6.033 Spring 2018

Lecture #19

- **Distributed transactions**
  - **Availability**
  - **Replicated State Machines**

goal: build reliable systems from unreliable components

the abstraction that makes that easier is

transactions, which provide **atomicity** and **isolation**, while not hindering **performance**

atomicity ⟶ **shadow copies** (simple, poor performance) or **logs** (better performance, a bit more complex)

isolation ⟶ **two-phase locking**

we also want transaction-based systems to be **distributed** — to run across multiple machines

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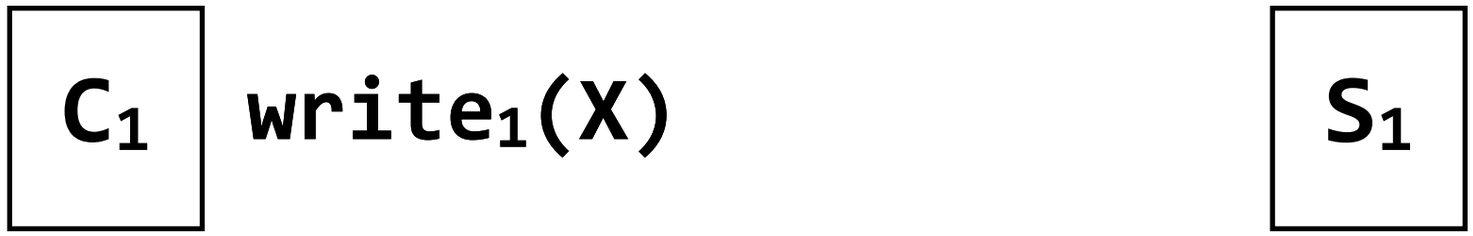
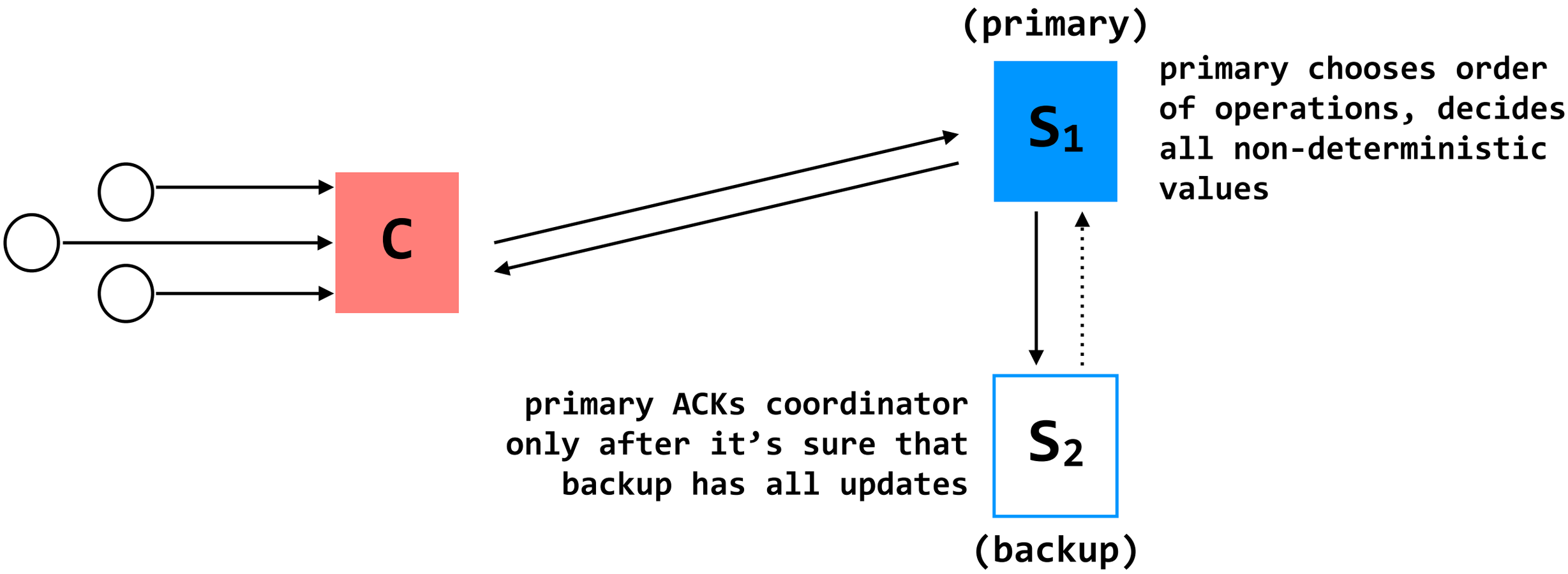
we also want transaction-based systems to be **distributed** — to run across multiple machines — and to remain **available** even through failures


C1
write1(X)
S1


C2
write2(X)
S2
(replica of S1)

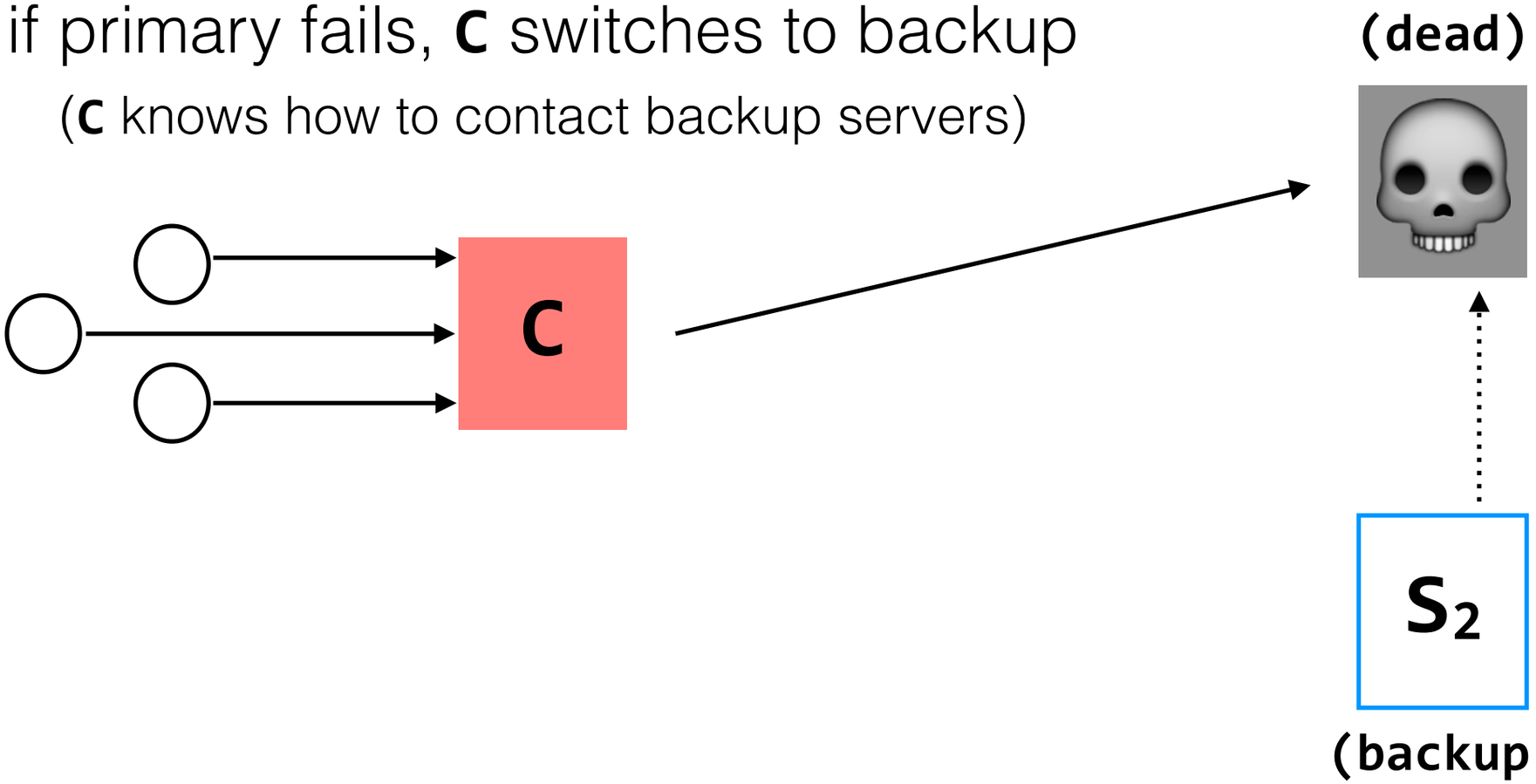
problem: replica servers can become inconsistent



attempt: coordinators communicate with primary servers, who communicate with backup servers

if primary fails, **C** switches to backup

(**C** knows how to contact backup servers)



