

# Solution 3: A shared priority queue

- By Lamport, using Lamport clocks
- Each process  $i$  locally maintains  $Q_i$ , part of a shared priority queue
- To run critical section, must have replies from all other processes AND be at the front of  $Q_i$ 
  - When you have all replies:
    - #1: All other processes are aware of your request
    - #2: You are aware of any earlier requests for the mutex

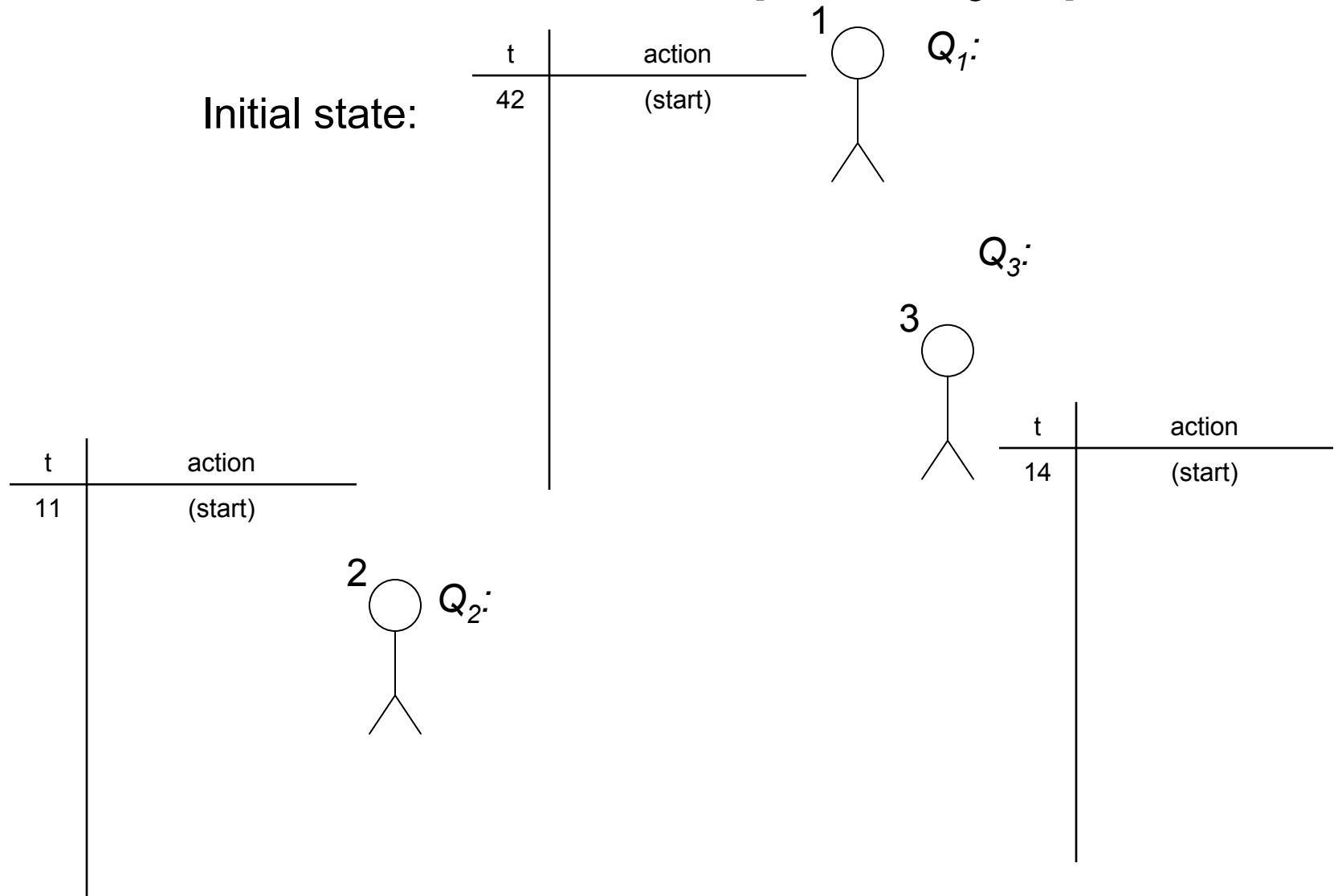
# Solution 3: A shared priority queue

- To enter critical section at process  $i$  :
  - Stamp your request with the current time  $T$
  - Add request to  $Q_i$
  - Broadcast REQUEST( $T$ ) to all processes
  - Wait for all replies and for  $T$  to reach front of  $Q_i$
- To leave:
  - Pop head of  $Q_i$ , Broadcast RELEASE to all processes
- On receipt of REQUEST( $T'$ ) from process  $j$ :
  - Add  $T'$  to  $Q_i$
  - If waiting for REPLY from  $j$  for an earlier request  $T$ , wait until  $j$  replies to you
  - Otherwise REPLY
- On receipt of RELEASE
  - Pop head of  $Q_i$

