Fall 2013: Question 1

Why is processor affinity important in a NUMA (non-uniform memory access) multiprocessor system?

An operating system will try to allocate memory from the region that is local to the running process. If a process gets rescheduled to another processor, memory operations will be slower. Moreover, any cached contents will be lost.

Fall 2014 - Question 2

Explain the benefit of multi-canonical marshaling.

Multiple data encoding formats are allowed. The hope is that at least one will fit the architecture of one or both machines and avoid the overhead of data conversion.

Fall 2014 - Question 3

Why is using only reference-count based distributed garbage collection a problem?

It is not fault tolerant. If a client dies or gets disconnected from the network, the server will not know to clean up the object. This is why lease-based collection wins.

Not: race condition when transferring an object reference—we know how to deal with that.

Fall 2014 - Question 1

Is the statement below true or false? Explain your answer.

You should use a reliable transport protocol such as TCP for clock synchronization.

No.

Reliable, in-order transport comes at the price of incurring extra delays due to buffering and retransmission. A lost packet in one direction will skew the latency of one of the messages dramatically.

An unreliable transport does not mean the message is usually lost! It usually is NOT! If it is, you just try the synchronization again.

No.
Assign vector timestamps to the six remaining events

\[ P_1 = (0, 0, 0) \]
\[ P_2 = (2, 0, 2) \]
\[ P_3 = (3, 0, 3) \]

Which events are concurrent with event e?

\( g, h, c, i \)

Example:
- \( i \) is concurrent with e because (2, 0, 3) is not greater than or less than (2, 2, 0).
- \( i \) is not concurrent because (2, 3, 3) = (2, 2, 0).
That means (222), (322), (360).

The National Institute of Standards and Technology (NIST), an agency of the U.S. Department of Commerce, is responsible for keeping track of the official time in the U.S. Why not just sync your time from a stratum 1 server directly, such as time.nist.gov, and get the time from the most accurate source instead of syncing with a higher stratum server?

You might experience high latency and/or high jitter when communicating with a stratum 1 server but achieve a lower total error when synchronizing with a higher-stratum server because you can communicate with it more reliably.

You are synchronizing with a server using Cristian's algorithm. You send a message at 1:10.100 (according to your clock). The server receives the message at 1:15.000 (according to its clock), processes the request, and sends a response containing 1:15.005, which you receive at 1:10.150. To what value do you set your clock?

The time at which the server receives the message (1:15.000) is irrelevant.

Note that 1:15.005 is not the time the response was sent; it is the server clock time. We can just plug it into Cristian's algorithm and set the time to the server time plus 1/2 of the round-trip time.

\[
\text{New time} = T_s + \frac{1}{2}(1:15:005 - 1:10:100)
\]
\[
= 1:15:005 + \frac{1}{2}(0.050)
\]
\[
= 1:15:005 + 0.025 = 1:15:030
\]

Compare reference count based distributed garbage collection with lease-based garbage collection.

What advantages of the latter made it become the dominant technique for distributed garbage collection?

Reference counting requires clients to send increment and decrement operations to a server so it can maintain a reference count and free the object when the count goes to zero.

Because of possible software errors, software crashes, and client crashes, the server may end up with inaccurate counts and never free an object.

Lease-based garbage collection requires a client to periodically renew its leases on any objects that it uses. If the client dies, then it will fail to renew its leases and the server will free the object. It's more fault tolerant. With reference counting, you still had to take care of the case of a client abnormally terminating (or improper counting).
You have a set of servers that manage shopping cart data. Clients may send updated carts to any server and servers propagate these updates to other members of the group.

Unfortunately, the network sometimes gets partitioned temporarily so only a subset of servers get updates.

You need to reconcile the shopping cart for a user.

The vector timestamp is a set of values associated with processors $P_0, P_1, \ldots, P_n$. Items in the cart are a subset of $\{A, B, \ldots, Z\}$.

Causal updates should overwrite previous contents. Concurrent updates merge with previous contents. What is the final set of items in the user's shopping cart when reconciling the following timestamps?

- Clock $= \{ P_0 : 2 \}$ Value $= \{A, C\}$
- Clock $= \{ P_0 : 1, P_1 : 2 \}$ Value $= \{A, B, Q\}$
- Clock $= \{ P_0 : 1, P_1 : 2, P_2 : 1 \}$ Value $= \{A, E, H\}$
- Clock $= \{ P_0 : 1, P_1 : 2, P_2 : 2 \}$ Value $= \{A, K\}$

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- Clock $= \{ P_0 : 1, P_1 : 2, P_2 : 2 \}$ Value $= \{A, K\}$

We see with two concurrent events:

- Shopping cart $= \{A, C\} \cup \{A, K\} = \{A, C, K\}$

Note: if a vector clock value is missing a specific process, that means that it has not been seen and has a value of 0.

