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## TRANSFERENCIA CONFIABLE, TCP Y CONTROL DE CONGESTIÓN

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### Knowledge Checks

#### Network Layer: Data plane

##### The network layer - where is it?

All the next statements about where (*in the network*) the network layer is implemented are true

- The network layer is implemented in hosts at the network's edge.
- The network layer is implemented in routers in the network core.

#### Forwarding versus routing

Consider the travel analogy discussed in the textbook - some actions we take on a trip correspond to forwarding and other actions we take on a trip correspond to routing. The following travel actions correspond to *forwarding*.

- A car stops at an intersection to "gas-up" and take a "bathroom break".
- A car waits at light and then returns left at the intersection.
- A car takes the 3rd exit from a roundabout.

The following travel actions correspond to *routing*

- A car takes highway 80 between New York and Chicago, rather than highway 87 to Albany and from there take interstate 90 to Chicago.
- A traveler decides to fly to Sydney through Singapore rather than Dubai.
- a climber decides to take the South Col Route to the top of Mt Everest rather than the Northeast Ridge route.

### The control plane versus the data plane

The following actions are primarily in the network-layer data plane

- Looking up address bits in an arriving datagram header in the forwarding table.
- Dropping a datagram due to a congested (*full*) output buffer.
- Moving an arriving datagram from a router's input port to output port.

The following actions correspond to control-plane actions

- Monitoring and managing the configuration and performance of a network device.
- Computing the contents of the forwarding table.

### What type of control plane?

We've seen that there are two approaches towards implementing the network control plane: a per-router control-plane approach and a software-networking (*SDN*) control-plane approach. The following actions occur in a per-router control-plane approach

- Routers send information about their incoming and outgoing links to other routers in the network.
- A router exchanges messages with another router, indicating the cost for it (*the sending router*) to reach a destination host.

These actions correspond to actions in an SDN control plane

- All routers in the network send information about their incoming and outgoing links to a logically centralized controller.
- A control agent in a router receives a complete forwarding table, which it installs and uses to locally control datagram forwarding.

### Best Effort Service

The following quality-of-service guarantees are part of the Internet's best-effort service model

- The best-effort service really means no *guarantees* at all!

### Network Layer: Control plane

#### What's a "good" path?

What is the definition of a "good" path for a routing protocol? Routing algorithms typically work with abstract link weights that could represent any of, or combinations of, all of the other answers.

### Dijkstra's Link-State routing algorithm

Consider Dijkstra's link-state routing algorithm that is computing a least-cost path from a node a to other nodes b, c, d, e, f. The following statements are true

- The values computed in the vector  $D(v)$ , the currently known least cost of a path from a to any node v, will never increase following in iteration.
- In the initialization step, the initial cost from a to each of these destinations is initialized to either the cost of a link directly connecting a to a direct neighbor, or infinity otherwise.
- Suppose node b, c and d are in the set  $N'$ . These nodes will remain in  $N'$  for the rest of the algorithm, since the least-cost paths from a to b, c, and d are known.

### What type of routing?

Here are the names of a general approach to routing with characteristics of that approach

**Centralized, global routing** - All routers have complete topology, and link cost information.

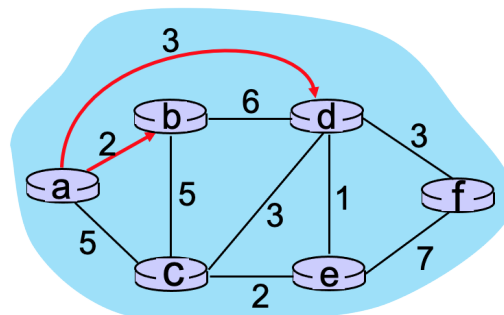
**Decentralized routing** - An iterative process of computation, exchange of information with neighbors. Routers may initially only know link costs to directly-attached neighbors.