This delay  
enforces  
property #2

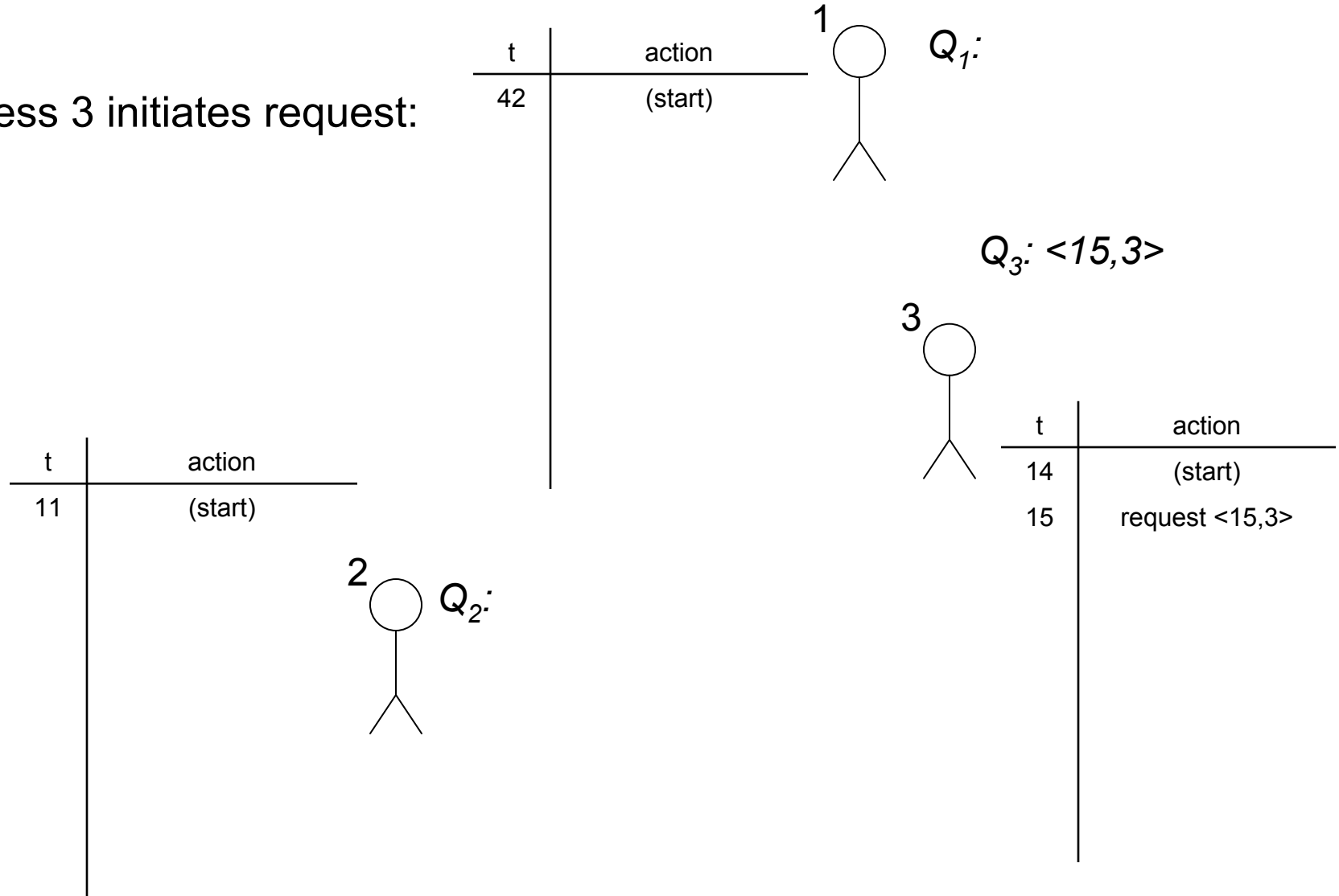


# Solution 3: A shared priority queue



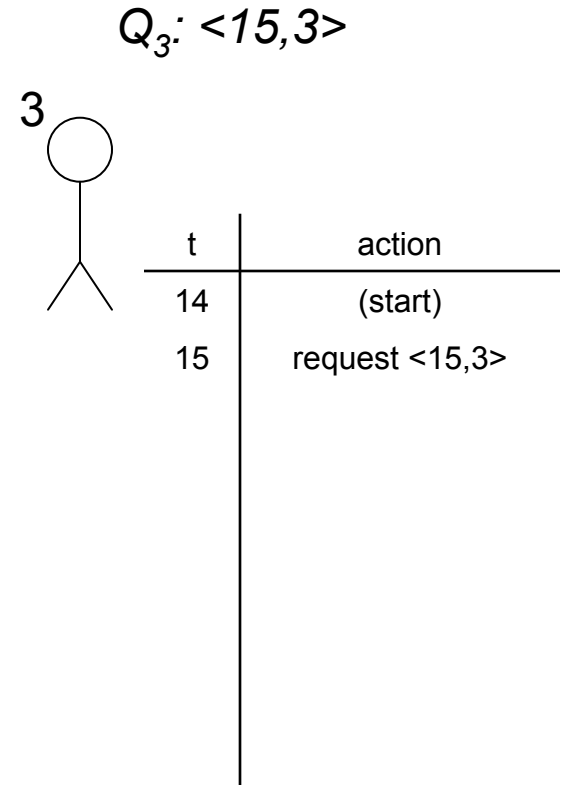
