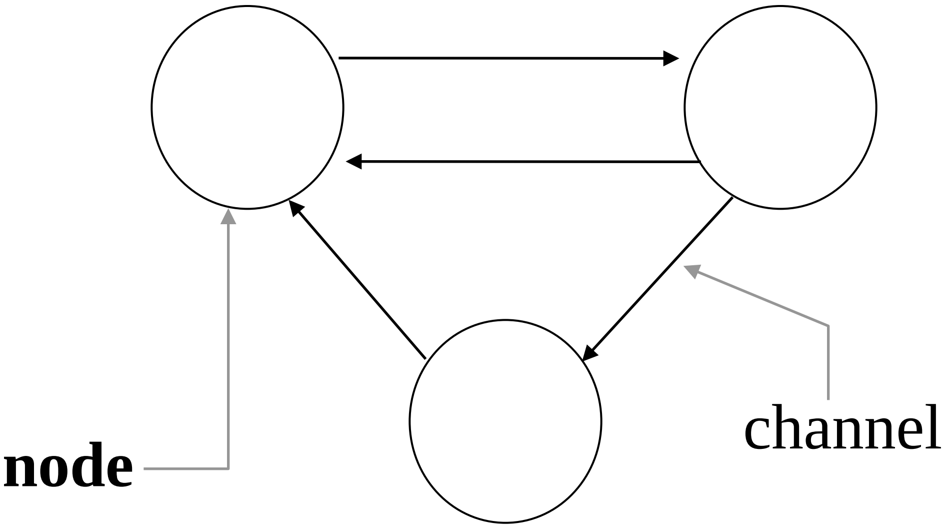
Uncoordinated Checkpointing

The Global State Recording Algorithm

The Model



node

channel

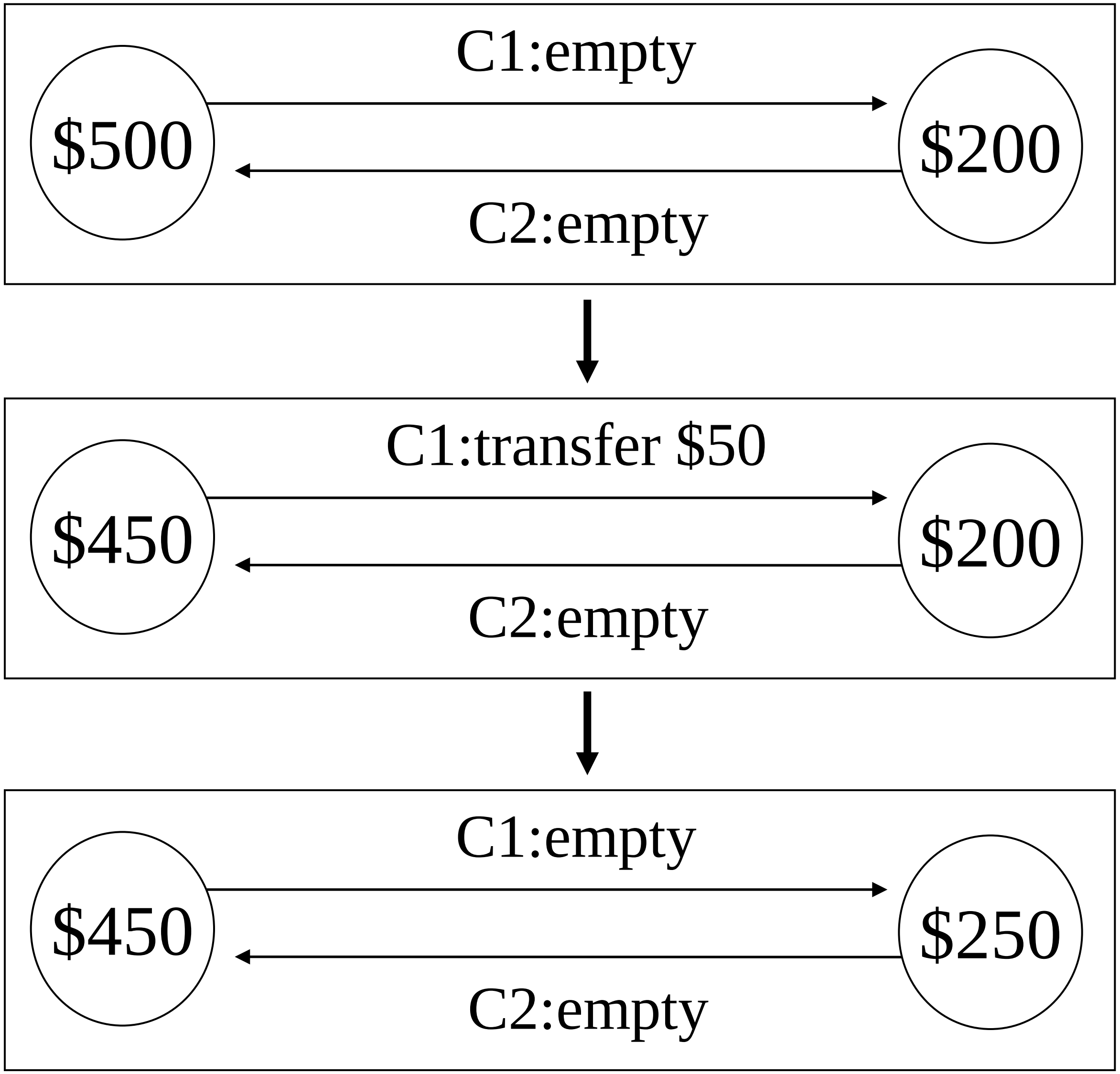
Node properties

- No shared memory
- No global clock

Channel properties:

- FIFO
- loss free
- non-duplicating

The Problem



$500

C1:empty

C2:empty

$200

$450

C1:transfer $50

C2:empty

$200

$450

C1:empty

C2:empty

$250

Distributed Snapshot (Global State Recording)

- Motivation for recording a “consistent” state of the global computation:
  - checkpointing for fault tolerance (rollback, recovery)
  - testing and debugging
  - monitoring and auditing
- Method: detecting stable properties in a distributed system via snapshots. A property is “stable” if, once it holds in a state, it holds in all subsequent states.
  - termination
  - deadlock
  - garbage collection

Definitions

Local State and Actions:

local state:	LS_i
message send:	$send(m_{ij}\ )$
message receive:	$rec(m_{ij}\ )$
time:	$time(x)$

$send(m_{ij}\ ) \varepsilon LS_i$ iff $time(send(m_{ij}\ )) < time(LS_i\ )$

$rec(m_{ij}\ ) \varepsilon LS_j$ iff $time(rec(m_{ij}\ )) < time(LS_j\ )$

Predicates:

$transit(LS_i\ , LS_j\ ) =$

$\{m_{ij} \mid send(m_{ij}\ ) \varepsilon LS_i \Lambda\ !(\ rec(m_{ij}\ ) \varepsilon LS_j\ )\ )\ \}$

$inconsistent(LS_i\ , LS_j\ ) =$

$\{m_{ij} \mid\ !(send(m_{ij}\ ) \varepsilon LS_i\ ) \Lambda\ rec(m_{ij}\ ) \varepsilon LS_j\ )\ \}$

Consistent Global State:

$\forall\ i, \forall\ j : 1 <= i, j <= n :: inconsistent(\ LS_i\ , LS_j\ ) = \Phi$

