CLOUD COMPUTING CONCEPTS

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MULTICAST

Lecture B

IMPLEMENTING MULTICAST ORDERING 1

Multicast Ordering

- How do we implement each of the ordering schemes we’ve seen
  1. FIFO ordering (this lecture)
  2. Causal ordering (next lecture)
  3. Total ordering (this lecture)

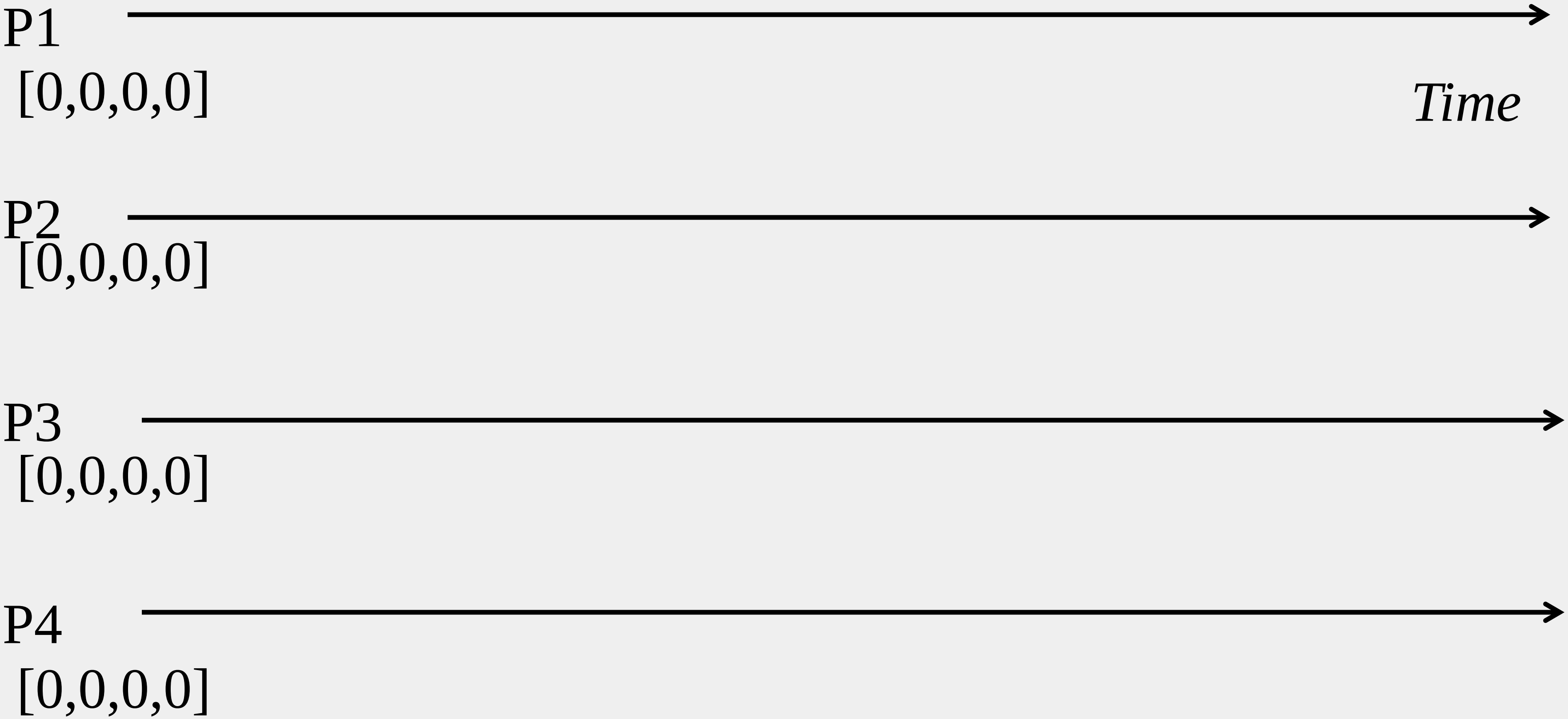
FIFO Multicast: Data Structures

- Each receiver maintains a per-sender sequence number (integers)
  - Processes P*1* through P*N*
  - P*i* maintains a vector of sequence numbers P*i*[1…N] (initially all zeroes)
  - P*i*[*j*] is the latest sequence number P*i* has received from P*j*