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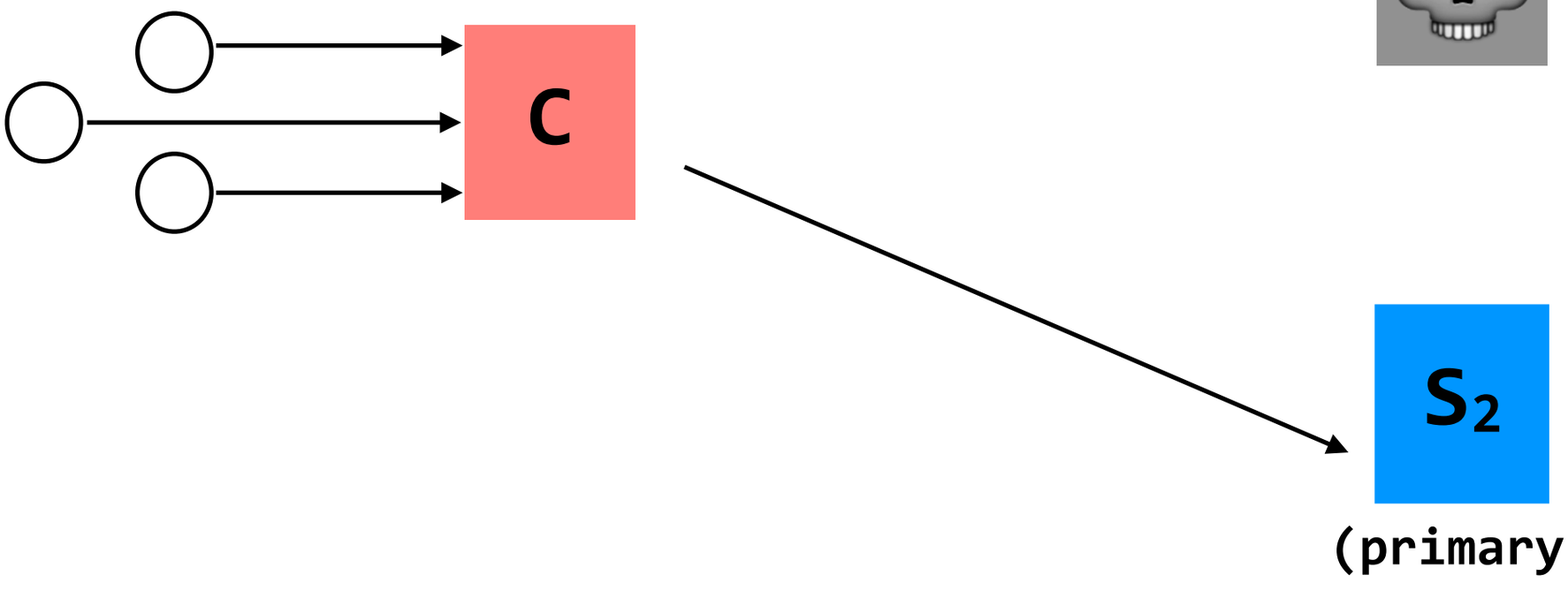
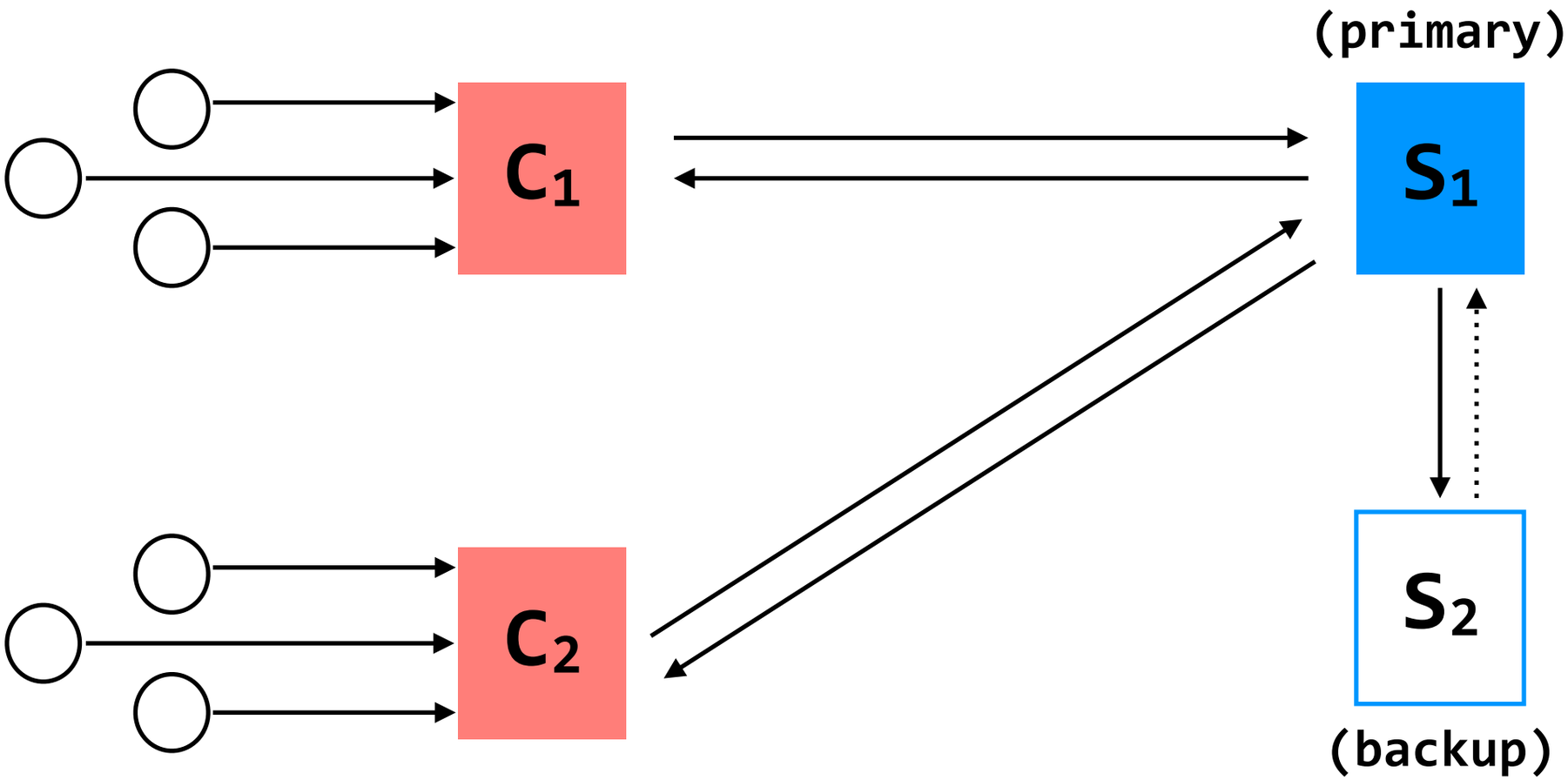


attempt: coordinators communicate with primary servers, who communicate with backup servers

multiple coordinators + the network = problems



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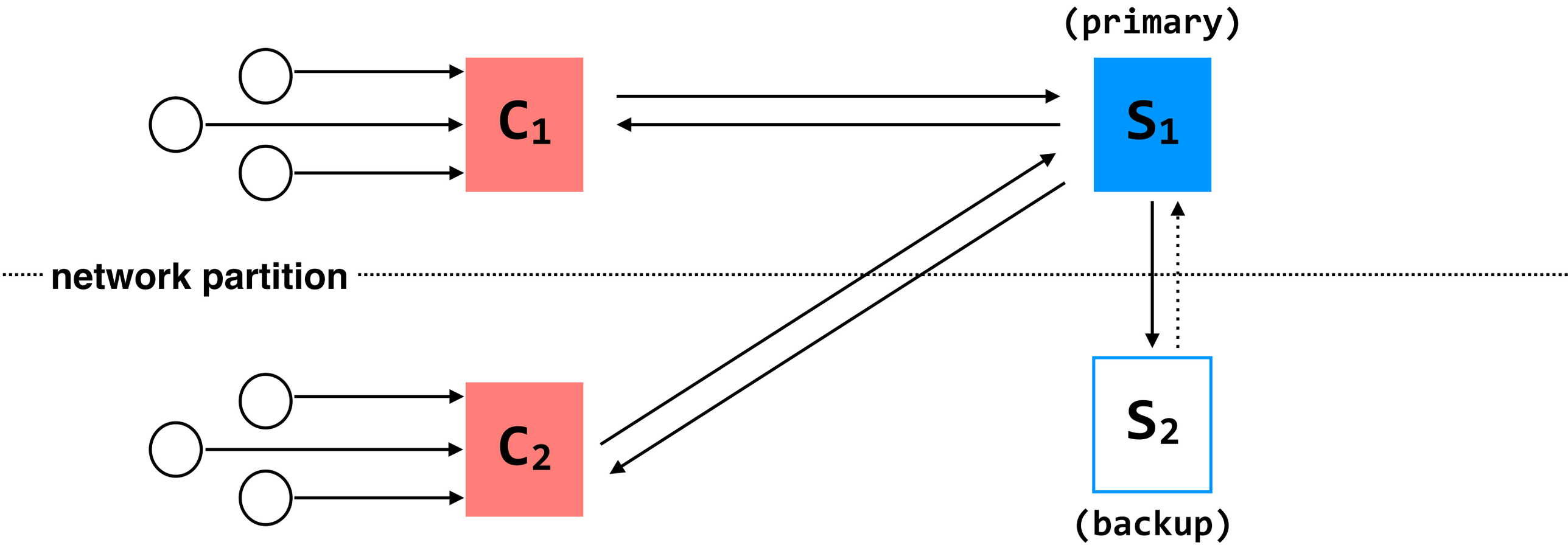

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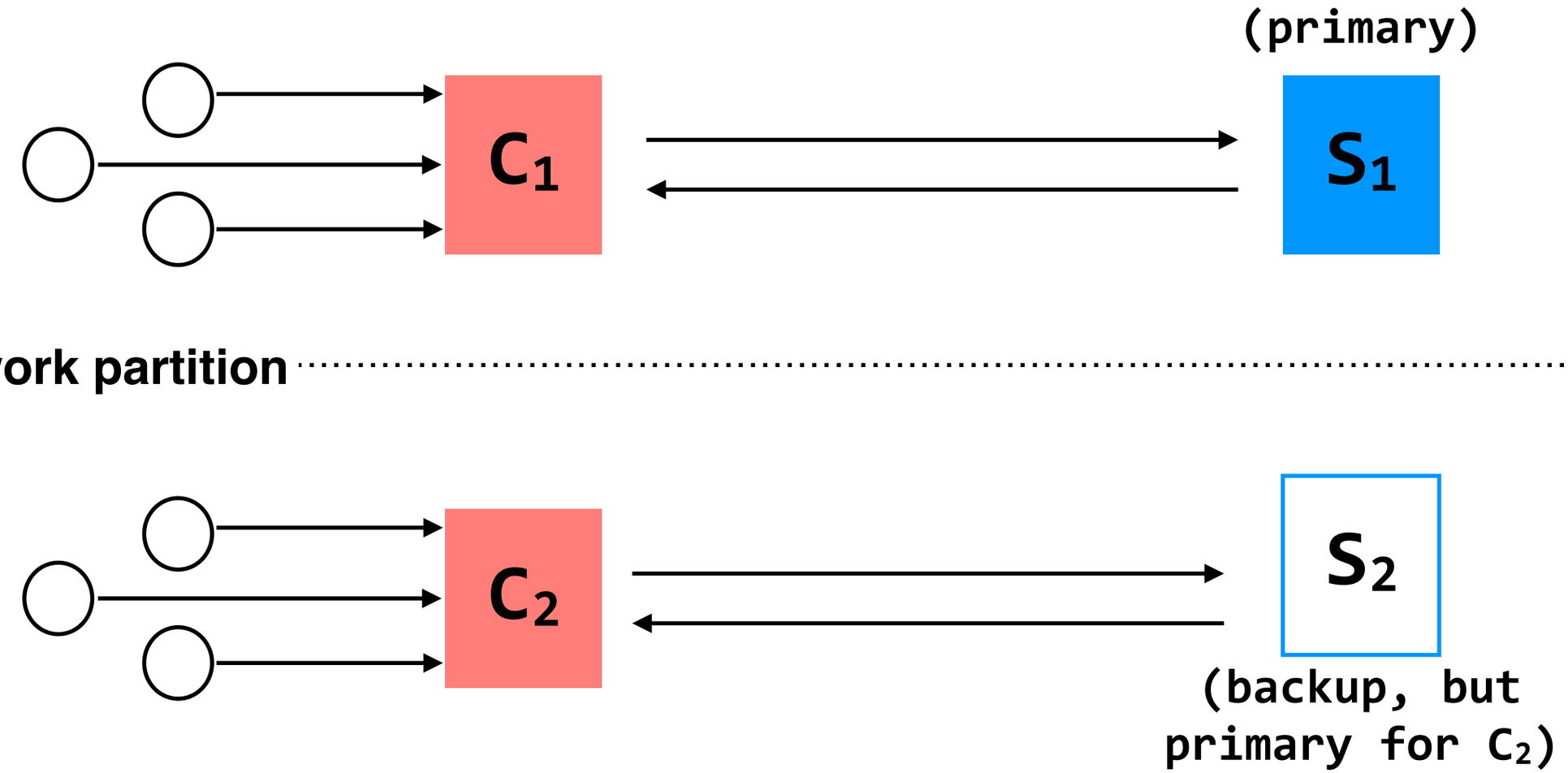
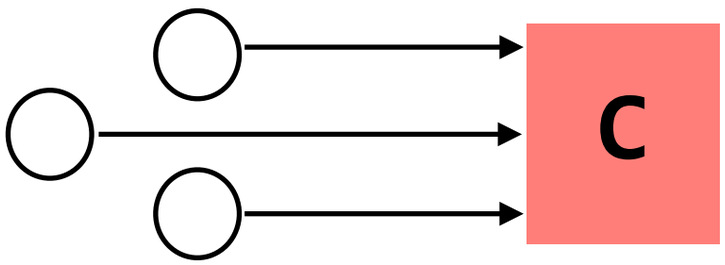
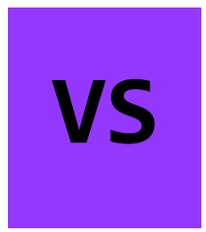