**Static routing** - Routes change slowly over time.

**Dynamic routing** - Routing changes quickly over time.

### Dijkstra's link-state routing algorithm (*Part 1*)

Consider the graph shown below and the use of Dijkstra's algorithm to compute a least cost path a to all destinations. Suppose that nodes b and d have already been added to  $N'$ . What is the next node to be added to  $N'$  (*refer to the text for an explanation of notation*)? **The next node is e**

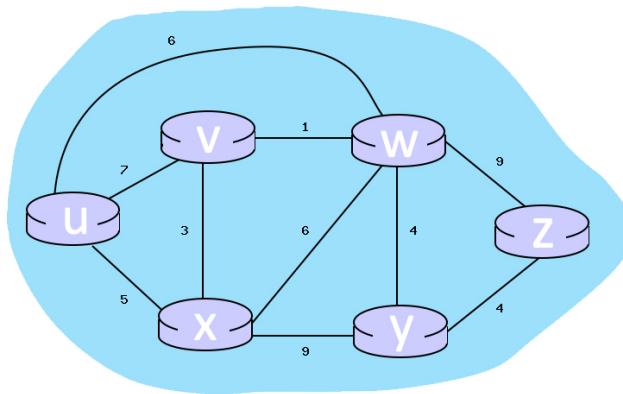


### Dijkstra's link-state routing algorithm (*Part 2*)

Consider the graph previously shown and the use of Dijkstra's algorithm to compute a least cost path from a to all destinations. Suppose that b and d have already been added to  $N'$ . What is the path cost to the next node to be added to  $N'$  (refer to the next for an explanation of notation)? **The path cost is 4**

### Dijkstra's link state algorithm (*for computing least cost paths*)

Consider the 6-node network shown below, with the given link costs. Using Dijkstra's algorithm, find the least cost path from source node U to all other destinations



**What is the shortest distance to node v and what node is its predecessor?**

The answer is: 7, u.

**What is the shortest distance to node y and what node is its predecessor?**

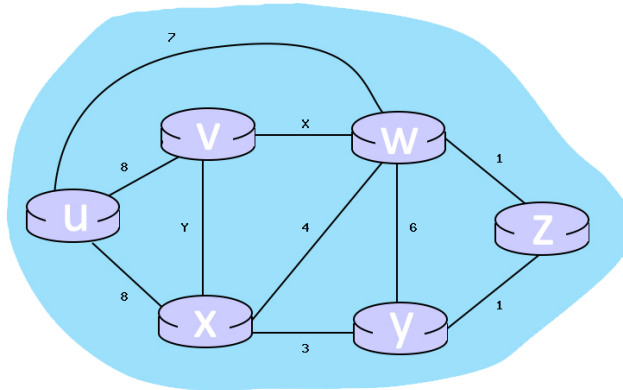
The answer is: 10, w.

**What is the shortest distance to node w and what node is its predecessor?**

The answer is: 6, u.

### Dijkstra's link state algorithm - advanced

Consider the incomplete 6-node network shown below, with the given link costs



Consider the completed table below, which calculates the shortest distance to all node from X:

Node	Shortest distance from X	Previous Node
X	0	n/a
Y	3	X
W	4	X
Z	4	Y
V	7	X
U	8	X

For link X, what is the cost associated with this link? The answer is: n/a.

For link Y, what is the cost associated with this link? The answer is: 7.

### Link Layer

#### Link-layer services

The following services may be implemented in a link-layer protocol?

- Flow control between directly connected nodes.
- Multiplexing down from / mutiplexing up to a network-layer protocol.
- Reliable data transfer between directly connected nodes.
- Coordinated access to a shared physical medium.
- Bit-level error detection and correction.

### Two dimensional parity

The following statements are true about a two-dimensional parity check (*2D-parity*) computed over a payload

- 2D-parity can detect any case of two bit flips in the payload.
- 2D-parity can detect any case of a single bit flip in the payload.
- 2D-parity can detect and correct any case of a single bit flip in the payload.