FIFO Multicast: Updating Rules

- Send multicast at process $\mathrm{P}j$:
  - Set $\mathrm{P}j[j] = \mathrm{P}j[j] + 1$
  - Include new $\mathrm{P}j[j]$ in multicast message as its sequence number
- Receive multicast: If $\mathrm{P}i$ receives a multicast from $\mathrm{P}j$ with sequence number S in message
  - if $(\mathrm{S} == \mathrm{P}i[j] + 1)$ then
    - deliver message to application
    - Set $\mathrm{P}i[j] = \mathrm{P}i[j] + 1$
  - else buffer this multicast until above condition is true

FIFO Ordering: Example



P1

[0,0,0,0]

Time

P2

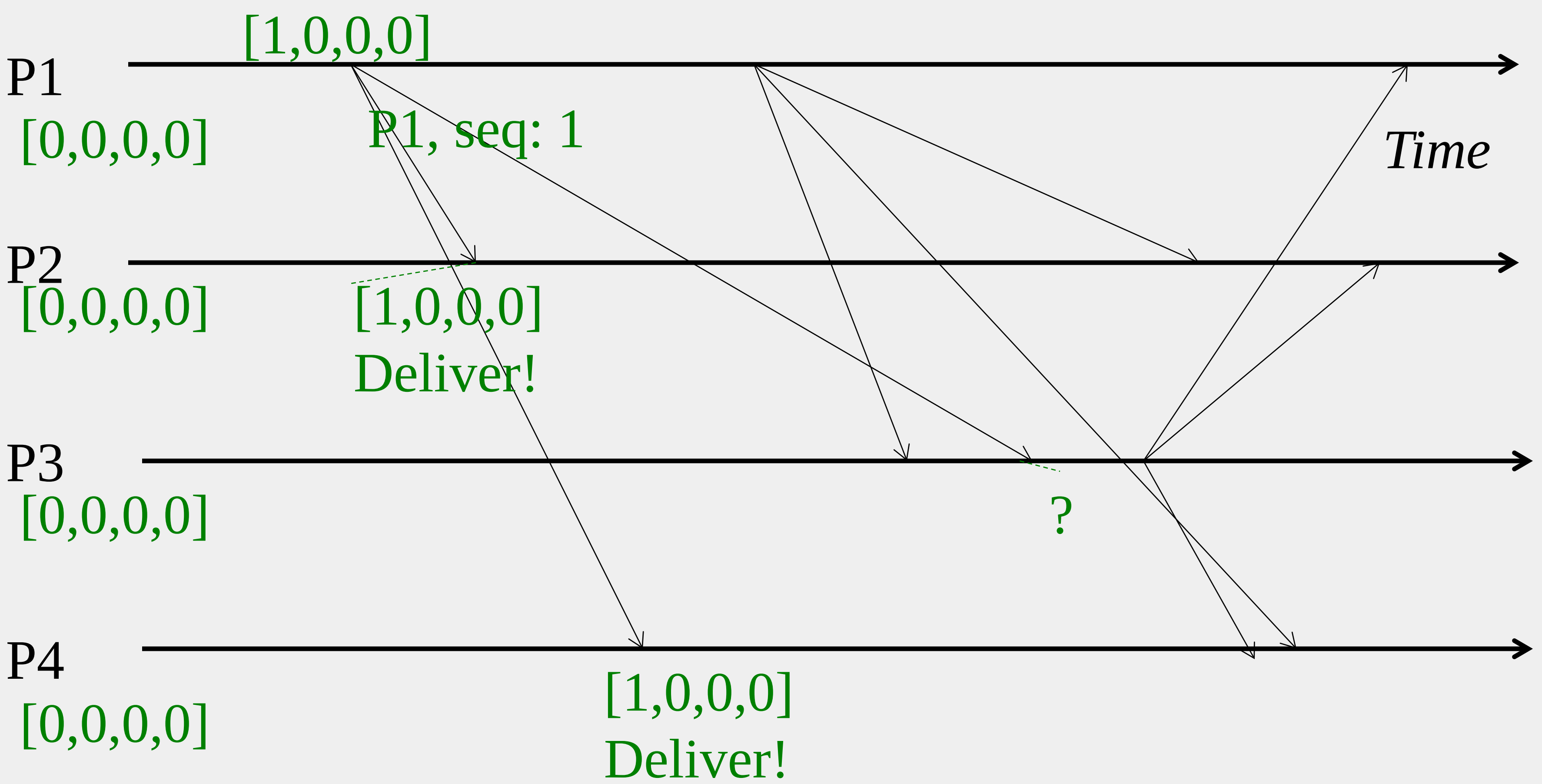
[0,0,0,0]