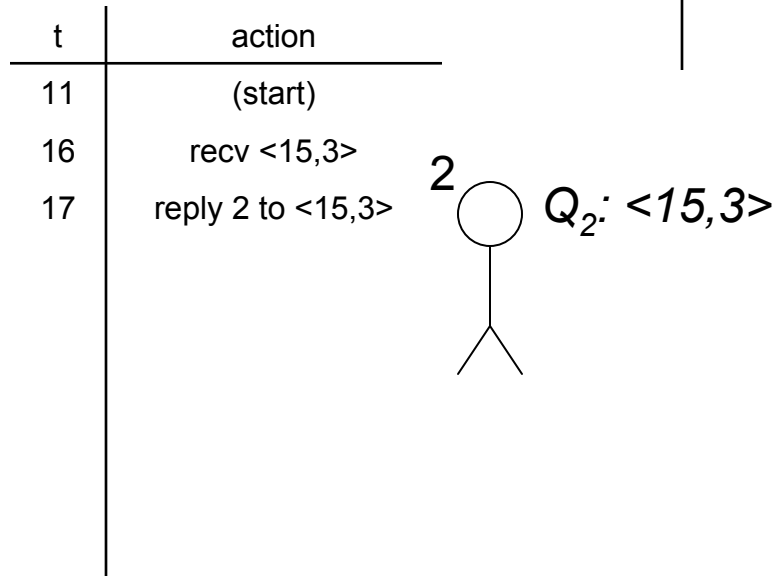
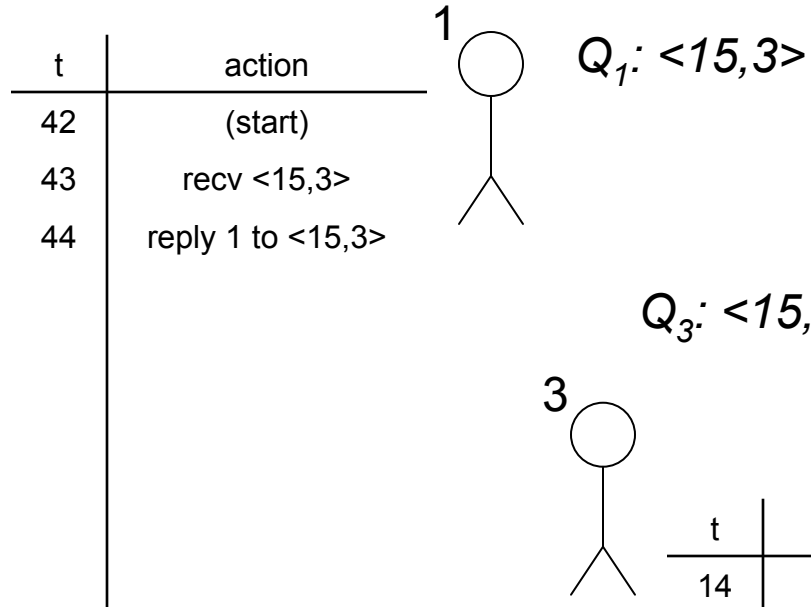
# Solution 3: A shared priority queue