C_1 and C_2 are using different primaries;

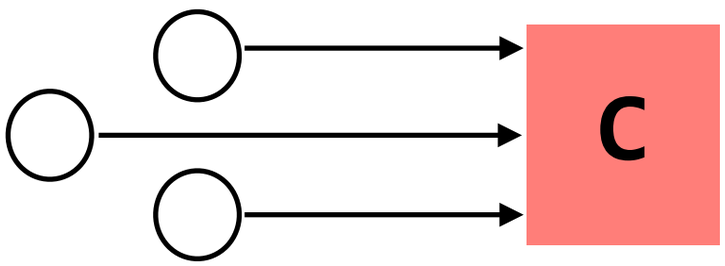
S_1 and S_2 are no longer consistent

attempt: coordinators communicate with primary servers, who communicate with backup servers





use a **view server**, which determines which replica is the primary



C

VS

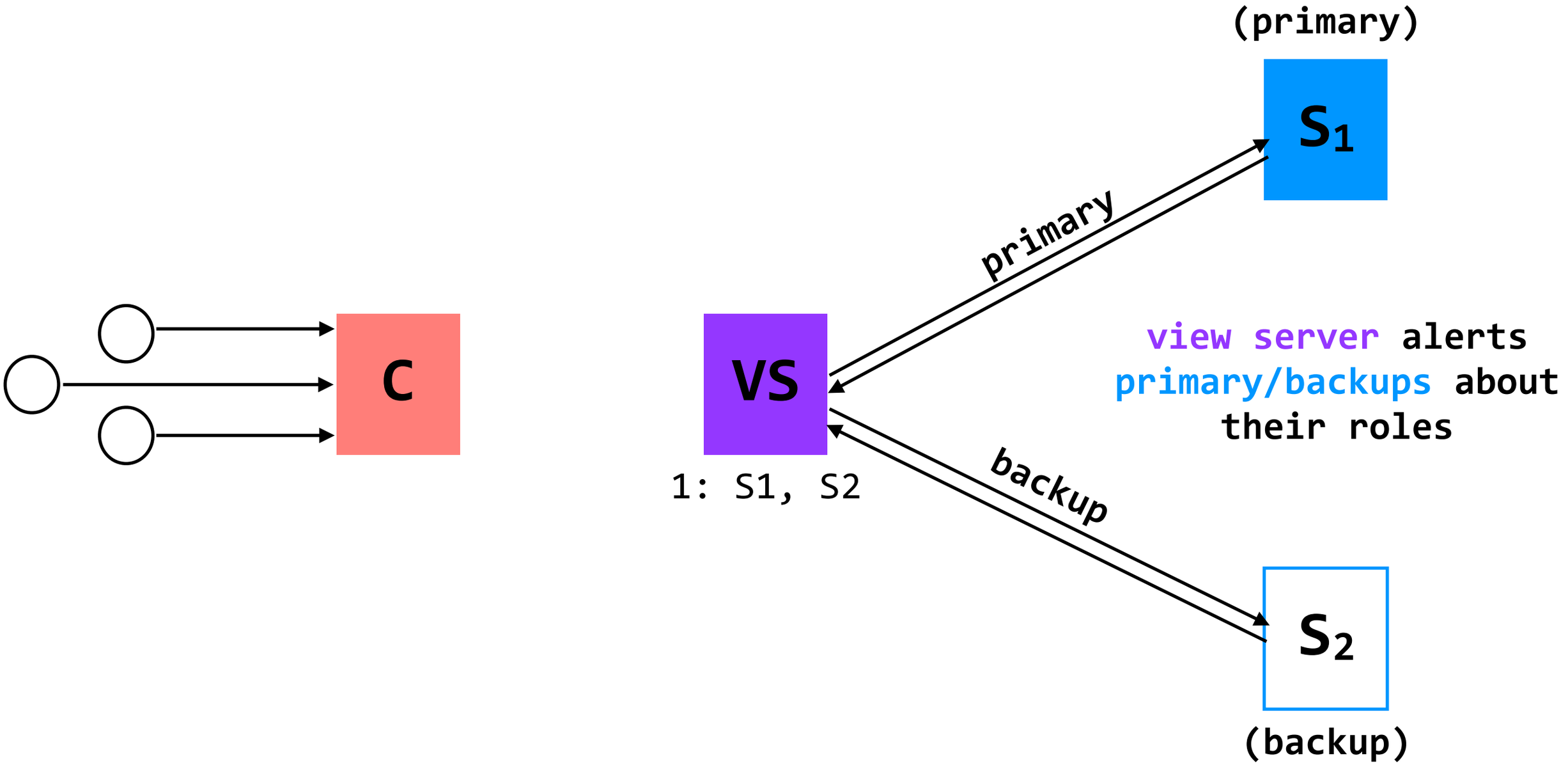
1: S1, S2

S_1

view server keeps a table that maintains a sequence of *views*

S_2

use a **view server**, which determines which replica is the primary



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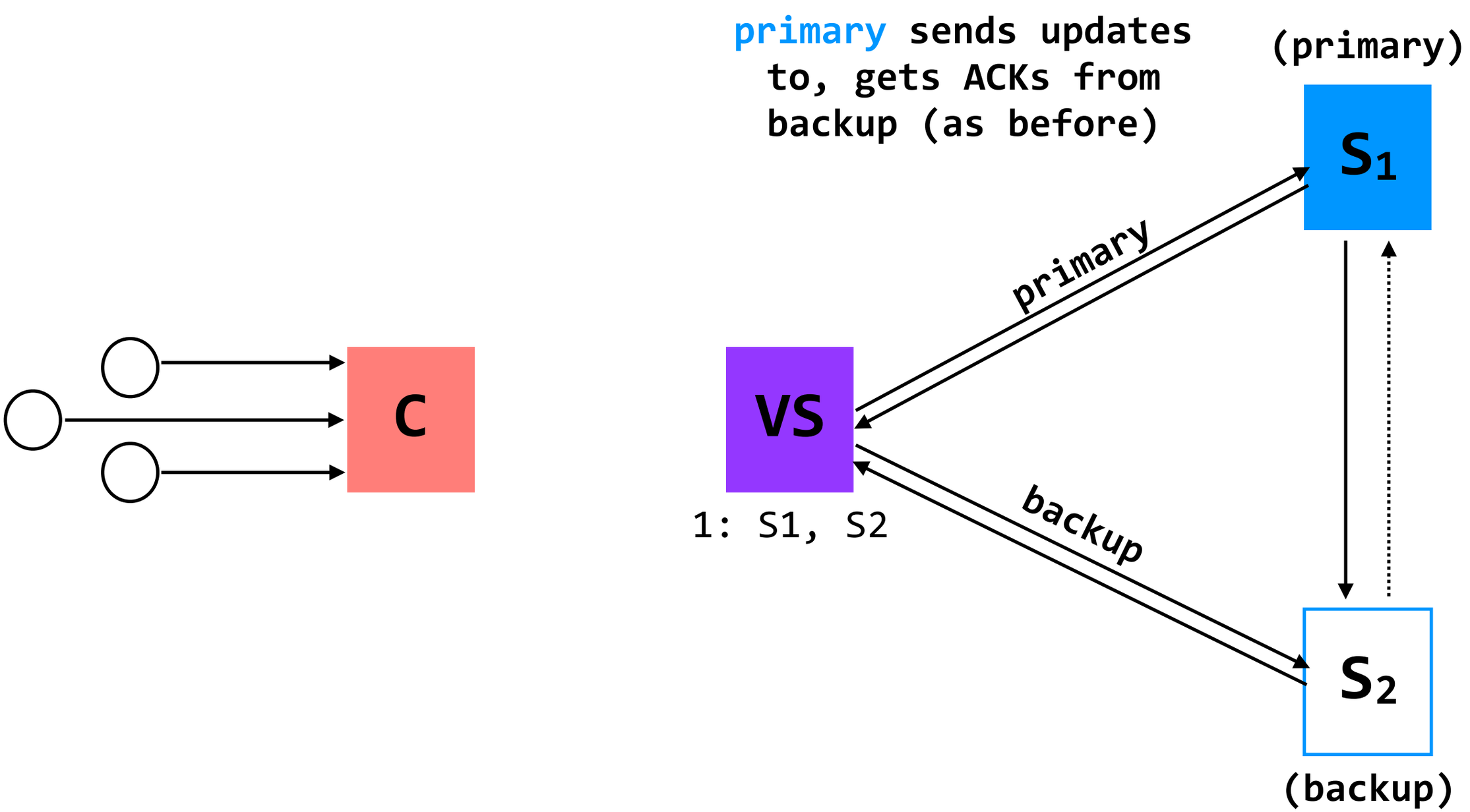