P3

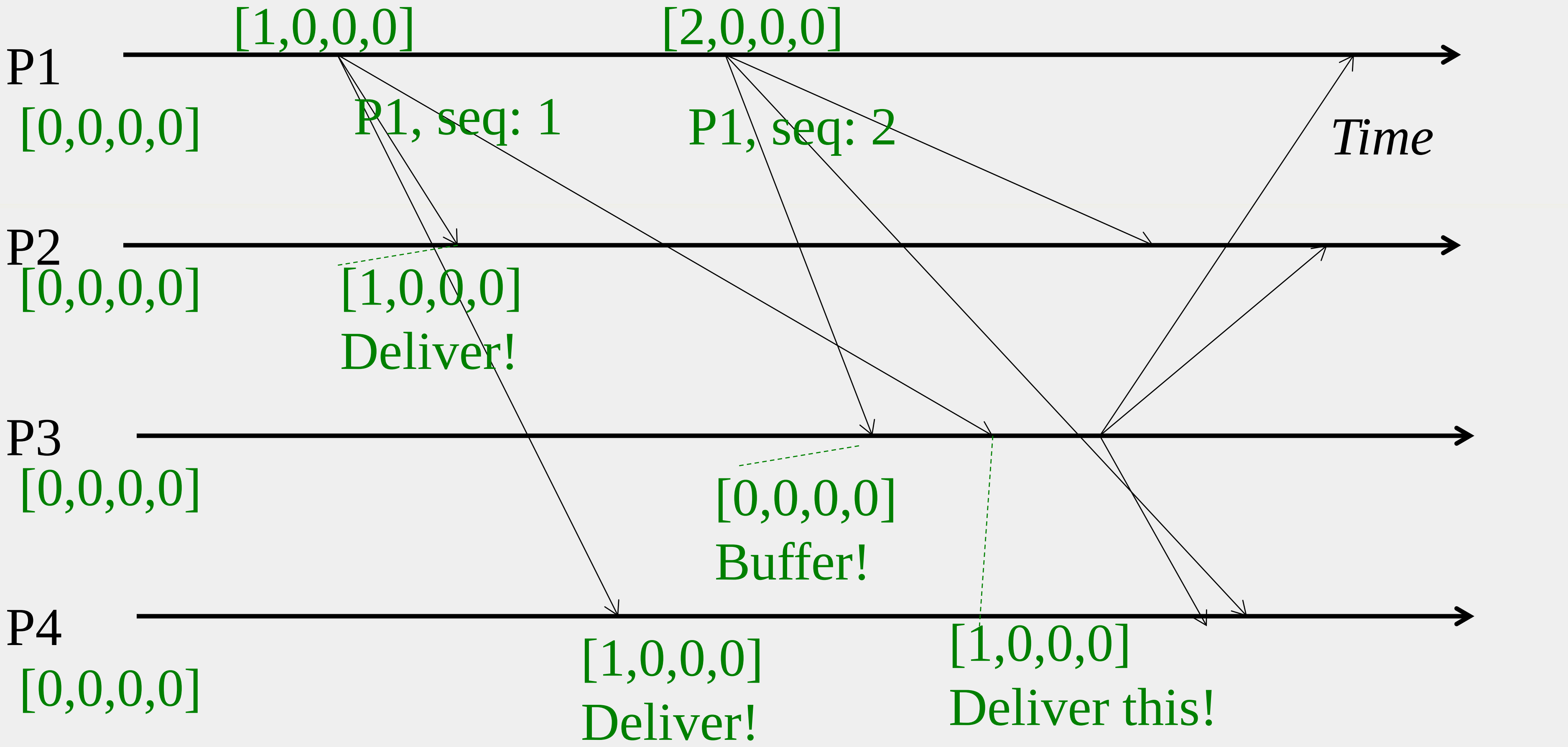
[0,0,0,0]