Process 3 initiates request:



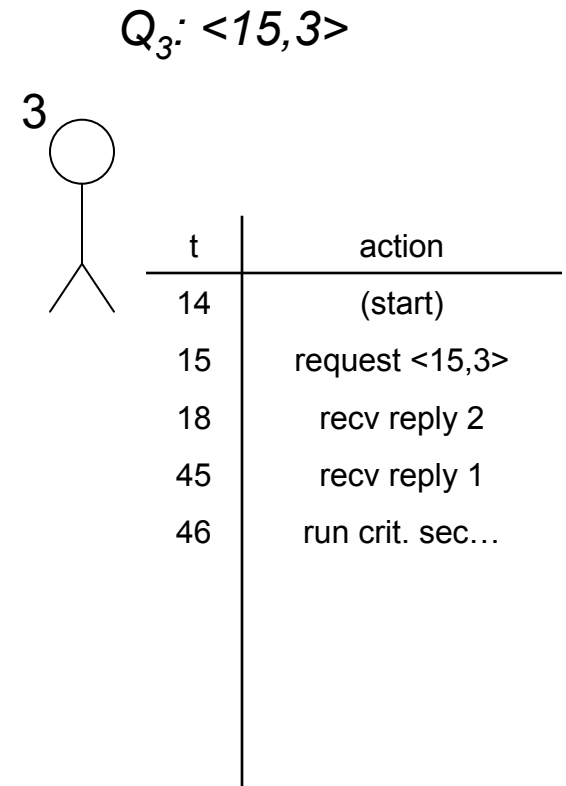
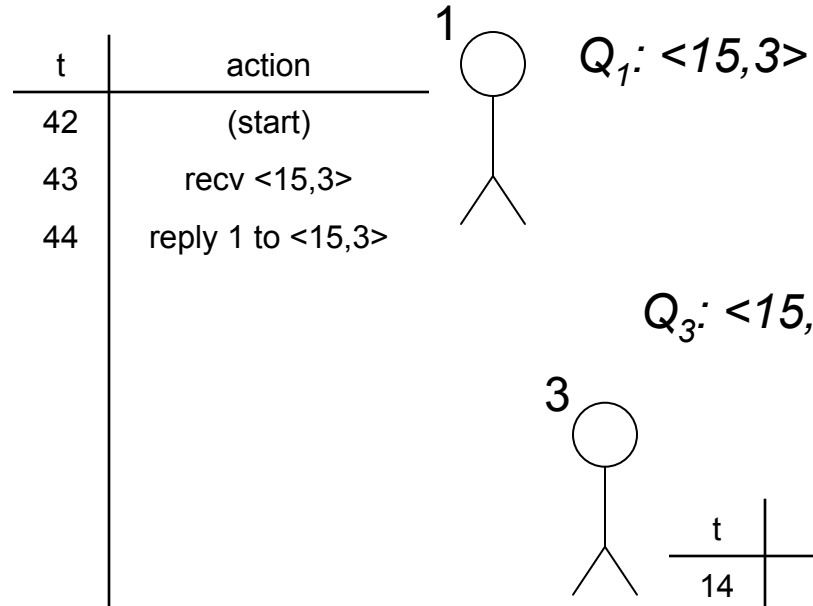
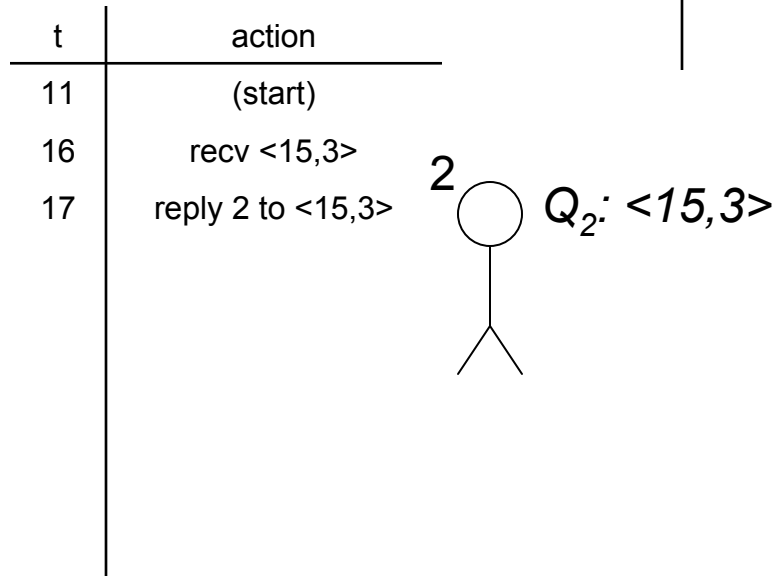
# Solution 3: A shared priority queue