Global-State-Recording Algorithm

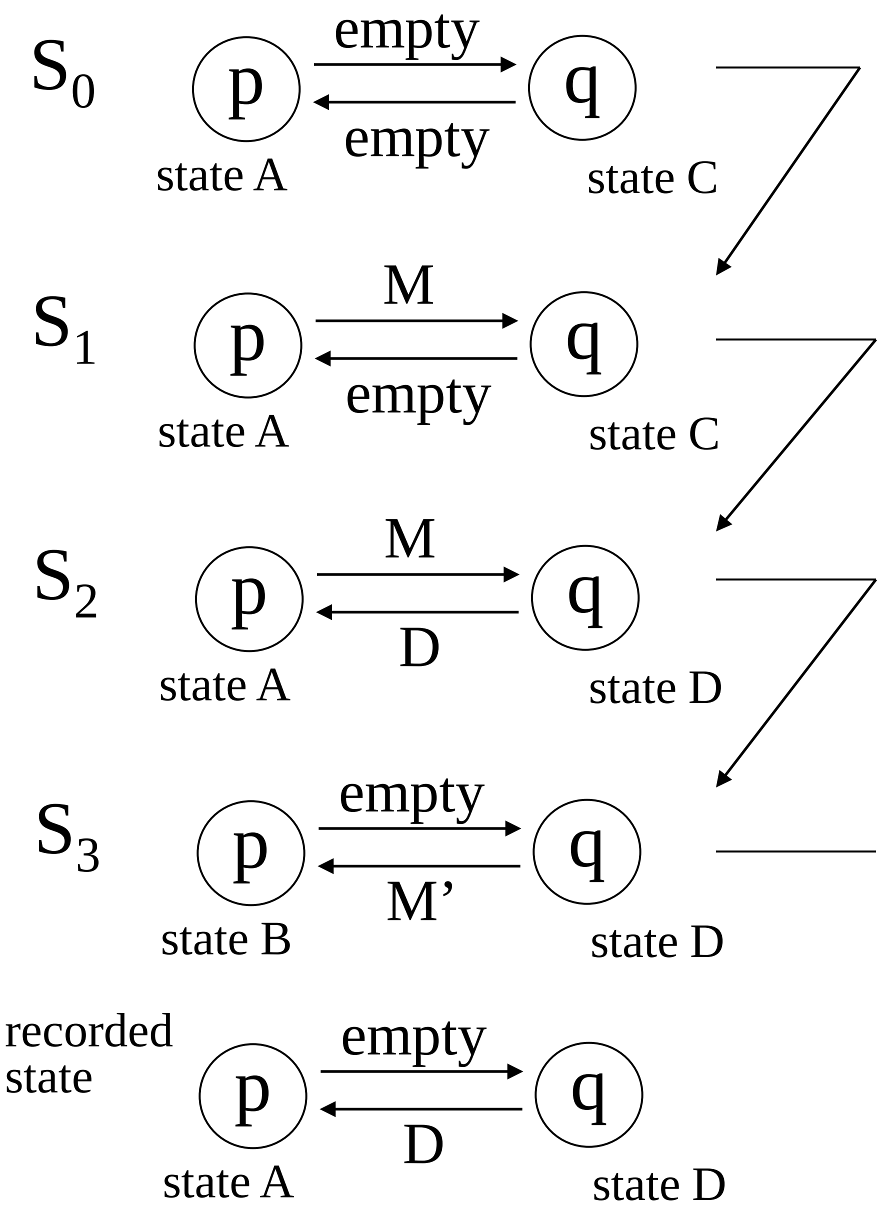
Marker-Sending Rule for a Process p:

```
for (each channel c, incident on, and directed away from p)
    { p sends one marker along c after p records its state
      and before p sends further messages along c; }
```

Marker-Receiving Rule for a Process q:

```
if (q has not recorded its state) then
    { q records its state;
      q records the state of c as the empty sequence;
    }
  else { q records the state of c as the sequence of message
         received along c after q's state was recorded and before
         q received the marker along c.
    }
```

Global State Recording



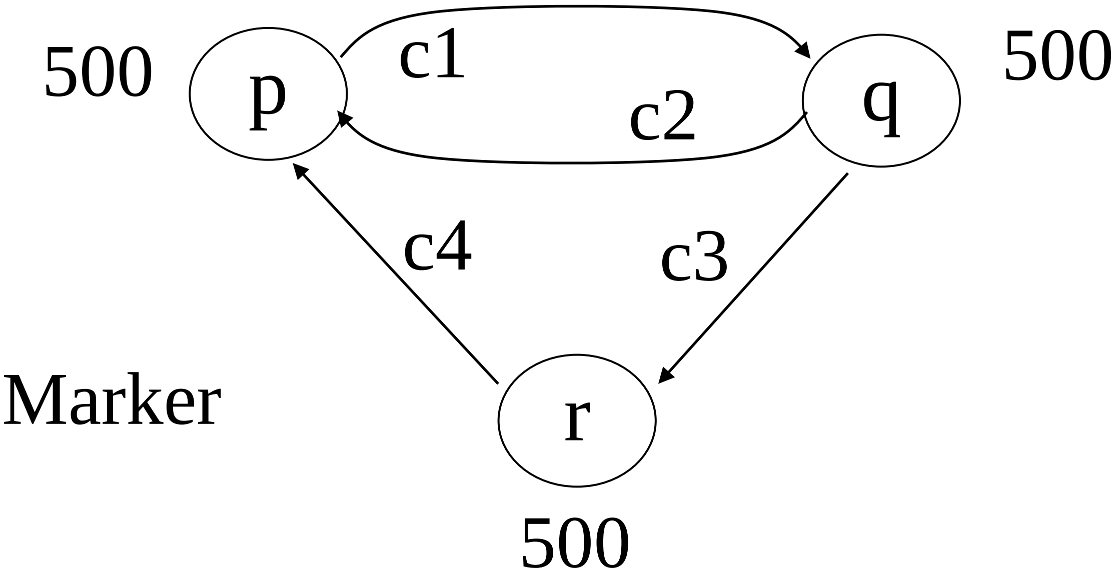
p records its state (A) and sends marker M on channel