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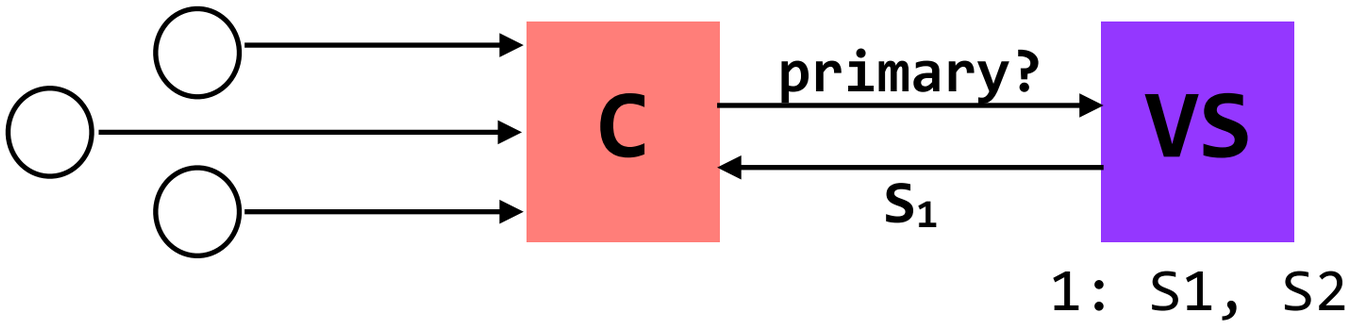
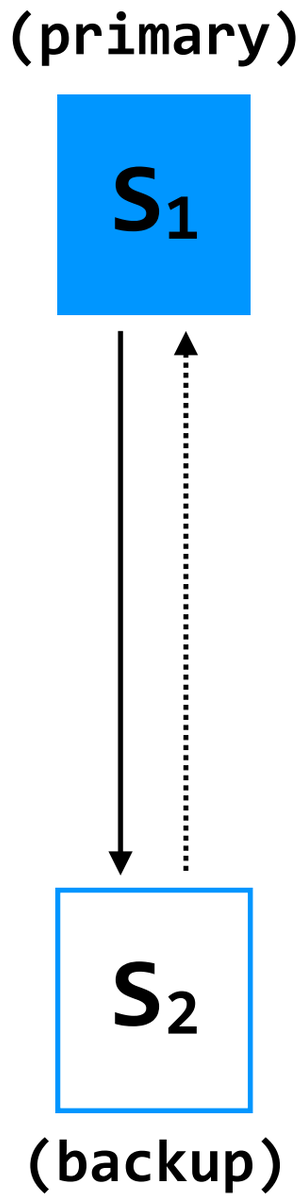


coordinators make requests to view server to find out who is primary



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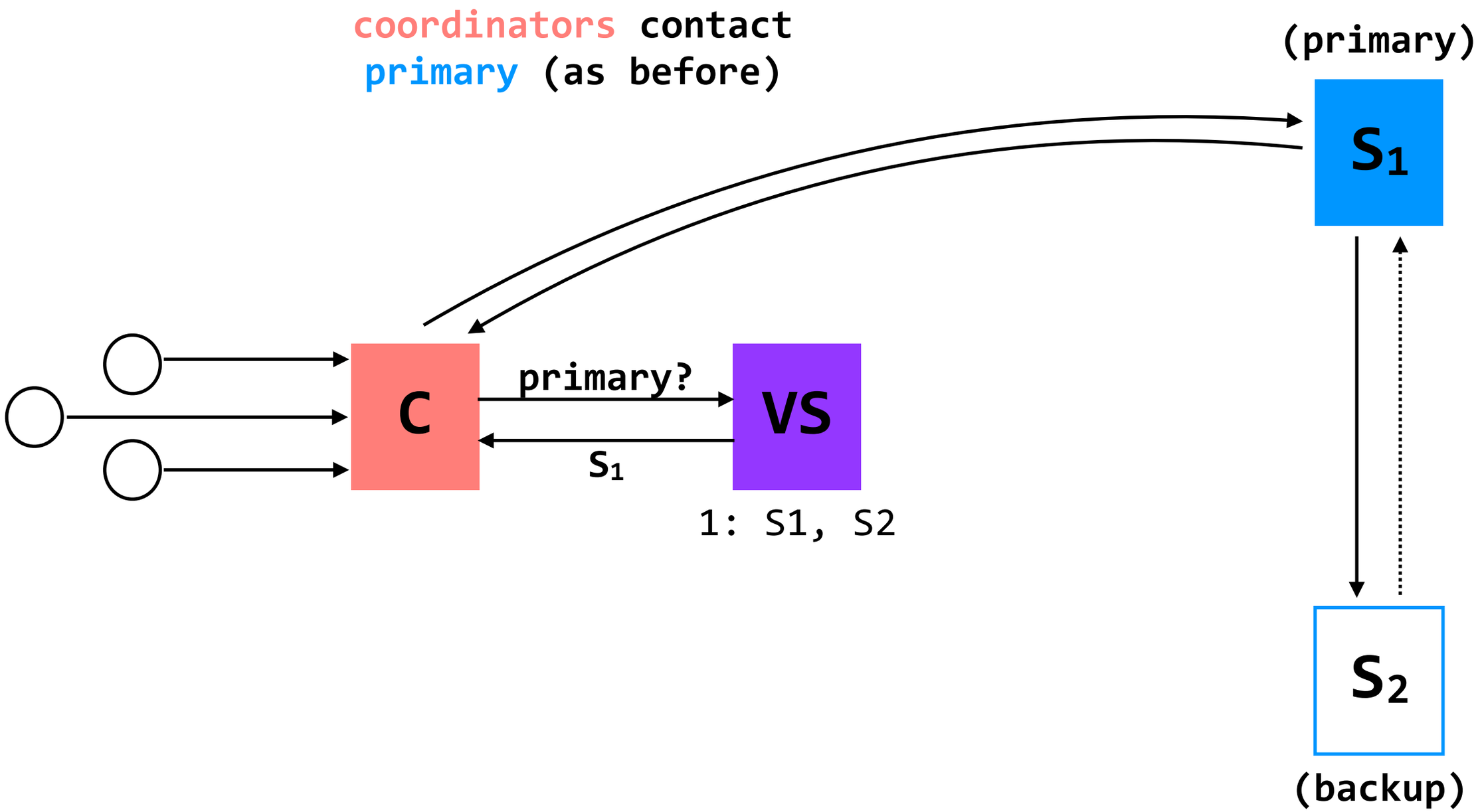

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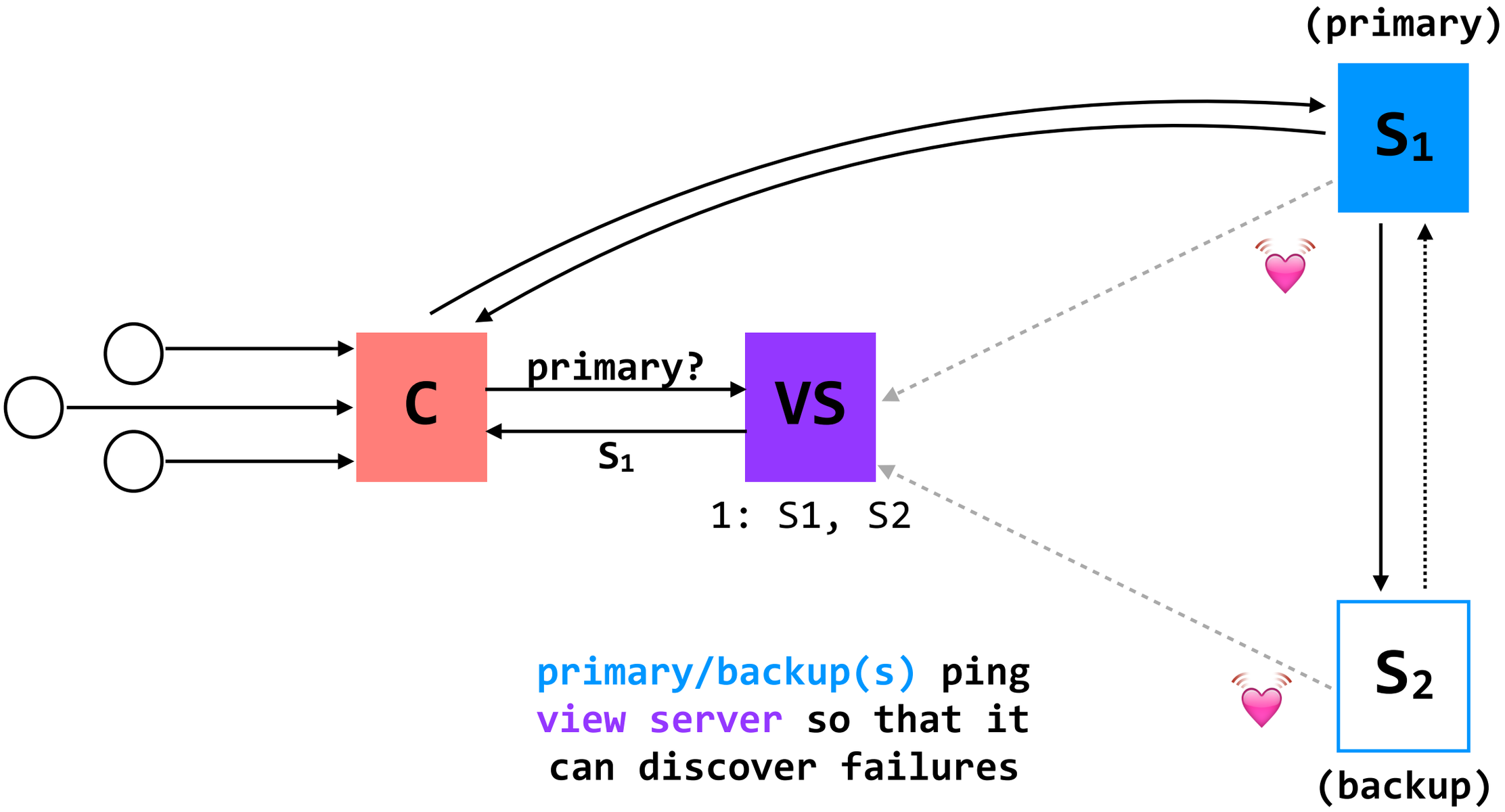
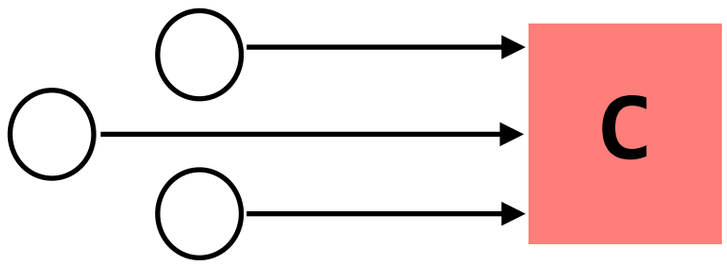
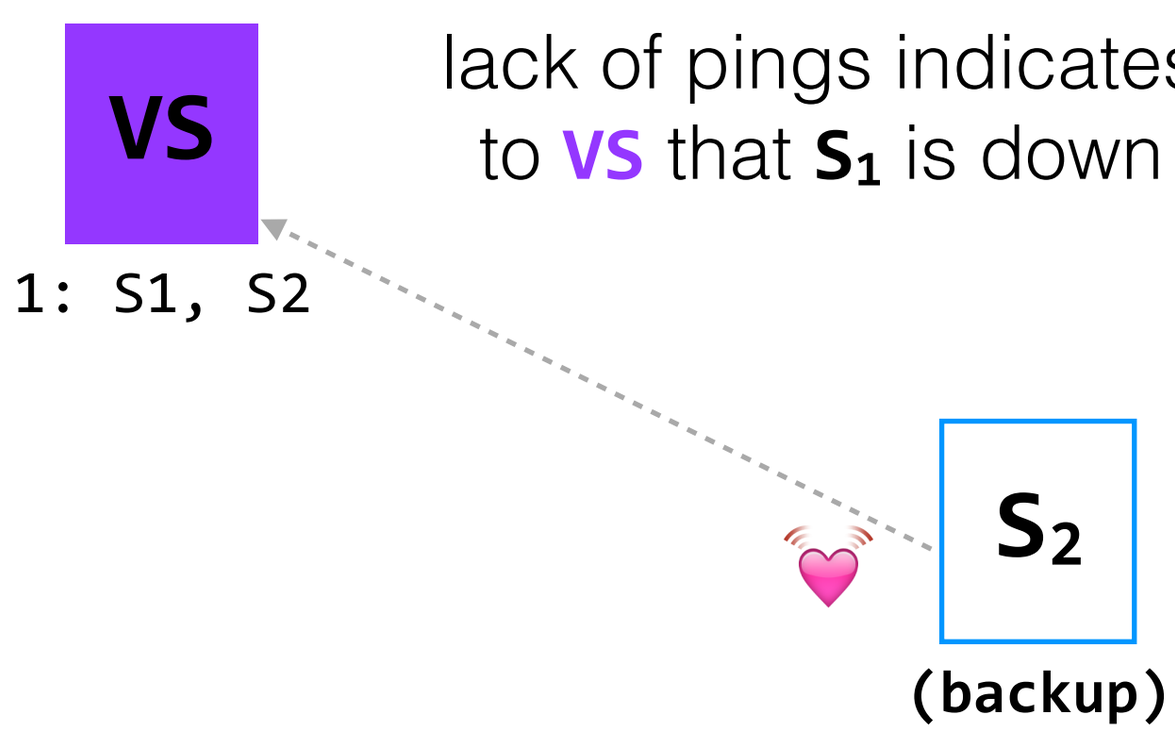