1 & 2 receive and reply



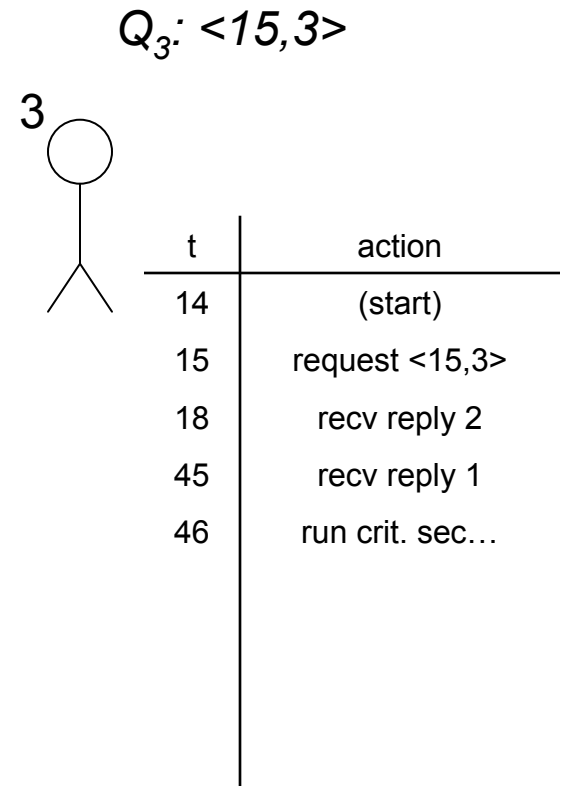
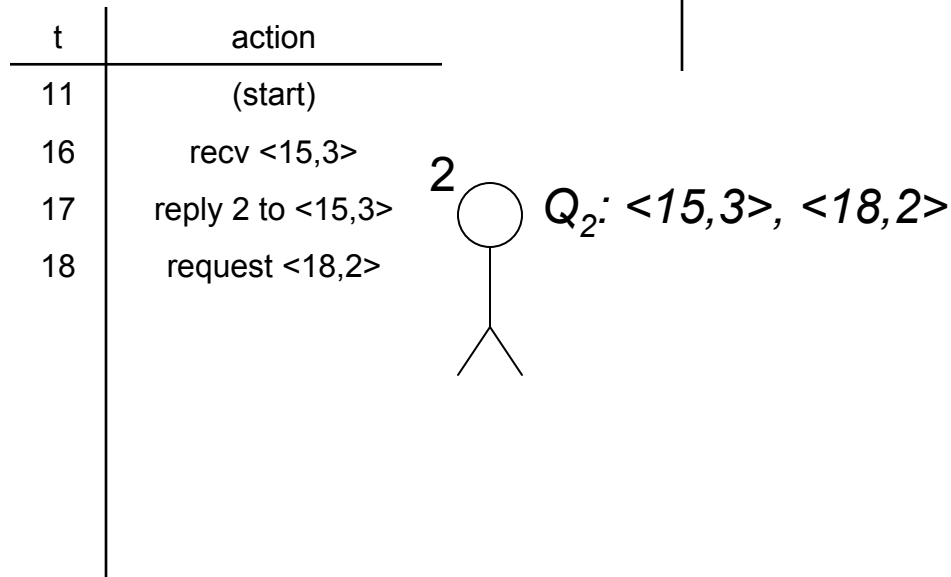
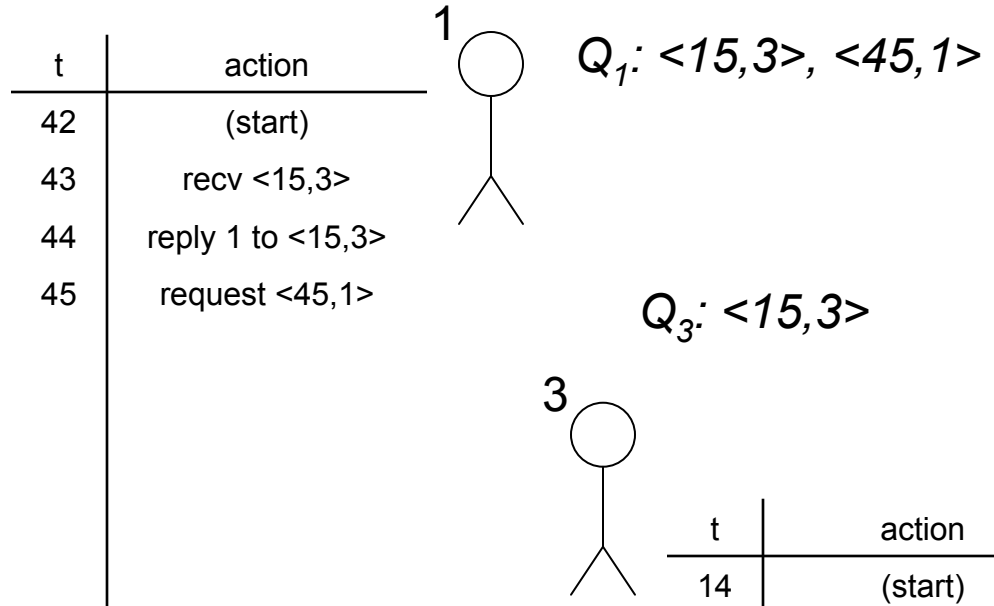
# Solution 3: A shared priority queue