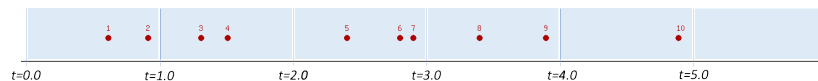
### Pure Aloha and CSMA

The following statements are true about Pure ALOHA, and CSMA (*both with and without collision detection*)

- Pure Aloha and CSMA can achieve 100 % utilization, in the case that there is only one node that always has frames to send.
- There can be simultaneous transmissions resulting in collisions.

### Multiple Access Protocols: Collisions

Consider the figure below, which shows the arrival of 10 messages for transmission a different multiple access wireless nodes at times  $t = \langle 0.6, 0.9, 1.3, 1.5, 2.4, 2.8, 2.9, 3.4, 3.9, 4.9 \rangle$  and each transmission requires exactly one time unit



- ALOHA
  - Suppose all nodes are implementing the Aloha protocol. For each message, indicate the time at which each transmission begins The answer is: 0.6,0.9,1.3,1.5,2.4,2.8,2.9,3.4,3.9,4.9.
  - Which messages transmit successfully? The answer is: 10.
- SLOTTED-ALOHA
  - Suppose all nodes are implementing the Slotted Aloha protocol. For each message, indicate the time at which each transmission begins The answer is: 1,1,2,2,3,3,3,4,4,5.
  - Which messages transmit successfully? The answer is: 10.

■ CSMA

- Suppose all nodes are implementing Carrier Sense Multiple Access (*CSMA*), but without collision detection. Suppose that the time from when a message transmission begins until it is beginning to be received at other nodes is 0.4 time units. (*Thus if a node begins transmitting a message at  $t=2.0$  and transmits that message until  $t=3.0$ , then any node performing carrier sensing in the interval  $[2.4, 3.4]$  will sense the channel busy.*) For each message, indicate the time at which each message transmission begins, or indicate that message transmission does not begin due to a channel that is sensed busy when that message arrives. The answer is: 0.6,0.9,s,s,2.4,s,s,s,3.9,s.
- Which messages transmitted successfully? The answer is: 5, 9.

■ CSMA-CD

- Suppose all nodes are implementing Carrier Sense Multiple Access (*CSMA*), with collision detection (*CSMA/CD*). Suppose that the time from when a message transmission begins until it is beginning to be received at other nodes is 0.4 time units, and assume that a node can stop transmission instantaneously when a message collision is detected. (*Thus if a node begins transmitting a message at  $t=2.0$  and transmits that message until  $t=3.0$ , then any node performing carrier sensing in the interval  $[2.4, 3.4]$  will sense the channel busy.*) For each message, indicate the time at which each message transmission begins, or indicate that message transmission does not begin due to a channel that is sensed busy when that message arrives. The answer is: 0.6,0.9,s,s,2.4,s,s,s,3.9,s.
- Which messages transmit successfully? The answer is: 5, 9.

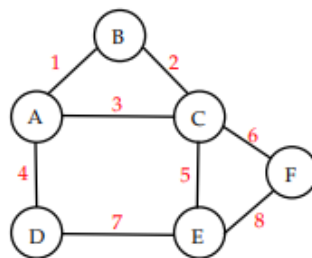
## Encaminamiento por vector-distancia, direccionamiento IP y detección de errores con CRC

1. Aplique el algoritmo de encaminamiento de vector-distancia a la siguiente topología de red.

- a) Indique el estado de las tablas de ruteo para las etapas de cold-start y luego para el envío de los primeros dos mensajes.

