

National University of Singapore  
School of Computing  
CS5229: Advanced Computer Networks  
Semester I, 2021/2022

**Lecture 10 Training**  
**Introduction to Distributed Systems**

In Lecture 10 we talked about Quorum-based consistency, a simple but effective way to maintain consistency between replicas in a distributed system. To recap, a quorum system maintains  $n$  replicas and waits for  $w$  successful writes before considering a write operation to be complete and  $r$  successful reads before considering a read operation to be complete. The Quorum consistency model applies the following constraints on these variables:

$$w + r > n \quad (1)$$

This ensures that during every round of read and write, there is **at least one** replica that has seen both the read and write operations, and is therefore consistent. Note that Equation 1 does not put any constraint on the individual values for  $w$  and  $r$ , just that their sum should be more than  $n$ . Now consider a network with 15 nodes in the Quorum group, with the nodes having different network latencies (Figure 1)

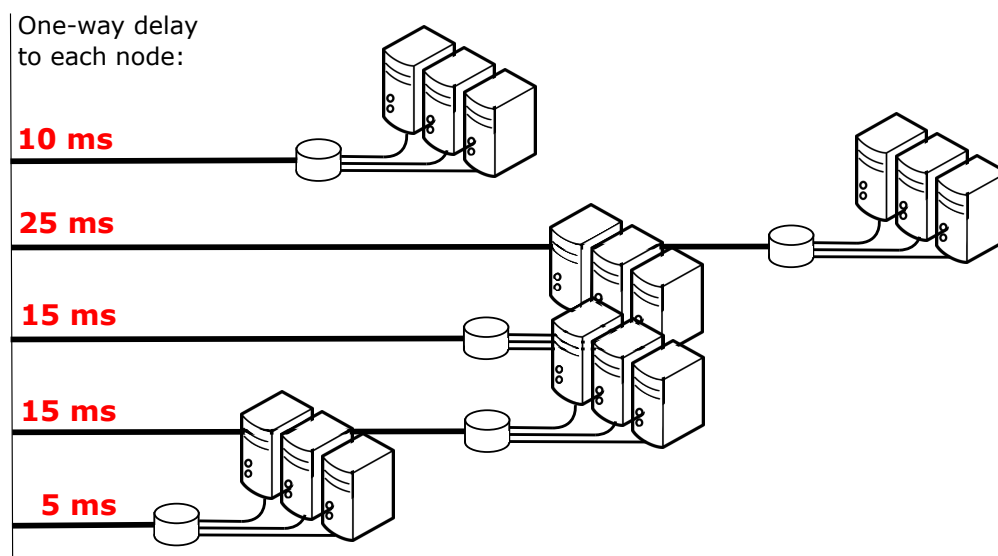


Figure 1: One-way delay to all the nodes in the Quorum group

Given this network (and assuming no failures), answer the following questions on Course-mology:

- Q1 What is the response time for **write requests** when  $w = 8$  and  $r = 8$ ?
- Q2 What is the response time for **read requests** when  $w = 8$  and  $r = 8$ ?
- Q3 Let's say all the requests in this distributed system are packaged as *read-write* requests, i.e a read request followed by a write request. You can assume that

the write operation is only started when the quorum system considers the read operation to be complete. What will be the response time for a *read-write* request when:

- (a)  $w = 7$  and  $r = 9$
- (b)  $w = 8$  and  $r = 8$
- (c)  $w = 4$  and  $r = 14$

- Q4 **[EXTRA]<sup>1</sup>** Is there a quorum allocation that can yield a better response time for *read-write* requests? If yes, what is the improved response time under this allocation?
- Q5 **[EXTRA]** Assume that this distributed system relies on the Quorum's pigeonhole principle-based consistency ONLY. Is the constraint described in Equation 1 sufficient to guarantee consistency? You can assume there are fixed quorum groups and no failures.

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<sup>1</sup>EXTRA questions carry no marks.