3 gets replies, is on front of queue, can run crit. section:



# Solution 3: A shared priority queue

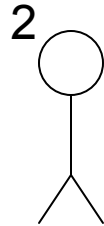
Processes 1 and 2  
concurrently initiate  
requests:



# Solution 3: A shared priority queue

Process 3 gets requests and replies:

t	action
11	(start)
16	recv <15,3>
17	reply 2 to <15,3>
18	request <18,2>
51	recv reply 3

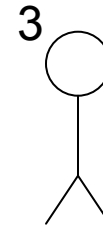


$Q_2: \langle 15,3 \rangle, \langle 18,2 \rangle$

t	action
42	(start)
43	recv <15,3>
44	reply 1 to <15,3>
45	request <45,1>
49	recv reply 3



$Q_1: \langle 15,3 \rangle, \langle 45,1 \rangle$



$Q_3: \langle 15,3 \rangle, \langle 18,2 \rangle, \langle 45,1 \rangle$

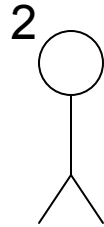
t	action
14	(start)
15	request <15,3>
18	recv reply 2
45	recv reply 1
46	run crit. sec...
47	recv <45,1>
48	reply 3 to <45,1>
49	recv <18,2>
50	reply 3 to <18,2>



# Solution 3: A shared priority queue

Process 2 gets request  $\langle 45,1 \rangle$ , delays reply because  $\langle 18,2 \rangle$  is an earlier request to which Process 1 has not replied

t	action
11	(start)
16	recv $\langle 15,3 \rangle$
17	reply 2 to $\langle 15,3 \rangle$
18	request $\langle 18,2 \rangle$
51	recv reply 3
52	recv $\langle 45,1 \rangle$