before receiving the marker, q changes its state and sends message D.

q receives the marker and records its state (D) and the incoming channel as empty; q send marker M' on its outgoing channel.

on receiving the marker, p records the channel as having message D

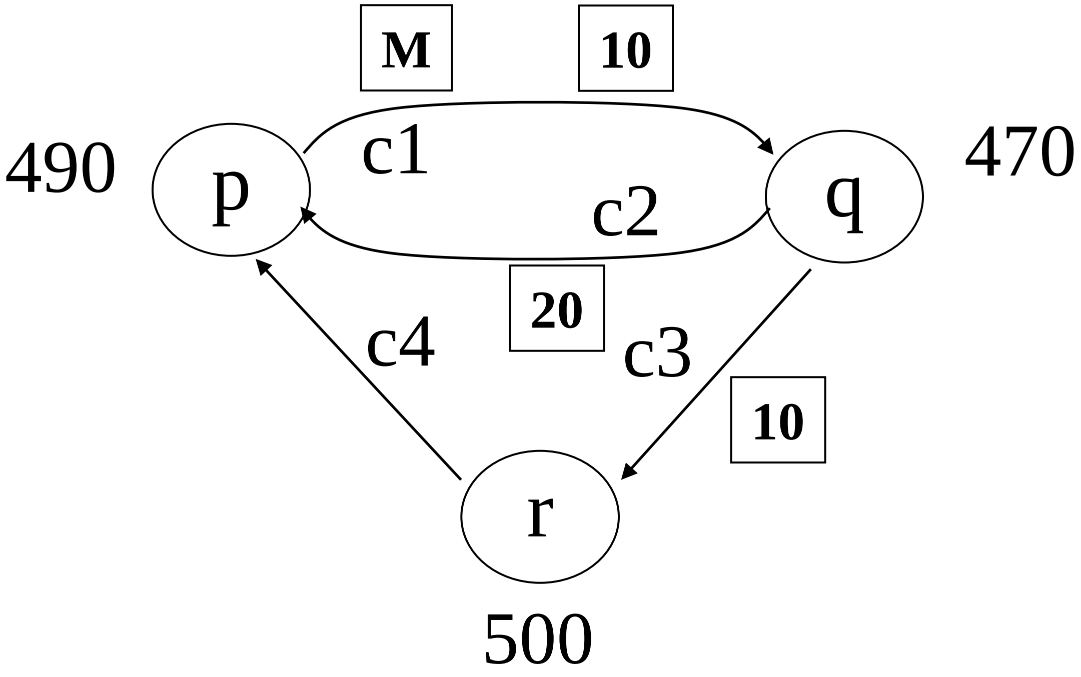
Snapshot/State Recording Example