From A to	Link	Cost	From B to	Link	Cost	From C to	Link	Cost
A	local	0	B	local	0	C	local	0
From D to	Link	Cost	From E to	Link	Cost	From F to	Link	Cost
D	local	0	E	local	0	F	local	0

- b) Luego, indique el estado de las tablas de ruteo para el estado estacionario.
- c) Una vez alcanzado el estado estacionario, el enlace 6 se rompe. Describa la manera en cómo procede el protocolo hasta retomar un nuevo estado estacionario.
- d) ¿Qué fenómeno podría causar un bucle de ruteo?
- e) Finalmente, ¿cuál protocolo en la práctica implementa el algoritmo de vector-distancia? ¿cuál es la frecuencia de los mensajes de refresco y cuál es la finalidad de los mismos?



2. Suponga que le han asignado el bloque de red 132.46.0.0/16 y que necesita configurar ocho subredes.

- a) ¿Cuántos dígitos binarios se requieren para definir ocho subredes?
- b) Especifique el prefijo de red extendido que permite la creación de las 8 subredes.
- c) Expresar las direcciones de subred en formato binario y decimal.
- d) Enliste el rango de direcciones IP que pueden asignarse a la subred número 4.
- e) ¿Cuál es la dirección de difusión (*broadcast*) de la subred número 4?



3. Suponga que se le ha asignado el bloque de direcciones de red 200.30.1.0/24.
  - a) Defina un prefijo de red extendido que permita crear 20 estaciones en cada subred.
  - b) ¿Cuál es el número máximo de estaciones que pueden asignarse a cada subred?
  - c) ¿Cuál es el número máximo de subredes que pueden definirse?
  - d) Especifique las subredes de 200.30.1.0/24 en formatos binario y decimal.
  - e) Enliste las direcciones de estación que pueden asignarse a la subred 6.
  - f) ¿Cuál es la dirección de difusión para la subred 2?
  
4. Se le ha asignado a una organización el número de red 140.20.0.0/16 y ésta planea desarrollar VLSM. En el primer nivel de jerarquía, se necesitan configurar ocho subredes. La subred 1 necesita configurar 32 sub-redes y la subred 6 necesita configurar 16 sub-redes. Finalmente, la sub-red 6-14 necesita configurar 8  $sub^2 - subredes$ .
  - a) Dibuje el árbol que ilustre la jerarquía necesaria para implementar VLSM.
  - b) Especifique las ocho subredes 140.20.0.0/16.
  - c) Enliste las direcciones de estación que pueden asignarse a la subred 3.
  - d) Indique la dirección de difusión de la subred 3.
  - e) Indique las 16 sub-redes de la subred 6.
  - f) Enliste las direcciones de estación que pueden asignarse a la sub-subred 6-3.
  - g) Indentifique la dirección de broadcast para la sub-subred 6-3.
  - h) Especifique las ocho  $sub^2 - subredes$  de la sub-subred 6-14.
  - i) Enliste las direcciones de estación que pueden asignarse en la  $sub^2 - subred$  6-14-2.
  - j) Indentifique la dirección de broadcast de la  $sub^2 - subred$  6-14-2.
  
5. En el nivel de enlace de datos se utiliza frecuentemente el mecanismo de verificación de redundancia cíclica (*CRC: Cyclic Redundance Check*) para que una interfaz receptora concluya sobre si la trama recibida,  $T'$  contiene o no errores. Suponga que el mensaje a transmitir es  $M = 1101011011$  y que el generador es  $G = 10011$ .
  - a) Encuentre la trama,  $T$  que envía el transmisor.
  - b) Realice la operación que ejecuta la interfaz receptora si el patrón de error inducido en el canal  $e = 00000000000000$ , ¿cuál es la conclusión del receptor?
  - c) Realice lo mismo que en (b), pero ahora con un error inducido en el canal físico  $e = 00100000010011$ , ¿cuál es la conclusión del receptor?

- d)* ¿Existe la posibilidad de que habiendo errores en  $T'$ , la trama recibida, el receptor sea incapaz de detectarlos? Explique.
- e)* Finalmente, realice (a)-(c) operando polinomialmente.