primary/backup(s) ping view server so that it can discover failures

use a **view server**, which determines which replica is the primary

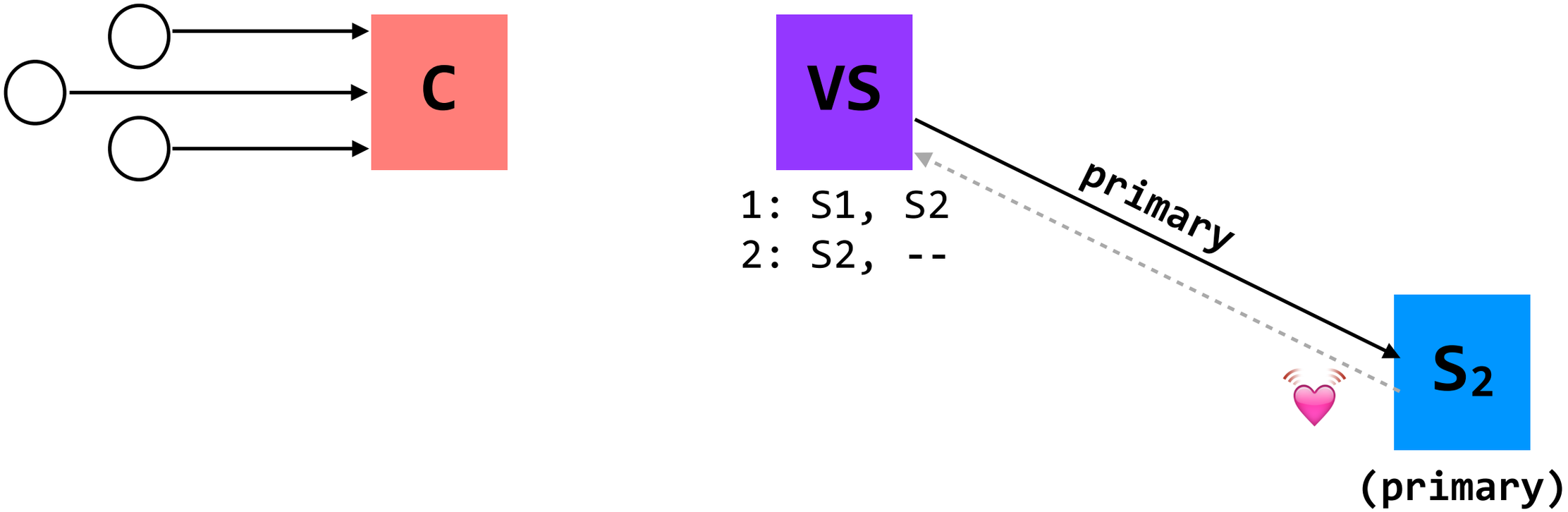
handling primary failure





lack of pings indicates to **VS** that S_1 is down

handling primary failure



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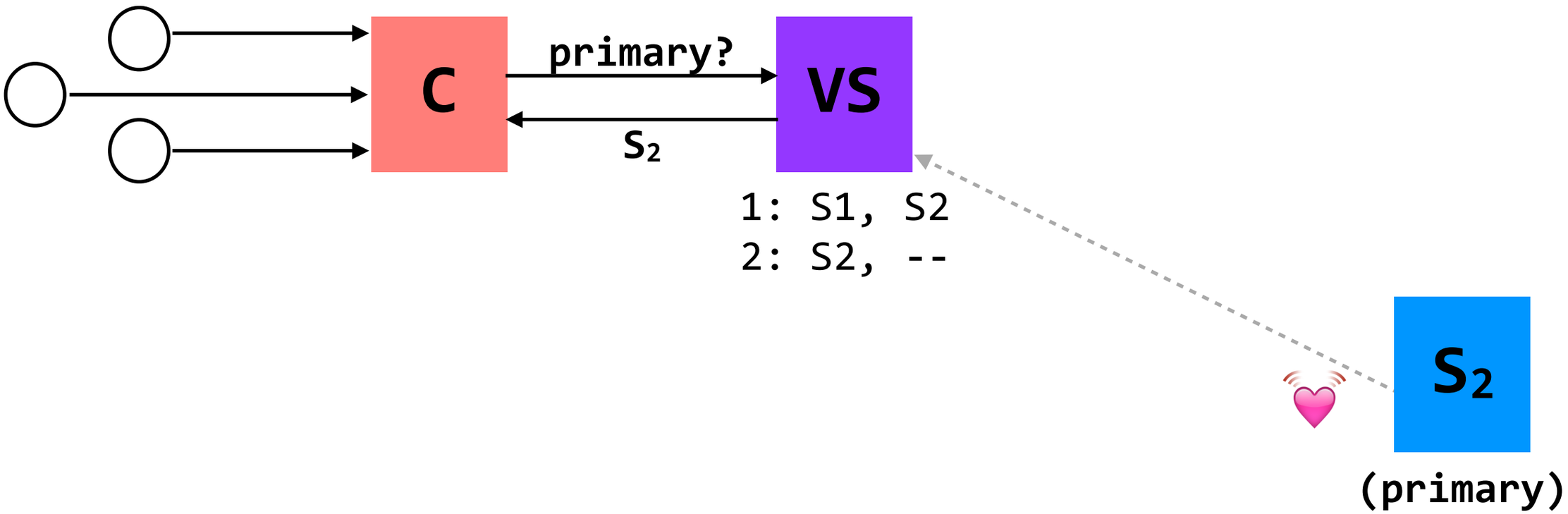