Metcalfe's law isn't really a law but basically states that:

(a) A network gets more useful with more people on it.
(b) Processors get twice as powerful every two years.
(c) Transistors get twice as small every two years.
(d) Network bandwidth doubles every two years.

An SMP (symmetric multiprocessor) system is a multiprocessor system where:

(a) The processors engage in the same computation for fault tolerance.
(b) All processors have equal access to memory.
(c) An even number (2, 4, \ldots) of processors allows workloads to be partitioned.
(d) Two or more computers are connected to a shared network.

A snoopy cache reduces traffic on the system bus:

(a) For read operations.
(b) For write operations.
(c) For both read and write operations.
(d) None of the above; it has no effect on bus traffic.
Fall 2014 - Question 6

Compared to home snooping, source snooping:
(a) Uses less bandwidth and has a lower latency.
(b) Uses more bandwidth and has a lower latency.
(c) Uses more bandwidth but has a higher latency.
(d) Uses less bandwidth but has a higher latency.

• Source snooping requires contacting all processors
• Latency is lower: the processor with the cached data is contacted directly rather than via the home agent

Fall 2012: Question 10

A single system image refers to:
(a) multiple computers that look and behave like one system.
(b) a single computer connected to a network.
(c) a cloned set of computers where multiple machines run the same software.
(d) an instance of a single computer connected to a network

Fall 2012: Question 11

A snoopy cache is designed for this architecture:
(a) Bus-based.
(b) Crossbar switch.
(c) NUMA.
(d) All of the above

Fall 2014 - Question 7

The most efficient use of a network is:
(a) Time division multiplexing (TDM).
(b) Frequency division multiplexing (FDM).
(c) A token passing protocol.
(d) Random access.

• TDM & FDM: bandwidth reserved even if not used
• Token passing: need to wait for a token

Fall 2014 - Question 8

Which of the following was NOT a design goal of the Internet?
(a) Provide reliable communication.
(b) Support the interconnection of different physical networks.
(c) Use routers to store and forward packets.
(d) Have decentralized control of the network.

• IP was designed on top of unreliable packet switched networks
• Any reliability would have to be provided via software at the endpoints

Fall 2012: Question 12

TCP/IP occupies which layer of the OSI protocol stack?
(a) Data Link (2)
(b) Network (3)
(c) Transport (4)
(d) Presentation (6)

TCP and UDP both operate at the transport layer. They allow application-to-application communication and use port numbers to identify communication endpoints (sockets).
Fall 2012: Question 13

UDP/IP occupies which layer of the OSI protocol stack?

(a) Data Link (2)
(b) Network (3)
(c) Transport (4)
(d) Presentation (6)

TCP and UDP both operate at the transport layer. They allow application-to-application communication and use port numbers to identify communication endpoints (sockets).

Fall 2012: Question 19

There are three systems on your network: A, B, C. Prior to synchronization, A’s clock reads 2:30, B’s clock reads 2:36, and C’s clock reads 2:42. B is the master. After synchronization via the Berkeley algorithm, what is the time on A’s clock (ignore synchronization or network latencies)?

(a) 2:30
(b) 2:33
(c) 2:36
(d) 2:39

October 2, 2015
Paul Krzyzanowski
CS 417

Fall 2014 - Question 16

A client requests a timestamp from the server at 3:52:20.200. The server response is received at 3:52:20.600. The response contains a server timestamp of 3:52:20.400. Using Cristian’s algorithm, the client should set its time to:

(a) 3:52:20.200
(b) 3:52:20.400
(c) 3:52:20.600
(d) 3:52:20.800

Cristian’s algorithm assumes the timestamp was generated ½ of the delay ago = 200 ms ago
Set time to [received timestamp] + 200 ms = 3:52:20.400 + 0.200 = 3:52:20.600

Fall 2014 - Question 17

A client synchronizes from a server. It sends a request at 3:52:20.200. The time between a request and a response is 52 ms. The best-case time is 40 ms. What is the error of the synchronization?

(a) ±16 ms
(b) ±12 ms
(c) ±20 ms
(d) ±106 ms

The error is the unaccounted time in our sync.
Best case time = 40 ms
Measured time = 52 ms
Unaccounted time = 52 – 40 = 12 ms.
Since the timestamp is set to the middle, the error is ± (12/2) = ± 6 ms

Fall 2014 - Question 18

If event A has a Lamport timestamp of 2 and event B has a Lamport timestamp of 3, you are certain that:

(a) A happened before B if the events took place on the same process.
(b) A happened before B regardless of the processes on which A and B took place.
(c) A and B are concurrent.
(d) B happened before A, regardless of the processes on which A and B took place.