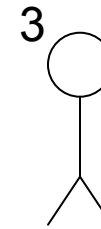


$Q_2: \langle 15,3 \rangle, \langle 18,2 \rangle, \langle 45,1 \rangle$

t	action
42	(start)
43	recv $\langle 15,3 \rangle$
44	reply 1 to $\langle 15,3 \rangle$
45	request $\langle 45,1 \rangle$
49	recv reply 3



$Q_1: \langle 15,3 \rangle, \langle 45,1 \rangle$



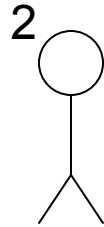
$Q_3: \langle 15,3 \rangle, \langle 18,2 \rangle, \langle 45,1 \rangle$

t	action
14	(start)
15	request $\langle 15,3 \rangle$
18	recv reply 2
45	recv reply 1
46	run crit. sec...
47	recv $\langle 45,1 \rangle$
48	reply 3 to $\langle 45,1 \rangle$
49	recv $\langle 18,2 \rangle$
50	reply 3 to $\langle 18,2 \rangle$

# Solution 3: A shared priority queue

Process 1 gets request  $\langle 18,2 \rangle$ , replies

t	action
11	(start)
16	recv $\langle 15,3 \rangle$
17	reply 2 to $\langle 15,3 \rangle$
18	request $\langle 18,2 \rangle$
51	recv reply 3
52	recv $\langle 45,1 \rangle$

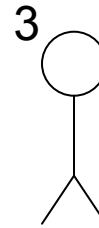


$Q_2: \langle 15,3 \rangle, \langle 18,2 \rangle, \langle 45,1 \rangle$

t	action
42	(start)
43	recv $\langle 15,3 \rangle$
44	reply 1 to $\langle 15,3 \rangle$
45	request $\langle 45,1 \rangle$
49	recv reply 3
50	recv $\langle 18,2 \rangle$
51	reply 1 to $\langle 18,2 \rangle$



$Q_1: \langle 15,3 \rangle, \langle 18,2 \rangle, \langle 45,1 \rangle$



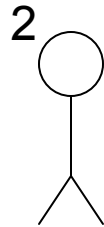
$Q_3: \langle 15,3 \rangle, \langle 18,2 \rangle, \langle 45,1 \rangle$

t	action
14	(start)
15	request $\langle 15,3 \rangle$
18	recv reply 2
45	recv reply 1
46	run crit. sec...
47	recv $\langle 45,1 \rangle$
48	reply 3 to $\langle 45,1 \rangle$
49	recv $\langle 18,2 \rangle$
50	reply 3 to $\langle 18,2 \rangle$

# Solution 3: A shared priority queue

Process 2 gets reply from process 1, finally replies to  $\langle 45, 1 \rangle$

t	action
11	(start)
16	recv $\langle 15, 3 \rangle$
17	reply 2 to $\langle 15, 3 \rangle$
18	request $\langle 18, 2 \rangle$
51	recv reply 3
52	recv $\langle 45, 1 \rangle$
53	recv reply 1
54	reply 2 to $\langle 45, 1 \rangle$

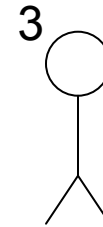


$Q_2: \langle 15, 3 \rangle, \langle 18, 2 \rangle, \langle 45, 1 \rangle$

t	action
42	(start)
43	recv $\langle 15, 3 \rangle$
44	reply 1 to $\langle 15, 3 \rangle$
45	request $\langle 45, 1 \rangle$
49	recv reply 3
50	recv $\langle 18, 2 \rangle$
51	reply 1 to $\langle 18, 2 \rangle$



$Q_1: \langle 15, 3 \rangle, \langle 18, 2 \rangle, \langle 45, 1 \rangle$



$Q_3: \langle 15, 3 \rangle, \langle 18, 2 \rangle, \langle 45, 1 \rangle$

t	action
14	(start)
15	request $\langle 15, 3 \rangle$
18	recv reply 2
45	recv reply 1
46	run crit. sec...
47	recv $\langle 45, 1 \rangle$
48	reply 3 to $\langle 45, 1 \rangle$
49	recv $\langle 18, 2 \rangle$
50	reply 3 to $\langle 18, 2 \rangle$