (connectionless, encapsulation, packets, latency, etc.) are covered after the fun activity has been completed and the student’s self-efficacy regarding computer concepts has been raised.

ACTIVITY SET-UP

The Address Book

We begin by mapping our classroom. In a traditional classroom this is accomplished by using the already present structure of the classroom. For example, we have a center aisle with six rows of desks on each side, with each row consisting of 4 chairs. This becomes our basic map which we will later translate into specific addresses (Section.Row.Seat). This map is then populated with the students in the class based upon either their assigned seat or their customary seat location (See Figure 1). Thus, each student is now identified by name and by a unique address within the classroom. This is important since we will be using this later as our network address book. If a room has additional aisles, then simply create additional address books for each section. This allows for the activity to be scaled to even large lecture halls. The segmentation also helps to keep the addressing to a reasonable scale.

	A	B	C	D	E
1					
2					
3		Door - DNS			
4		DOOR			AISLE
5		SEAT			
6	ROW	4	3	2	1
7	1				John Smith
8	2	Sally Simms		Andy Jackson	Steve Jones
9	3			Jane Doe	
10	4	Jim Johns	Joe Six	Jack Black	Karl Marx
11	5		John Silver	Bob Dillon	Ken Doll
12	6			John Doe	
13					
14					
15		ADDRESS			
16		DOOR.ROW.SEAT			
17		example: "John Doe"= DOOR 6 2			
18					
19		Computer - DNS			
20		AISLE			COMPUTER
21		SEAT			
22	ROW	1	2	3	4
23	1	James Bond	Perter Parker		
24	2		Clark Kent	Gina Quinn	John Houston
25	3	Bruce Lee	Adam Ant		Blake Stone
26	4	Sam Brown	Don Jones	Ben Parnell	
27	5		Adam Smith	Pat Taylor	Pat Smith
28	6				
29					
30					
31		ADDRESS			
32		COMPUTER.ROW.SEAT			
33		example: "Adam Smith"= COMPUTER 5 2			
34					

Figure 1: (DNS) Address Book

For the next portion of the activity we create a table in either a word processing document or a spreadsheet. We find the spreadsheet is easier to manage. A portion of what the spreadsheet would look like is shown in Figure 2.

	A	B	C	D	E	F	G
1							
2							
3	John Doe		A	1	of	4	Internet
4	John Doe		A	2	of	4	Is
5	John Doe		A	3	of	4	Really
6	John Doe		A	4	of	4	Fun
7	Jane Doe		B	1	of	5	Computers
8	Jane Doe		B	2	of	5	Are
9	Jane Doe		B	3	of	5	So
10	Jane Doe		B	4	of	5	Very
11	Jane Doe		B	5	of	5	Cool
12	Pat Smith		B	1	of	11	I
13	Pat Smith		B	2	of	11	Really

Figure 2: Messages

The Messages

Several messages of differing lengths are now prepared. These messages can be humorous (“I really love computers”) or more neutral (“This is message one”). We find the humorous messages tend to make the activity more interesting to the students involved, especially as the recipient reads it out loud. We recommend preparing at least 3 messages: one of 3-4 words, one of 6-8 words, and one of 10-12 words. These messages will later be converted into word long packets to be sent through our imaginary network to be reassembled by the targeted recipient. We often create two of each message addressed to different students just in case a specific student is absent or changes seats on the day of the activity.

Encapsulation

The messages are now broken down into smaller “packets.” To do this we simply type one word on each line of the table that you created (see Figure 2). Each word is put onto a different row and each row is then given a sequential number and the total number of segments in the message. This will allow the user to reassemble the message later in the activity. The letter to the left of the sequence number is just a quick way to regroup each message if like us you later accidentally drop all the slips of paper.

Addressing

Each message is addressed to someone in the classroom. This is done by entering the student’s name on the row associated with each segment of the message. So, if the message has 4 words, there should be 4 rows, each addressed to the same student, and each sequentially numbered indicating a total of 4 segments (see Encapsulation).

The address book created earlier should contain the name of the student who is the intended recipient of the message. This will later be used to find the student location given his/her name. We find it best to select several different students around the room to make this more interesting and more flexible, since specific students could be missing the day of the activity and to allow as many students as possible to be involved in the activity.

Cutting

Print the full list of messages to be sent and cut each row apart, remembering to keep each message together with all its numbered parts. The longer the message the more “packets” it is going to have, this will be nice later when wanting to demonstrate network congestion and automatic rerouting.

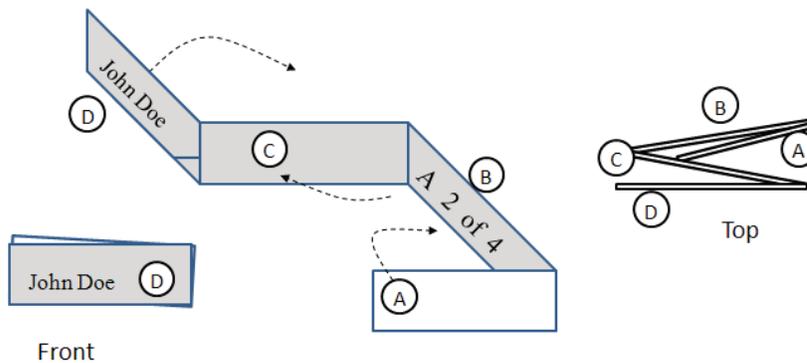


Figure 3: Folding each “packet”

Folding

Each of the message rows is now folded into an encapsulated packet with only the addressee visible on the outside of the message. We tend to fold the slips of paper from the right, so we fold A over B, then B over C, then we fold D backwards so only the addressee is showing (see Figure 3). This step represents the encapsulation of the message packets in preparation for transmission over the network.

