

Solutions to Homework 1

Please note that the following solutions may contain more information than you needed to provide to receive full credit and may only provide examples, rather than an exhaustive list, of correct answers.

1. MASS-MARKET BUSINESSES AND NETWORK EFFECTS (10 points)

A. A *mass-market business* is one that sells a standardized product or service to a very large number of customers. A business exhibits *network effects* if the value of its product or service to one customer depends on the number of customers. As discussed in class and in Chapter 1 of **Information Rules**, by Shapiro and Varian, communication products and services, including telephones, email, Internet access, and fax machines, often exhibit strong network effects.

B. Both Netscape and Amazon are mass-market businesses that were discussed in class. Netscape relies much more heavily on network effects.

2. INTERNET ARCHITECTURE AND PROTOCOLS (10 points)

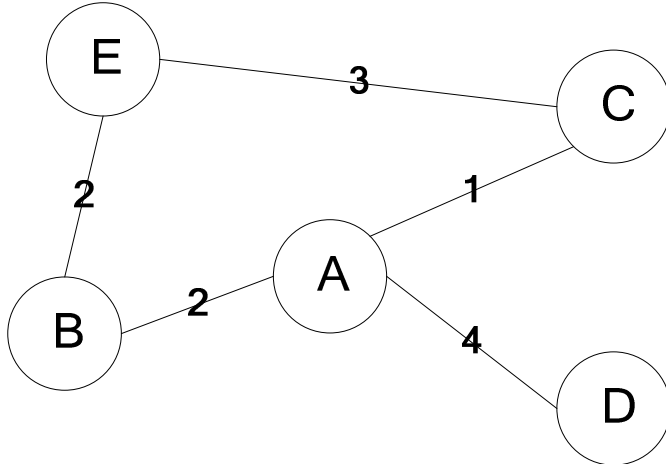
A. IP address

B. DNS (Domain Name Service). If my browser does not already know the IP address of www.microsoft.com, then this address is not stored in the *local cache* of my machine. For concreteness, assume that my machine is `concave.cs.yale.edu` – others work analogously. It first asks the domain-name server of `cs.yale.edu` for this address. If this server has the address in its cache, it sends it back, and my machine both uses it for this webpage request and stores it in its cache; otherwise, the `cs.yale.edu` domain-name server asks the domain-name server of `yale.edu`. If the `yale.edu` server has the address in its cache, it sends it back to the server at `cs.yale.edu`, which both caches it and sends it back to `concave.cs.yale.edu`. The lookup proceeds up the *domain hierarchy* until it either finds the address in a cache or consults a *root server*. The latter would first look up the address of the top-level `.com` domain, which in turn would look up the address of the `microsoft.com` domain, *etc.* All of these addresses are sent to the requesting servers (`yale.edu`, `cs.yale.edu`, *etc.*), which cache them for future use. See pages 12-15 of the notes from Lecture 2 (January 16, 2003) and www.howstuffworks.com/dns.htm/printable for a more precise and complete explanation.

- C.**
- i) Transport Layer
 - ii) Transport Layer
 - iii) Network Layer (also known as the IP layer)
 - iv) Physical Layer

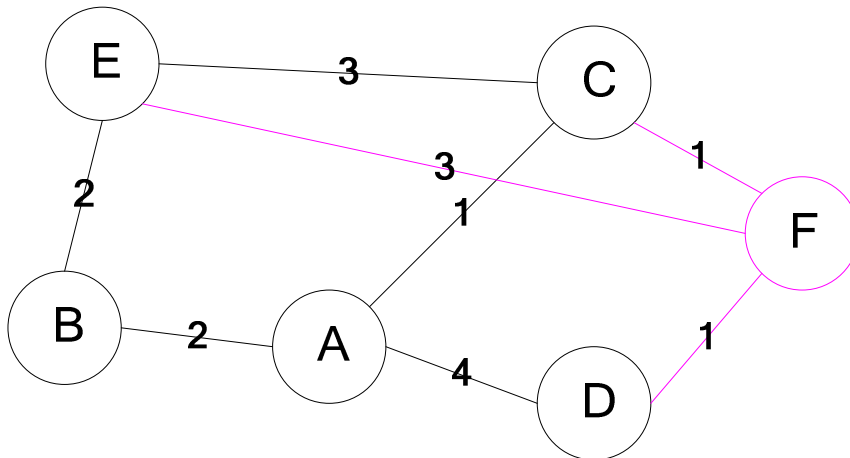
3. OSPF ROUTING (22 points)

A.



Destination	Next Hop	Shortest Path
B	B	A→B
C	C	A→C
D	D	A→D
E	C or B	A→C→E or A→B→E

B.