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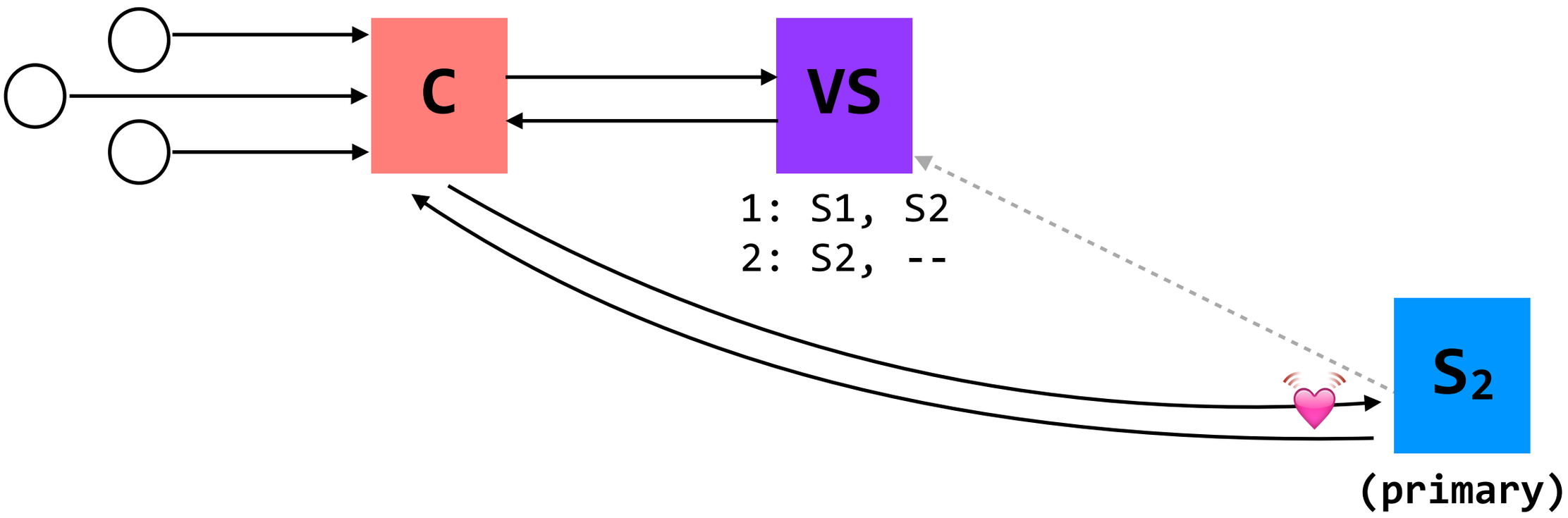
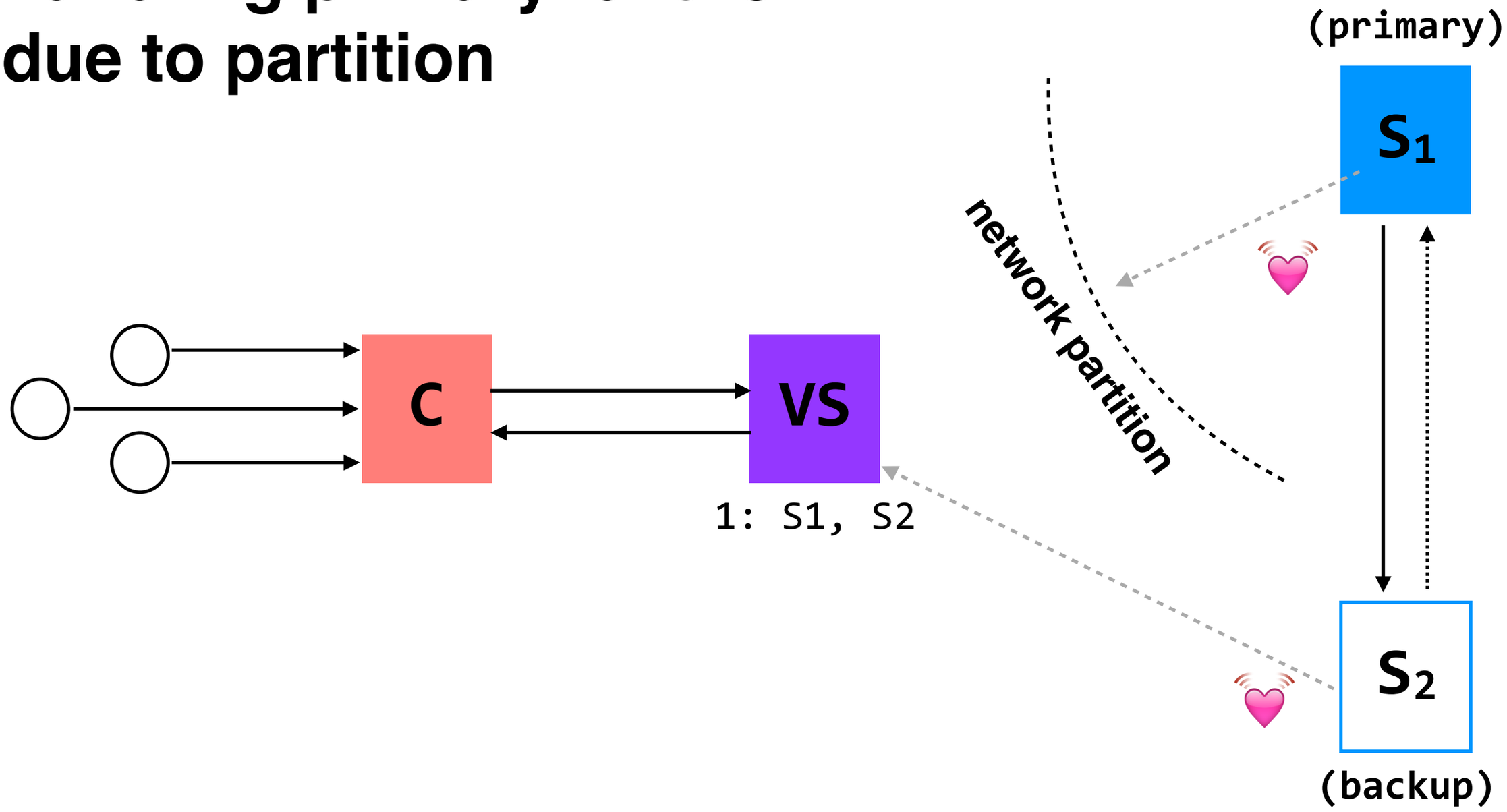
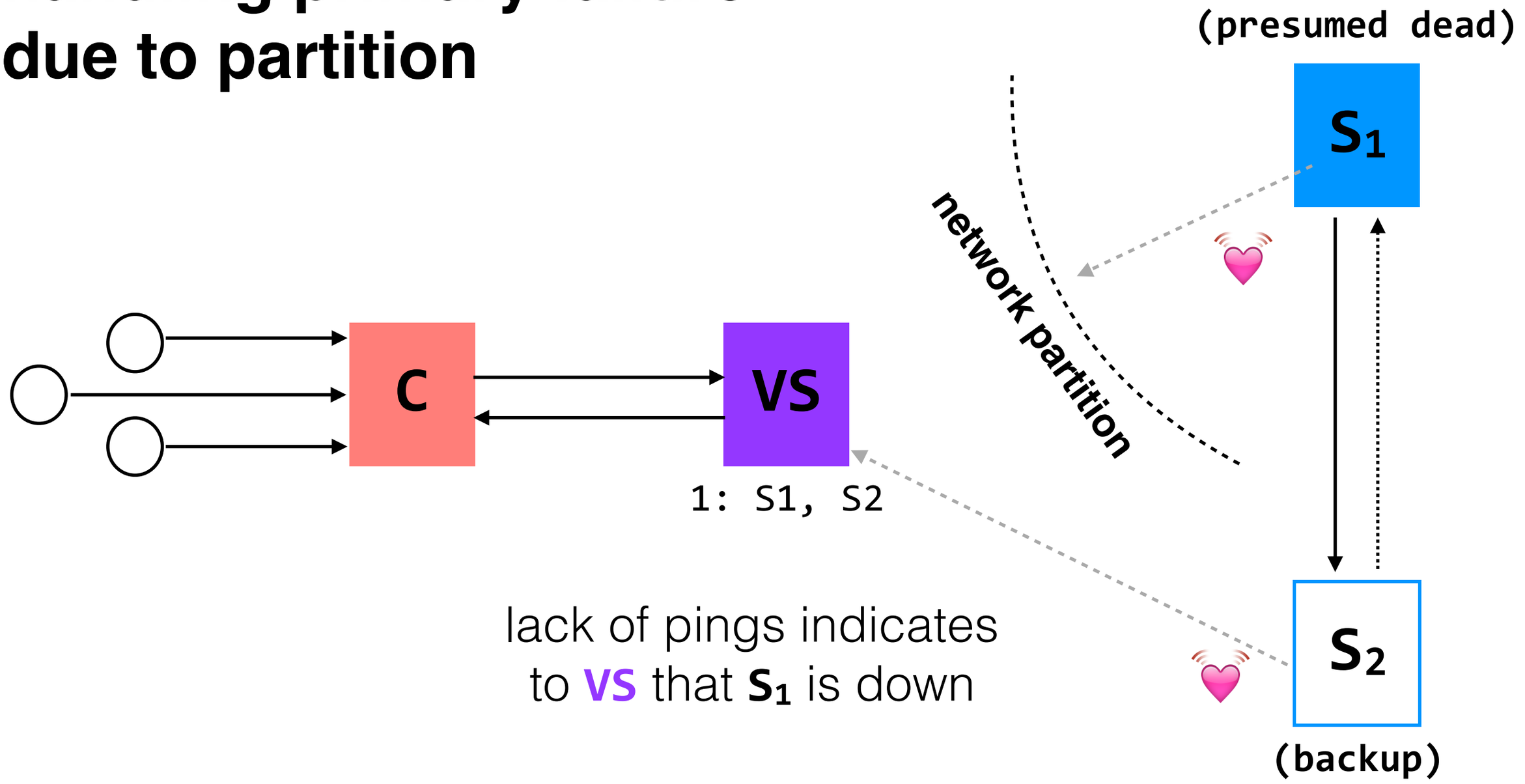