ACTIVITY

Game Day

On the day of the activity we start by explaining that the entire class is now going to be “the Internet.” Each student will be a “node” on this imaginary Internet and as such will be responsible for moving messages along based upon the message’s address and each student’s relation to that final address location. We explain that as a node each student is to move the packets (the small slips of paper) to the destination as quickly as possible without leaving his/her seat by passing the message only to those in the seats he/she can reach easily and directly. If someone is busy or not paying attention then the message must be passed to someone else immediately, even if it is in the wrong direction, he/she cannot wait for anyone. This is where the activity can get especially fun and, in some cases, silly.

Appoint one student at the front of each classroom section as the DNS. This person is given the address book that you prepared earlier with the name and “address” (Section.Row.Seat) for every student in his/her section. It is his/her job to address the message segments that he/she receives. Using the address book, the DNS will locate the student named on the message then start the message packets towards their destination (we find this is more enjoyable and challenging, although not quite accurate, if the DNS does not write the address down, but rather tells the next node, who must thus also tell the next and so forth in a fun throwback to the old game of telephone). This is also a great teaching moment to explain how the actual Internet DNS system works as our DNS’s provide numeric addresses based upon the more understandable student names. Since it is likely that not everyone in the class knows every other student, the DNS provides a way to send a message to the desired student, much like the now archaic phonebook or more modern cell phone contacts, allow us to call people without remembering everyone’s phone number.

Explain that after all the packets have made their trek the recipient should unfold each packet and check the sequence numbers on the messages and make sure that all the parts are there. If the message is complete the receiver is to send a confirmation back to the DNS by telling the node closest to him/her that it is “complete,” that node then repeats the message to the next available node and so forth until the DNS gets the message and tells you. If a message is incomplete a message should be sent back explaining the error or missing packet. If the message is complete the student can assemble and read the message out loud to the class (this is why we prefer a humorous message, as this can be an enjoyable moment in a class many view as challenging and not fun).

The Message

Using the smallest message start the activity by handing the first packet to the DNS. As soon as he/she finishes finding the address and starts to pass it along, give him/her the second packet, and so forth. Moving quickly forces the DNS to quickly process and forward the messages without being able to wait on the next level of nodes to be “ready.” Watch the various packets move through the student nodes to their destination. When all the packets have made it to the destination the student should read the message.

Repeat this process using the remaining message packets. The faster that you send out the packets the more likely you are to have dropped packets and congestion issues. These can lead to excellent demonstrations of how nodes automatically shift the traffic to avoid congestion or how the Internet protocols verify that messages are received and complete.

Watch the activity and note the following as teachable moments:

1) Congestion. Students who are talking or not paying attention are obstacles to the efficient flow of the packets to the recipient. Also, some individuals may attempt to give another node two packets at once or a second packet before the node has finished passing on the first packet. Stop at this point and use this to explain that the node should always route to the next available node, rather than wait or try to overload a node. Also, you can randomly identify a node as out of service (this works best for someone who is a critical juncture between different parts of the room) forcing the nodes around him/her to reroute the packets to another available node, regardless of whether the next node is in the direction of the packet’s destination. This serves as a nice illustration of the robustness of the Internet and the packet switching protocols.

2) Sniffing. Watch for any student node that unfolds a message packet and peaks at its content. Stop everything when you see this and use it as an opportunity to discuss the inherent insecurity of the Internet packet switching model. This can often lead to great discussions of privacy and security and how encryption might help secure the message contents. Do not focus on the student node that opened the packet, this could cause them some embarrassment for a simple misunderstanding about the packet concept, especially since we intentionally do not explain this beforehand. If no student tries to look at a packet tell a student node to read the contents of each packet he/she sees and see how much of the message, he/she can understand.

3) Dropped Packets. If a node drops a packet on the floor it is lost and should be returned to the instructor. When the rest of the packets have been received and reassembled the recipient should notice the sequential absence and send a request for the packet back through the nodes to the DNS. Once the DNS notifies the instructor then you can send the dropped packet back through the nodes to the recipient. This can lead to a discussion of acknowledgement and control, illustrating again the robust nature of the Internet.

Afterwards

Following the activity, we begin a more serious discussion of the fundamentals of networks, packet switching, and how the Internet functions, referring often to the activity for illustration of various concepts. Examples include the setting and identification of node addressing and the DNS system, the idea of circuit switching versus packet switching, and the architecture of local and wide-area networks. This is also used to help illustrate and discuss the traffic and routing differences in hubs, switches, and network routers, as well as other network concepts like packet inspection and network security. Students now understand basic network concepts in a way that is relevant and understandable, but more importantly not arcane and scary. Nodes have been transformed into fellow classmates and abstract concepts into laugh generating activities.

CONCLUSION

The activity discussed in this paper was designed to help reduce some of the resistance and disconnect we found in students in a principles of information systems course. While this particular iteration of the activity deals specifically with packet switching, minor modifications can be made to demonstrate other telecommunications concepts. Understanding how connecting devices affect the traffic on a network is much easier when students see the physical embodiment of every message being copied and sent to every other network node with a hub versus a switch that only sends the message to the targeted node. In addition, topics outside of information systems can be

illustrated. For example, structured programming logic can be shown, with lines of code placed on paper and students serving as decision points for where to hand off control.

Students are often unsure, resistant, and overwhelmed by abstract information systems constructs and theoretical models. These students understand computers and the Internet as users, but often lack any understanding of how the technology works and are often not overly interested in learning something they see as difficult and potentially scary. With this activity we have found the students, even the non-technological resisters, to have higher self-efficacy and to be more engaged and interested in the concepts. Additionally, the reinforcement of abstract concepts with actual physical activity seems to help the students recall details of how networks function.

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