Destination	Next Hop	Shortest Path
B	B	A→B
C	C	A→C
D	C	A→C→F→D
E	C or B	A→C→E or A→B→E
F	C	A→C→F

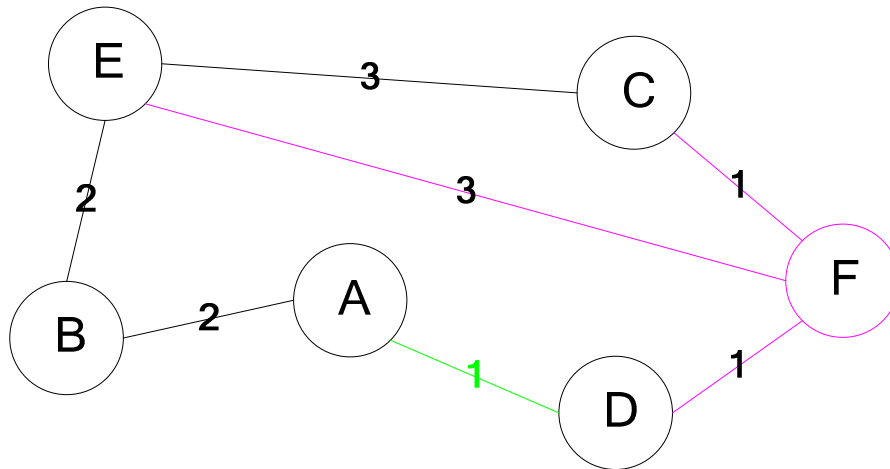
C.1.

Link	Weight
A→B	2
A→D	1

Link	Weight
C→E	3
C→F	1

Link	Weight
D→A	1
D→F	1

C.2.



Destination	Next Hop	Shortest Path
A	F	C→F→D→A
B	E or F	C→E→B or C→F→D→A→B
D	F	C→F→D
E	E	C→E
F	F	C→F

C.3.

Destination	Next Hop	Shortest Path
A	A	D→A
B	A	D→A→B
C	F	D→F→C
E	F	D→F→E
F	F	D→F

4. BUSINESS ON THE INTERNET (12 points)

This is a very open-ended question, and there is not necessarily one right answer for each stage. You will get full credit if your answer is well justified. Correct answers include but are not limited to the following; note that they include justifications for some conflicting opinions.

Browsing or Discovery: The Internet offers consumers a vast improvement in browsing and discovery by reducing search costs. Google offers compelling evidence of the newfound ability of consumers to find more and better information about products and services quickly than they can in other shopping venues. Future generations of Internet shoppers may have routine access to even more powerful search technology in the form of “bots” (such as those featured on DealTime). The basic property that enables this qualitative improvement is the fact that search programs can process vastly more information automatically than consumers can “by hand.”

Price Negotiation: Consumers are in a much better position to negotiate on the Internet than they are in other shopping venues. For example, eBay offers compelling evidence that consumers can now bargain for good deals on far more products than they could offline. Face-to-face swap meets have long offered the opportunity for price negotiation in consumer-to-consumer transactions, but the massive scale, great speed, and enforced auction rules of eBay make it qualitatively different. The properties of the Internet that enable this qualitatively better consumer experience include the massive-scale, universal access that a website can offer to both sellers and buyers and the programmability of the auction site.

Payment: Because consumers generally pay for merchandise with credit cards when they shop on the Internet, and they also use credit cards in many other shopping venues, this stage does not offer a fundamentally new consumer experience.

Payment: Personalization services (e.g., “one-click shopping” on Amazon) make using credit cards easier on the Internet than it is in other shopping venues; thus the Internet-consumer experience is better in the payment stage. The property of the Internet that enables this improvement is that it puts the full power of general-purpose computers at the disposal of both merchants and consumers. For example, browser cookies can store information on the buyer’s computer, and customer databases can store information on the seller’s computer, and all of it can be used to speed up payment for repeat customers.

Merchandise Delivery: Physical goods such as books, CDs, DVDs, theatre tickets, and computers are generally sent to consumers by UPS, regular postal mail, or another similar delivery service. There is nothing new about this; consumers have had the same merchandise-delivery experience for years when ordering goods remotely via phone, fax, and postal mail.

Merchandise Delivery: A wide variety of electronic goods, including digital books, songs, and movies, can be obtained and used by purchasers almost instantaneously. This makes the consumer experience much better on the Internet than in other shopping venues when the merchandise consists of electronic goods. The property of the Internet that enables this improvement is the fact that it provides a direct communication channel from a wide variety of merchants to a wide variety of player applications, all of which can be installed on the consumers’ general-purpose computers. (Pay-per-view TV programs can also be obtained instantaneously over the cable-TV system, but the Internet provides the potential for instantaneous delivery of a much wider variety of electronic goods.)

5. INFORMATION ECONOMY (12 points)

The following three general techniques are discussed in Chapter 1 of **Information Rules**, by Shapiro and Varian:

- *Legal protection*, e.g., copyrights:

When information products are protected by intellectual-property law, their legal owners can sue others who illegally misappropriate them. Large-scale misappropriation is both the most important for legitimate owners to stop and the easiest to detect. Legitimate owners can also try to deter illegal misappropriation by creating awareness, through advertising and marketing campaigns, of intellectual-property law and the penalties for violating it.