M = Marker

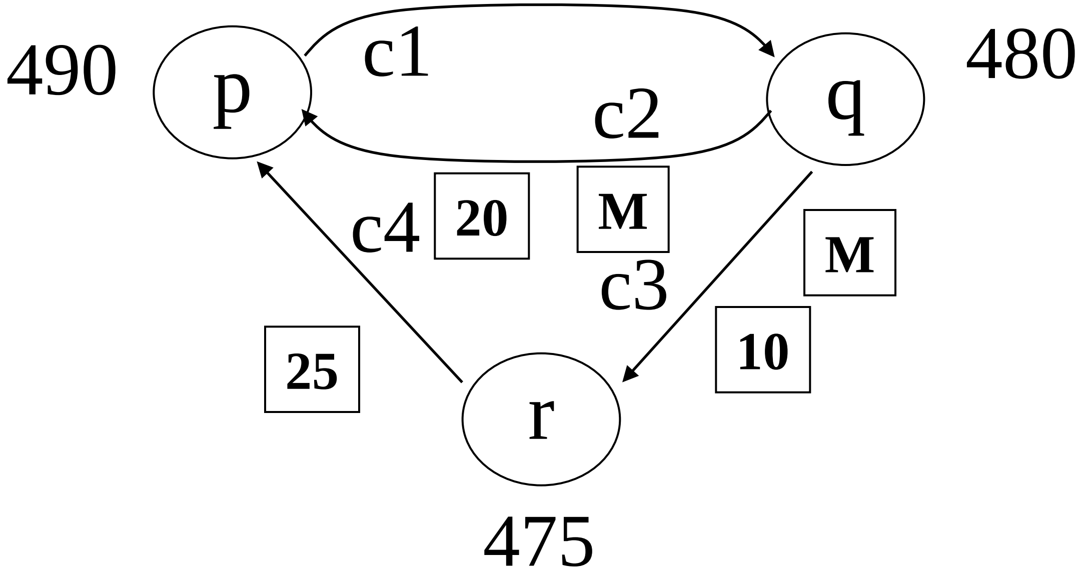
Node	Recorded state				
		c1	c2	c3	c4
p			{}		{}
q		{}			
r				{}	

Snapshot/State Recording Example (Step 1)



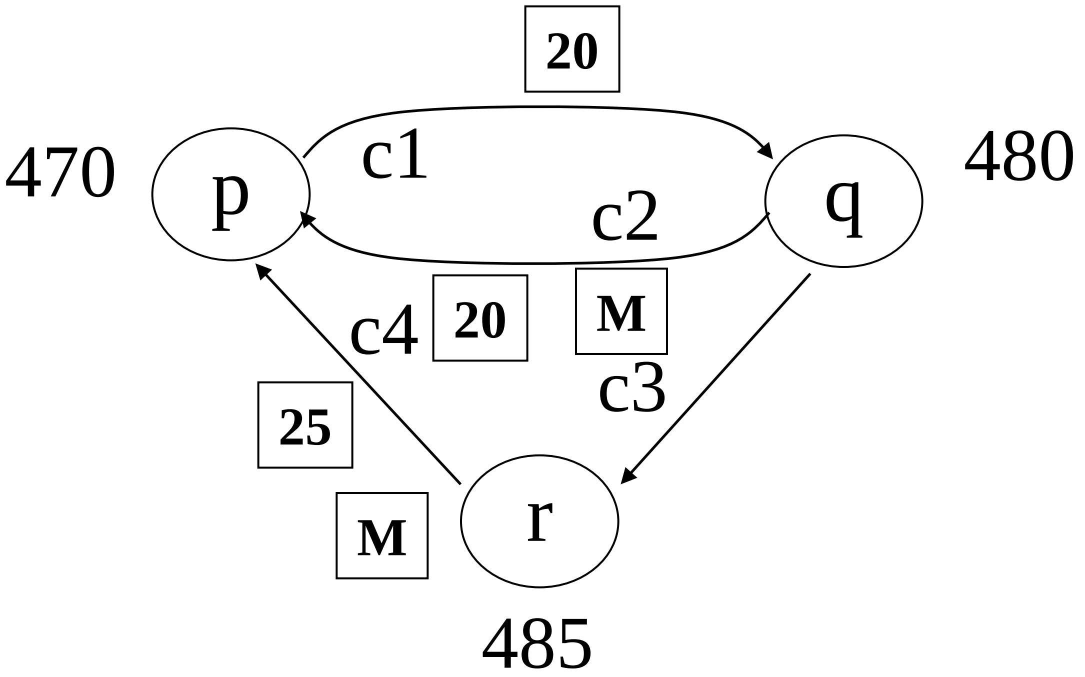
Node	Recorded state				
	state	c1	c2	c3	c4
p	490		{}		{}
q		{}			
r				{}	

Snapshot/State Recording Example (Step 2)