Fall 2012: Question 20

Based on their vector timestamps, which event causally precedes (4, 2, 8, 5)?

(a) (3, 1, 7, 7)  (b) (5, 1, 6, 2)  (c) (4, 2, 8, 4)  (d) (4, 3, 8, 5)

No: element 1: 3 < 4  but element 4: 7 > 5
No: element 1: 5 > 4  but element 4: 2 < 5
No: each element of (d) ≥ each element of (4, 2, 8, 5).
This vector causally follows (4, 2, 8, 5).

We’re looking for a vector that is neither ≥ nor ≤ (4, 2, 8, 5) when doing an element-by-element comparison.
Fall 2012: Question 21

The implementation of which message ordering technique is not a feasible one to implement?

(a) Global time ordering
(b) Total ordering
(c) Sync ordering
(d) Unordered

Global time ordering requires globally exactly synchronized time stamps and the assumption that every single message will be generated at a different point in time. This is not feasible or realistic.

Fall 2014 - Question 20

Which of these multicasts can be implemented with a group-wide sequence number server?

(a) Global time ordered multicasts
(b) Total ordered multicasts
(c) Partial ordered multicasts
(d) Unordered multicasts

Fall 2012: Question 22

The following events took place on three systems at the stated physical (time of day) times:

System 1: a (3:00), b (3:01)
System 2: c (2:55), d (3:04)
System 3: e (3:03)

Event b is the sending of a message from system 1 to 2. Event d is the receipt of that message. Using Lamport’s happened-before relation, which events happened before event d?

(a) a
(b) a, b
(c) a, b, c
(d) a, b, c, e

Event d is the receipt of a message from system 1 to 2. Event b is the sending of the message from system 1 to 2.

Fall 2014 - Question 26

The Chang & Roberts ring election algorithm optimizes the ring election algorithm by:

(a) Contacting only higher-numbered processes.
(b) Multicasting the election request instead of passing messages in a ring.
(c) Choosing a leader as messages are sent instead of sending a growing list of candidates.
(d) Having a node always discard an election message that came from a process with a smaller ID.

Chang & Roberts optimizes in two ways:

1. Keep at most one process ID in the election message. No need to put process IDs that have no chance of being the leader.
2. Try to avoid concurrent elections. If a process gets an election message with a smaller ID and the process already is participating in an election, discard the message.

Fall 2012: Question 23

IP multicast provides which level of reliability?

(a) Atomic
(b) Reliable
(c) Unreliable
(d) User-selectable

(a) Ensures the message gets to all the clients, even if the sender dies partway through.
(b) Tries and retries, if necessary, but eventually gives up on delivery.
(c) Makes no sense.

Fall 2014 - Question 22

A precedence vector in a message is used by a receiver to:

(a) Ensure that all messages are received in the same order by all group members.
(b) Create timestamps of when each message has been received.
(c) Identify whether all previous causally related messages have been received.
(d) Create a log of received messages in the order they were received.
Fall 2014 - Question 23

IGMP, the Internet Group Management Protocol, is used to:
(a) Build a global list of hosts that are subscribed to a given multicast group.
(b) Tell a router that a connected host is interested in receiving a multicast group.
(c) Enable system administrators to manage multicast subscriptions.
(d) Allow a multicast sender to discover and contact a multicast receiver.

Fall 2012 exam 2: Part II: 5-7

5. ONC (Sun) RPC provides the ability to:
(a) Use XML as a transport.
(b) Start up the server process on demand.
(c) Perform distributed garbage collection.
(d) Have multiple versions of a function at the server.

6. A multi-canonical marshaling format
(a) Provides greater efficiency because both sides usually won’t have to convert data.
(b) Is a more compact way of representing data over a network.
(c) Encodes data concurrently into both binary as well as text formats.
(d) Allows one message to be sent to multiple servers.

7. For RPC, a DCE cell directory server allows:
(a) A client to find out on what server an interface is available.
(b) A client to find the port number of a service on a specific machine.
(c) A server to send callbacks to clients.
(d) An object to be distributed among multiple servers.

Fall 2012 exam 2: Part II: 8-9

8. Java’s Serializable interface:
(a) Allows an object’s data to be converted to a sequence of bytes.
(b) Creates a remote reference for an object.
(c) Enforces concurrency control to ensure that concurrent accesses to an object are serialized.
(d) Creates client and server stubs for an object.

9. Compared with SOAP, REST:
(a) Is based on remote method calls.
(b) Identifies resources in the URL of an HTTP command.
(c) Uses XML for creating a message within the HTTP message.
(d) Is not tied to a single language.

Fall 2014 - Question 23

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