P4

[0,0,0,0]



FIFO Ordering: Example



P1

[0,0,0,0]

[1,0,0,0]

P1, seq: 1

[2,0,0,0]

P1, seq: 2

Time

P2

[0,0,0,0]

[1,0,0,0]
Deliver!

P3

[0,0,0,0]

[0,0,0,0]
Buffer!

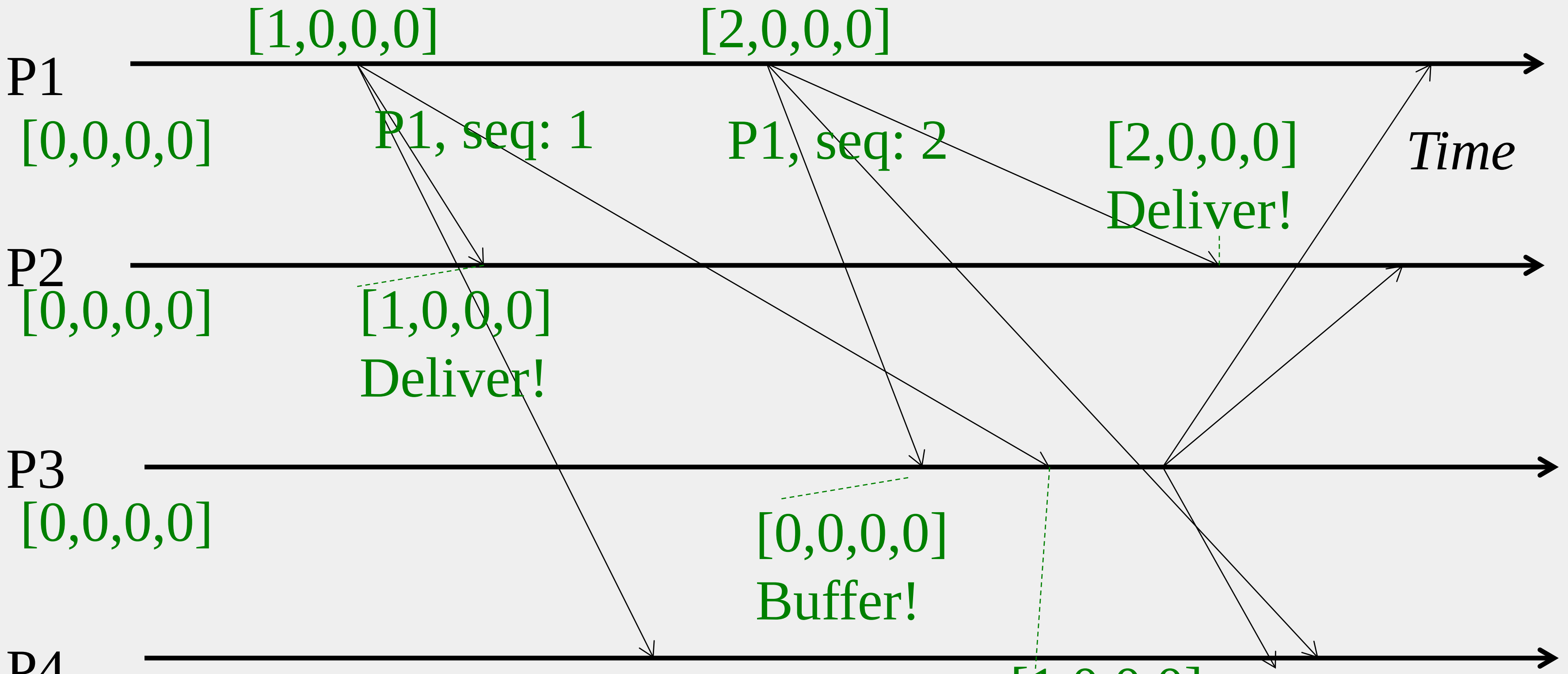
P4

[0,0,0,0]

[1,0,0,0]
Deliver!

[1,0,0,0]
Deliver this!
Deliver buffered <P1, seq:2>