- *Value-based pricing*:

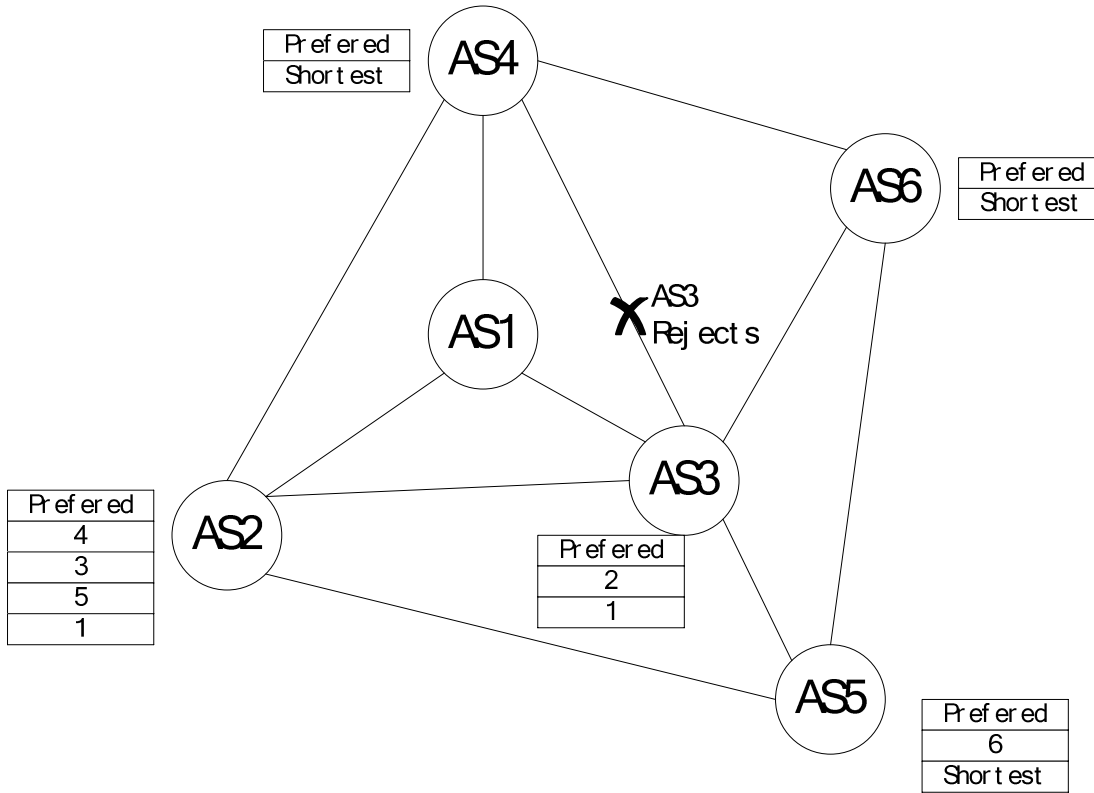
This class of techniques includes *differential pricing* and *versioning* and allows a merchant to charge a customer according to the *value* that the customer assigns to the product, rather than according to the merchant’s marginal cost.

- *Branding*:

Legal owners clearly have an advantage over others trying to market identical information products if they can establish trusted and recognizable brands.

Other reasonable answers will also be given full credit. Two that were discussed in class are *technical-protection services*, in which techniques such as encryption and access control are used to make it difficult to sell or use information products in ways other than those approved by their legal owners, and *bundling*, in which two or more information products are offered to customers (only) as a set for a price higher than the sum of the prices that customers would be willing to pay for each of them separately.

6. BGP ROUTING (34 points)



- (I) A. AS2→AS4→AS1
 AS3→AS2→AS4→AS1 or AS3→AS1
 AS4→AS1
 AS5→AS6→AS4→AS1
 AS6→AS4→AS1

Two answers are possible for AS3 depending on how you interpreted the constraint “AS3 rejects all paths through AS4.” If AS3 simply never uses the AS3-AS4 link, then the first answer is correct; if AS3 rejects any path that contains AS4 (not just as a next hop), then the second answer is correct.

- (II) B. AS12→AS14
 AS11→AS12→AS14
 AS13→AS11→AS12→AS14

- (II) C. AS13→AS14
 AS11→AS13→AS14
 AS12→AS11→AS13→AS14

- (II) D. AS12→AS14
 AS11→AS13→AS14
 AS13→AS14

Because AS11 prefers the link to its customer, AS11 will advertise “AS11→AS13→AS14” instead of “AS11→AS12→AS14.” Thus, AS13 will not immediately replace AS13→AS14.

- (II) E. AS12→AS14
 AS11→AS12→AS14
 AS13→AS11→AS12→AS14

While AS13→AS14 is disabled, AS11 advertises “AS11→AS12→AS14”, AS13 receives this advertisement, and AS3 replaces “AS13→AS14” with “AS13→AS11→AS12→AS14”.