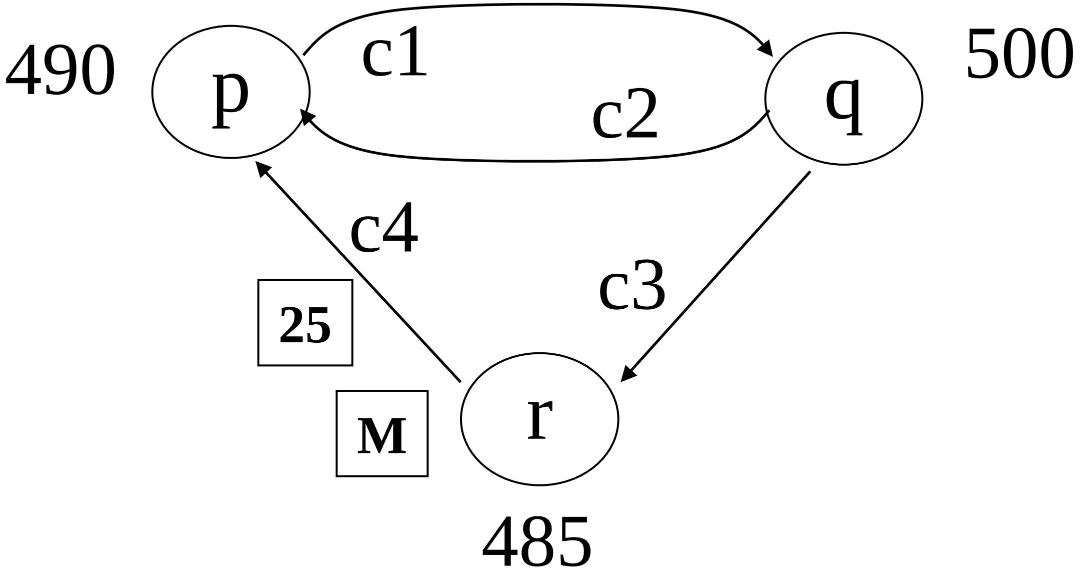
Node	Recorded state				
	state	c1	c2	c3	c4
p	490		{}		{}
q	480	{empty}			
r				{}	

Snapshot/State Recording Example (Step 3)



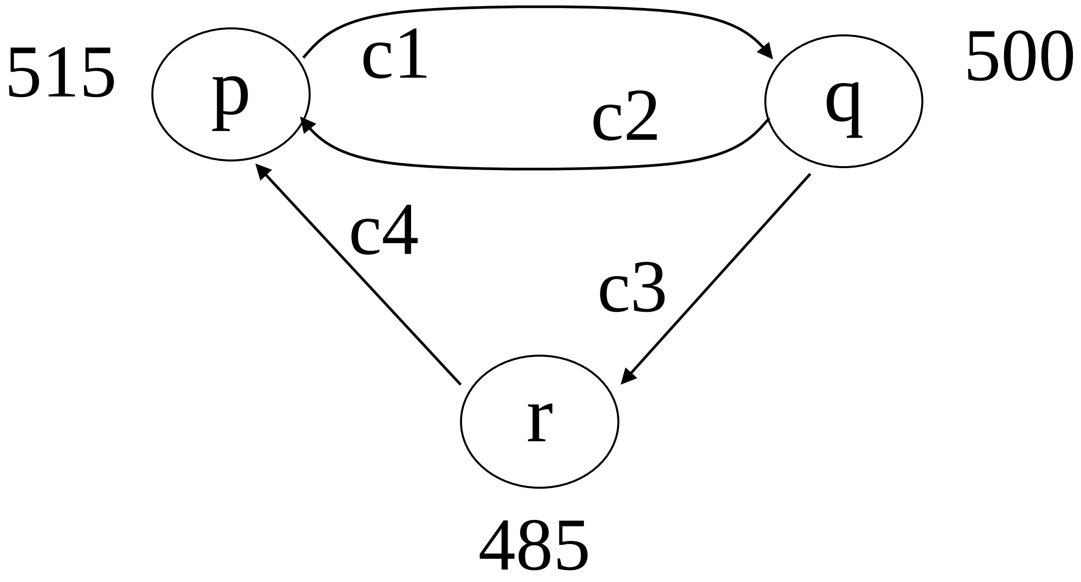
Node	Recorded state				
	state	c1	c2	c3	c4
p	490		{}		{}
q	480	{empty}			
r	485			{empty}	

Snapshot/State Recording Example (Step 4)



Node	Recorded state				
	state	c1	c2	c3	c4
p	490		{20}		{}
q	480	{empty}			
r	485			{empty}	

Snapshot/State Recording Example (Step 5)



Node	Recorded state				
	state	c1	c2	c3	c4
p	490		{20}		{25}
q	480	{empty}			
r	485			{empty}	