Update [2,0,0,0]

FIFO Ordering: Example



[1,0,0,0]

[2,0,0,0]

P1

[0,0,0,0]

P1, seq: 1

P1, seq: 2

[2,0,0,0]

Deliver!

Time

P2

[0,0,0,0]

[1,0,0,0]

Deliver!

P3

[0,0,0,0]

[0,0,0,0]

Buffer!

P4

[0,0,0,0]

[1,0,0,0]

Deliver!

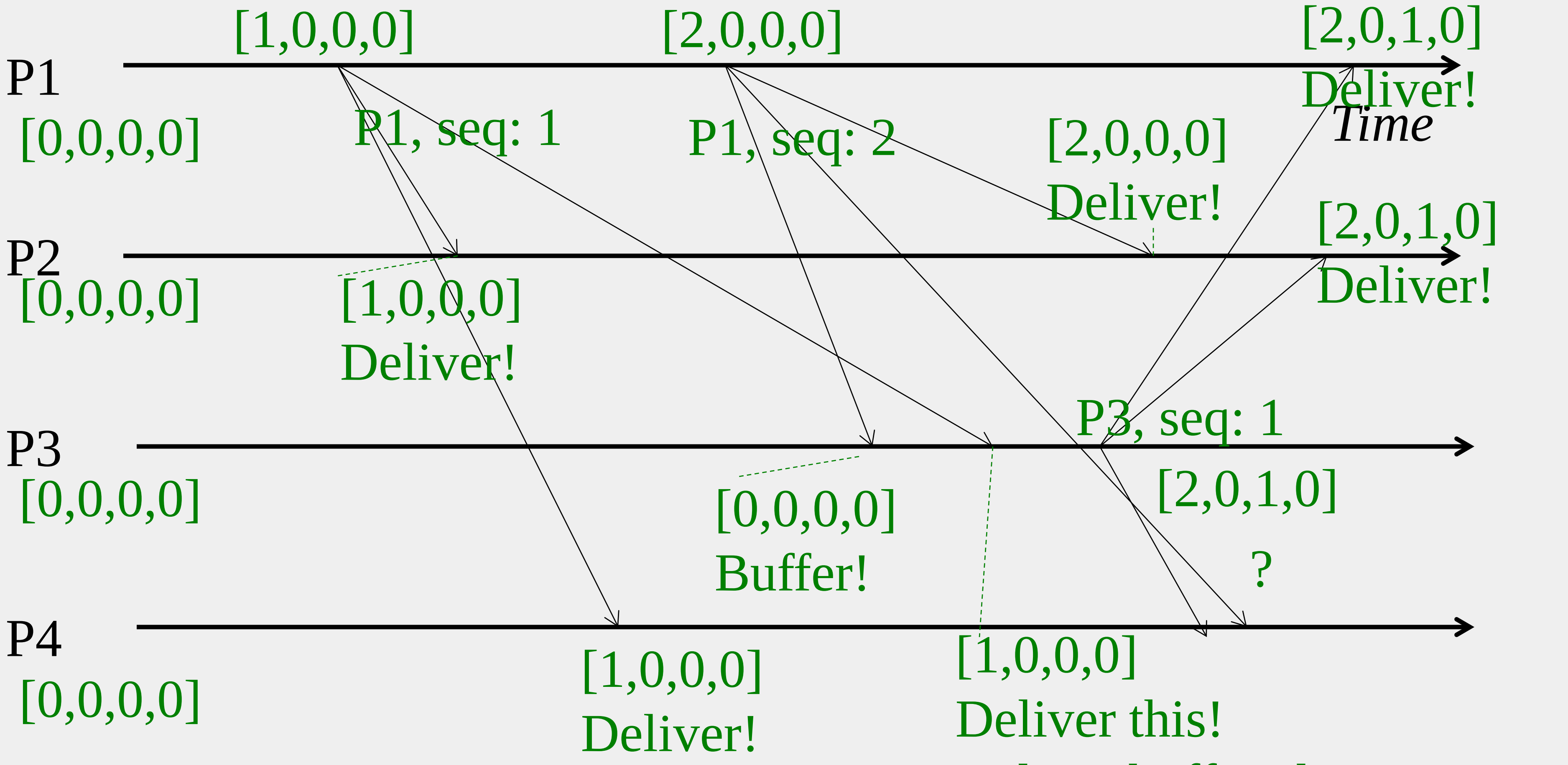
[1,0,0,0]