handling primary failure due to partition



suppose a partition keeps S_1 from communicating with the **view server**

handling primary failure due to partition



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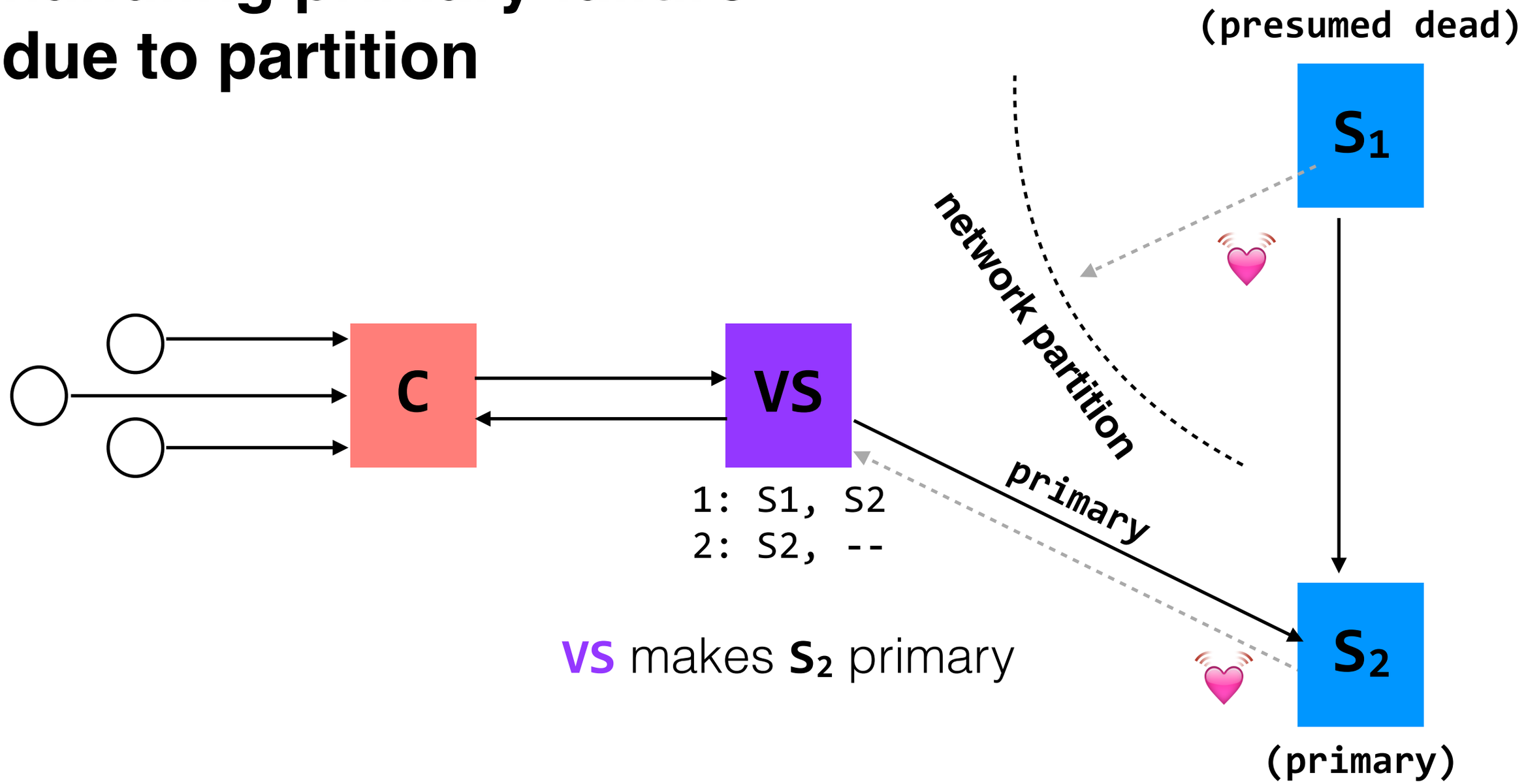
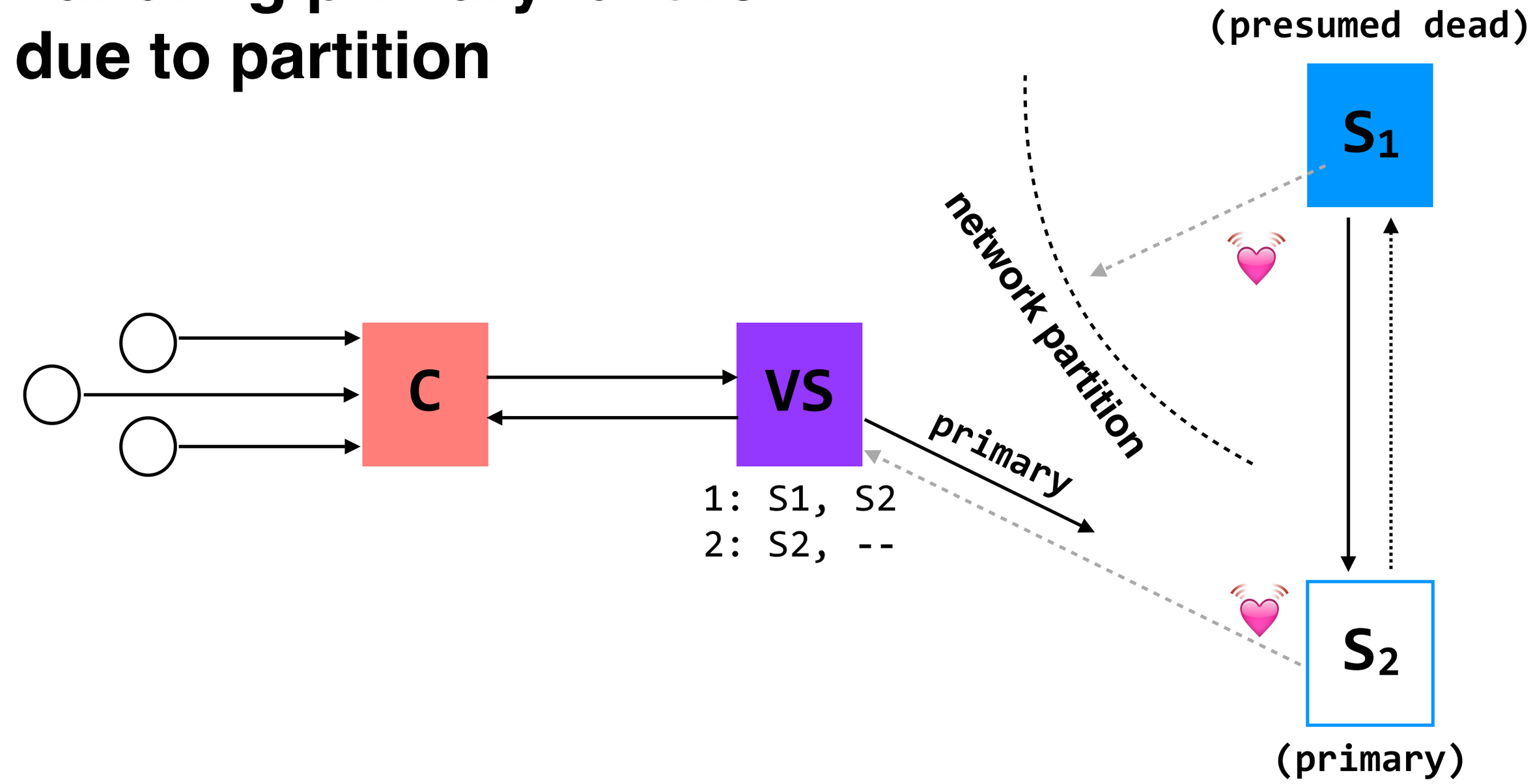
handling primary failure due to partition



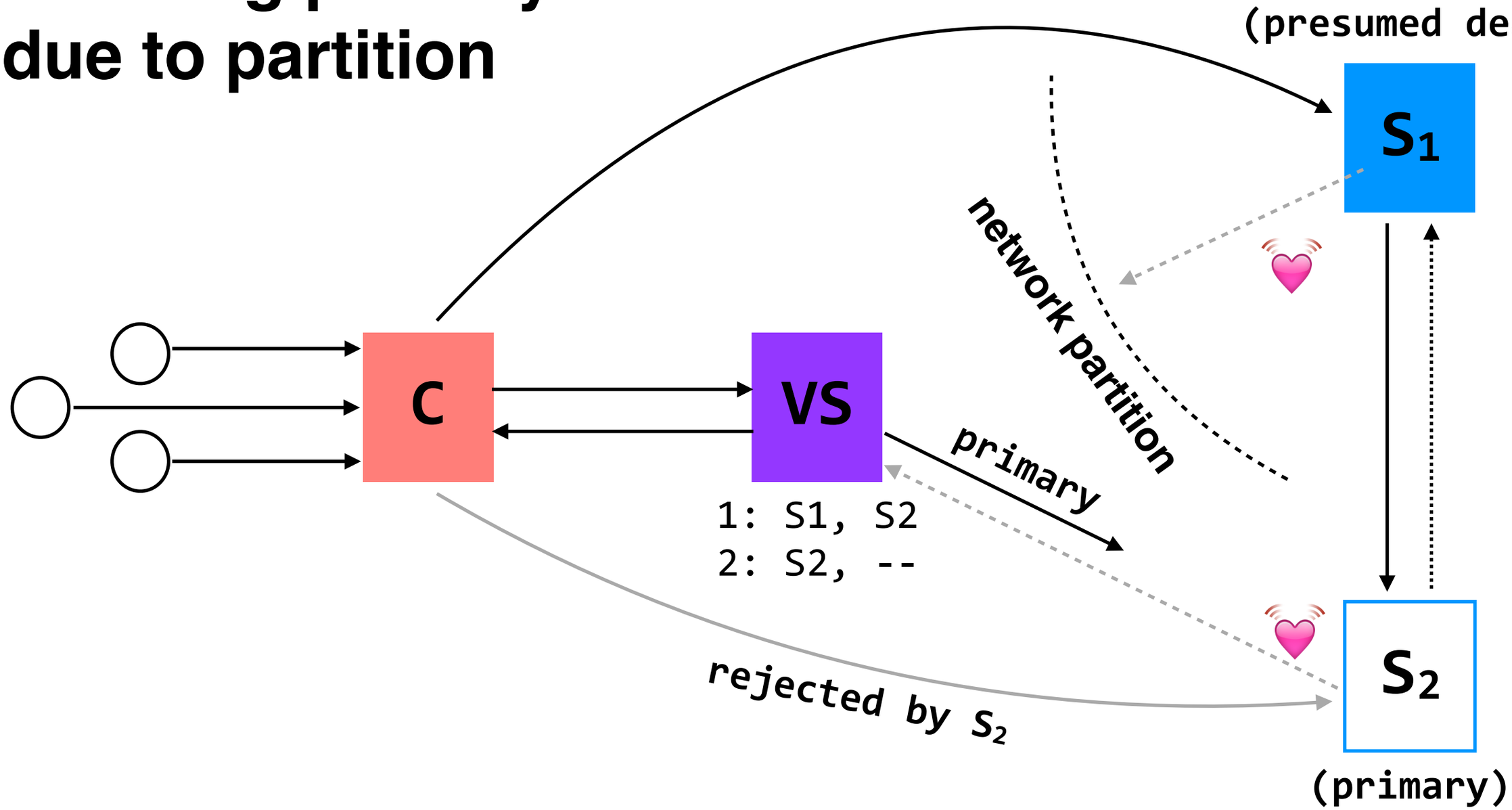
VS makes S_2 primary

handling primary failure due to partition



question: what happens before S_2 knows it's the primary?