Deliver this!

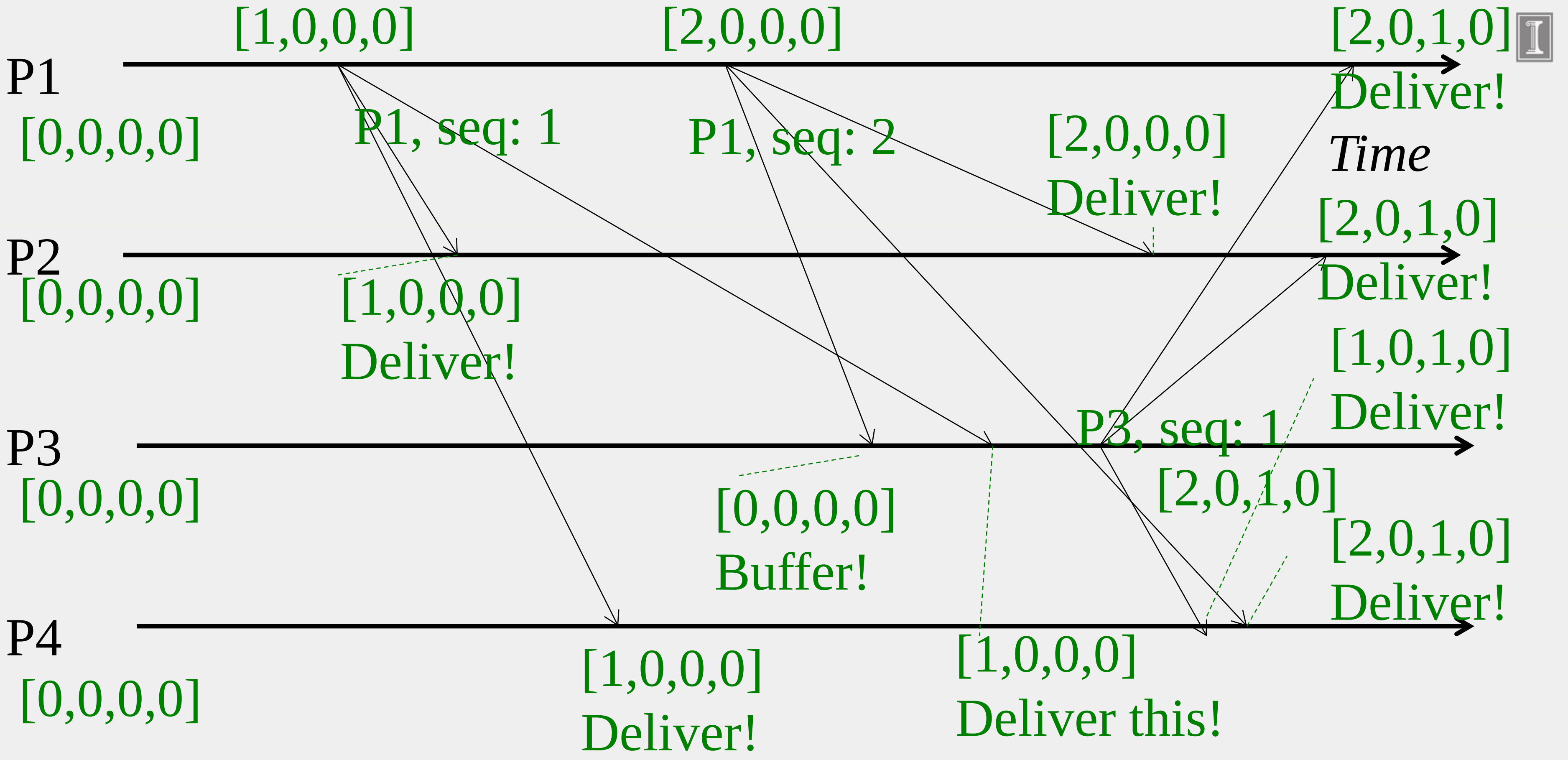
Deliver buffered <P1, seq:2>

Update [2,0,0,0]

FIFO Ordering: Example



FIFO Ordering: Example



P1

[0,0,0,0]

[1,0,0,0]

P1, seq: 1

[2,0,0,0]

P1, seq: 2

[2,0,1,0]

Deliver!

Time

P2

[0,0,0,0]

[1,0,0,0]

Deliver!

[2,0,0,0]

Deliver!

[2,0,1,0]

Deliver!

P3

[0,0,0,0]

[0,0,0,0]

Buffer!

P3, seq: 1

[2,0,1,0]

[1,0,1,0]

Deliver!

P4

[0,0,0,0]

[1,0,0,0]

Deliver!

[2,0,1,0]

Deliver!

[1,0,0,0]

Deliver this!

Deliver buffered <P1, seq:2>

Update [2,0,0,0]

FIFO Ordering: Example

Total Ordering

- Ensures all receivers receive all multicasts in the same order
- Formally
  - *If a correct process P delivers message m before m' (independent of the senders), then any other correct process P' that delivers m' would already have delivered m.*

Sequencer-based Approach

- Special process elected as leader or sequencer
- Send multicast at process P*i*:
  - Send multicast message M to group and sequencer
- Sequencer:
  - Maintains a global sequence number S (initially 0)
  - When it receives a multicast message M, it sets S = S + 1, and multicasts <M, S>
- Receive multicast at process P*i*:
  - P*i* maintains a local received global sequence number S*i* (initially 0)
  - If P*i* receives a multicast M from P*j*, it buffers it until it both
    1. P*i* receives <M, S(M)> from sequencer, and
    2. S*i* + 1 = S(M)
    - Then deliver it message to application and set S*i* = S*i* + 1

Next

- Implementing causal ordering