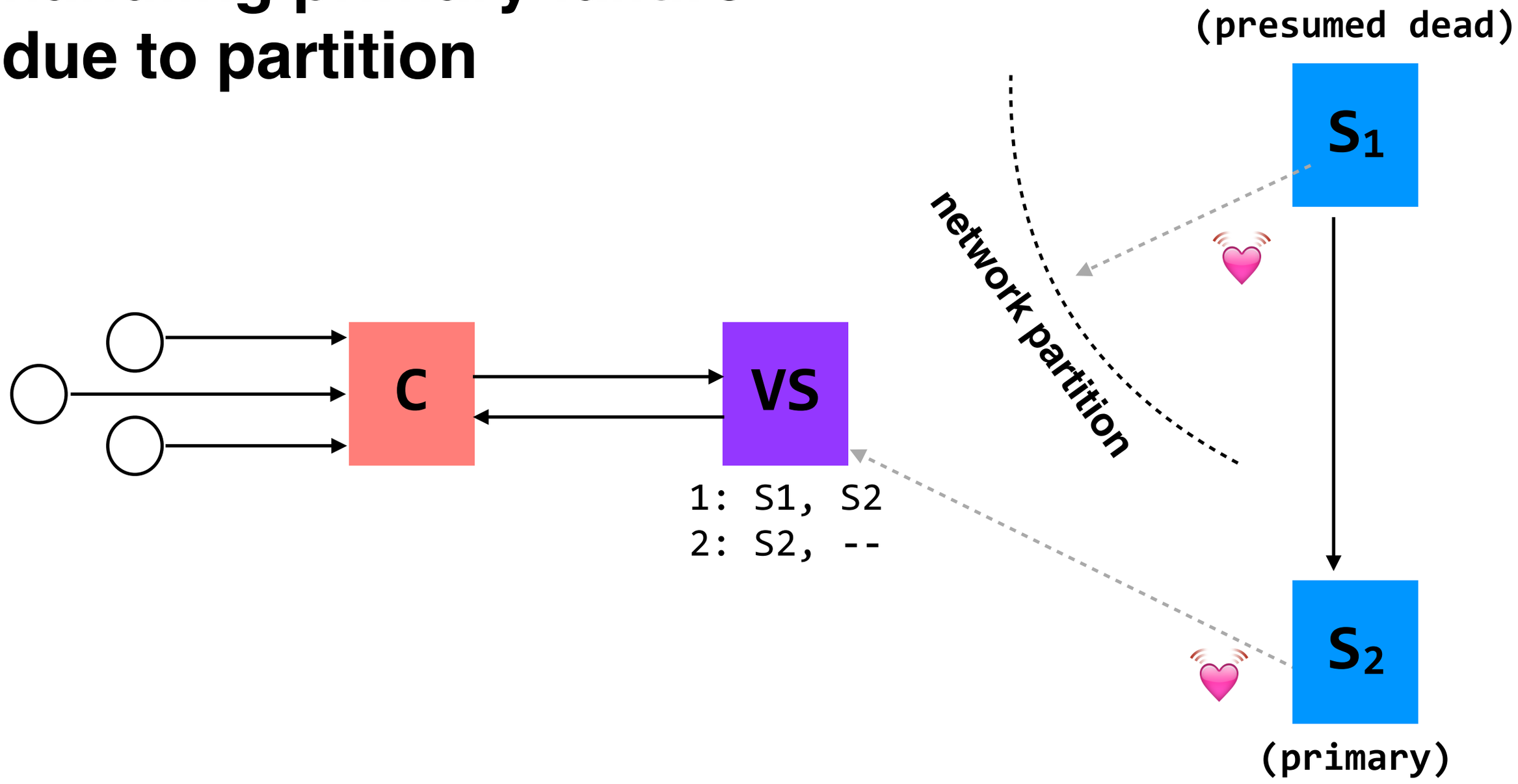
handling primary failure due to partition



S_2 will act as backup

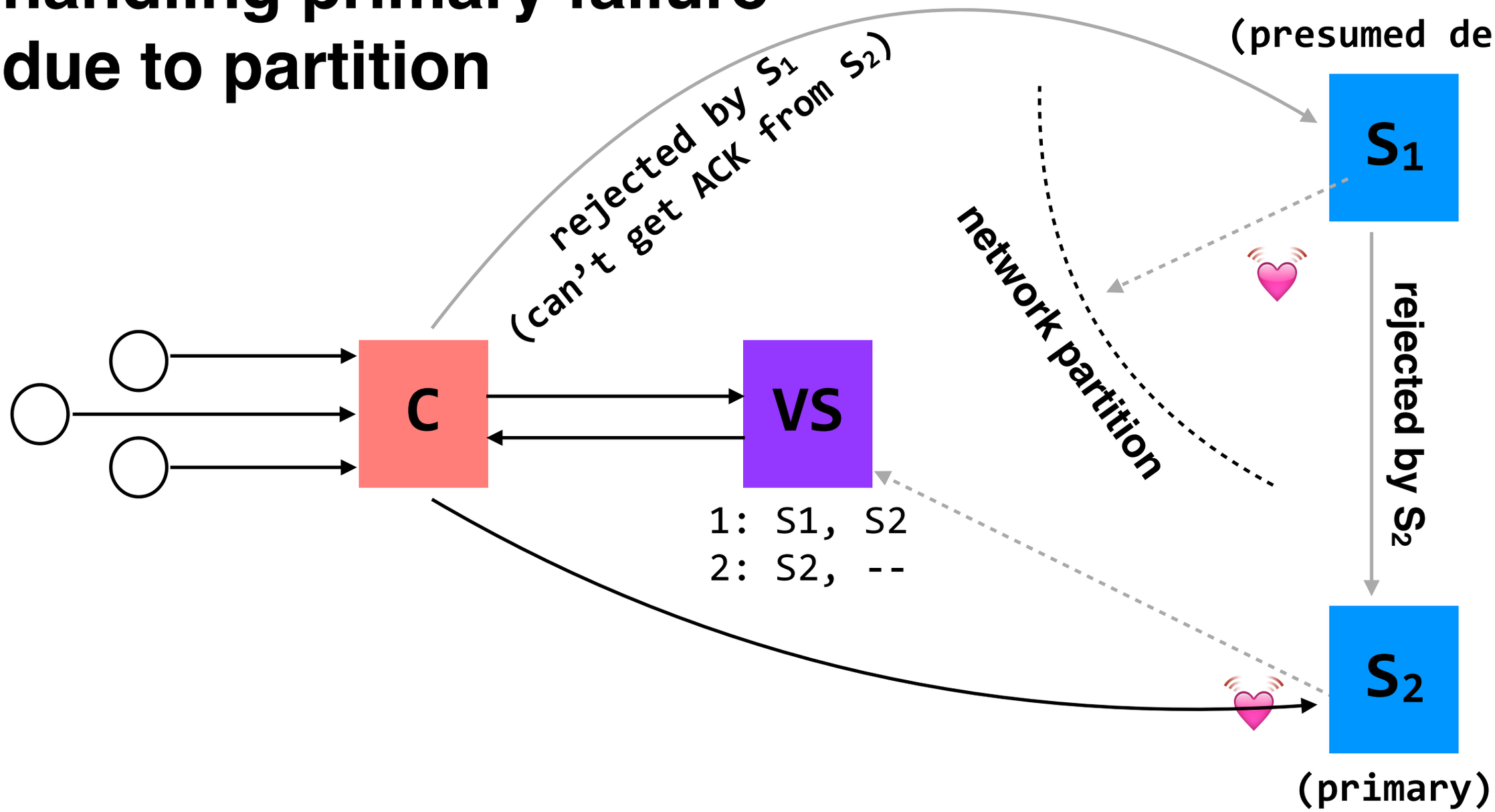
(accept updates from S_1, reject coordinator requests)

handling primary failure due to partition



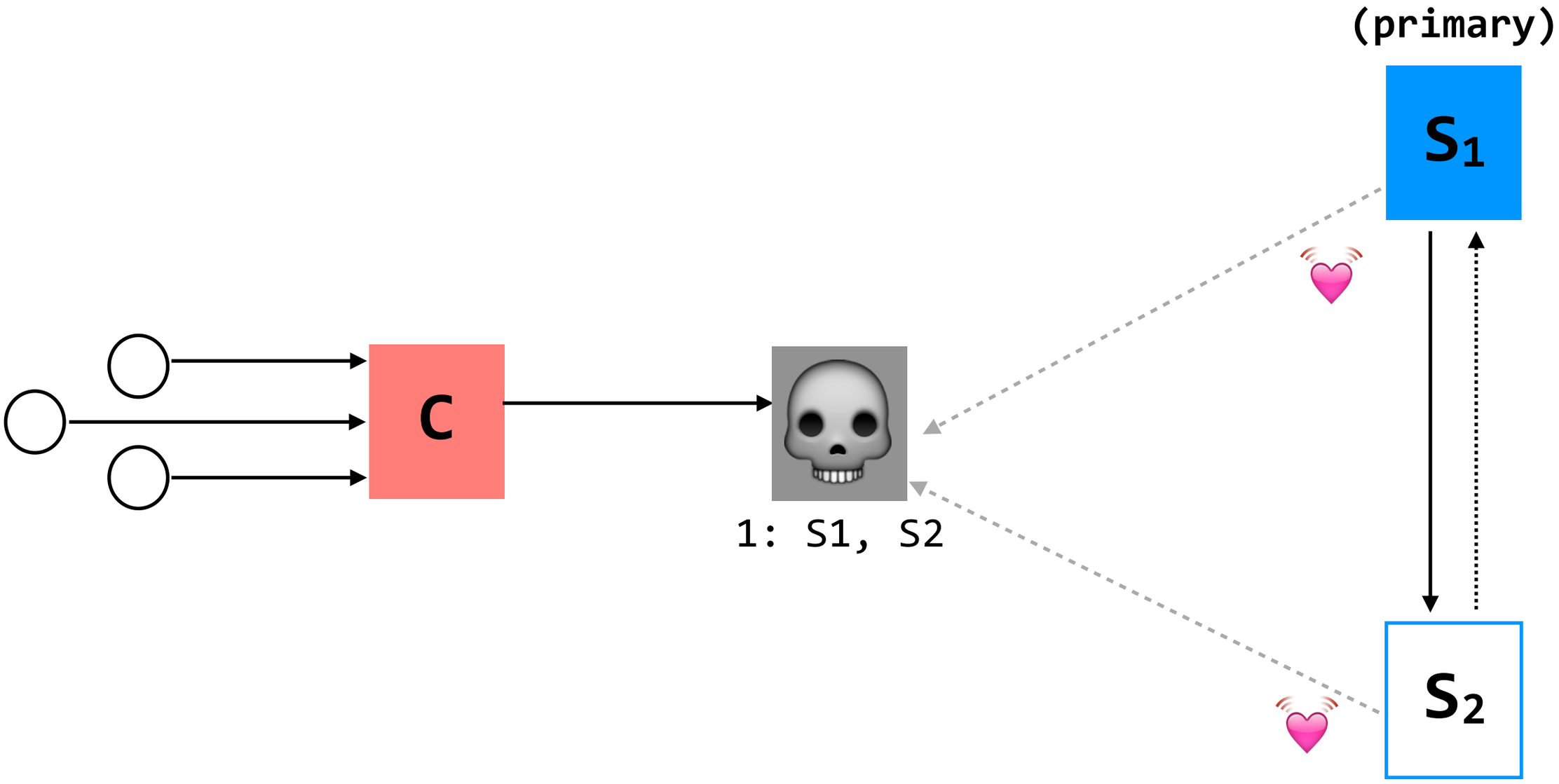
question: what happens after S_2 knows it's the primary, but S_1 also thinks it is?

handling primary failure due to partition



S_1 won't be able to act as primary

(can't accept client requests because it won't get ACKs from S_2)



problem: what if view server fails?

go to recitation tomorrow and find out!

- **Replicated state machines (RSMs)** provide **single-copy consistency**: operations complete as if there is a single copy of the data, though internally there are replicas.

- RSMs use a **primary-backup** mechanism for replication. The **view server** ensures that only one replica acts as the primary. It can also recruit new backups after servers fail.

- To extend this model to handle view-server failures, we need a mechanism to provide **distributed consensus**; see tomorrow's recitation (on Raft).