CLOUD COMPUTING CONCEPTS

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SNAPSHOTS

Lecture B

GLOBAL SNAPSHOT ALGORITHM

System Model

- **Problem: Record a global snapshot (state for each process, and state for each channel)**
- ***System Model*:**
  - *N* processes in the system
  - There are two uni-directional communication channels between each ordered process pair : P*j* → P*i* and P*i* → P*j*
  - Communication channels are FIFO-ordered
    - First in, first out
  - No failure
  - All messages arrive intact and are not duplicated
    - Other papers later relaxed some of these assumptions

Requirements

- **Snapshot should not interfere with normal application actions, and it should not require application to stop sending messages**
- **Each process is able to record its own state**
  - Process state: Application-defined state or, in the worst case:
  - Its heap, registers, program counter, code, etc. (essentially the coredump)
- **Global state is collected in a distributed manner**
- **Any process may initiate the snapshot**
  - We'll assume just one snapshot run for now

Chandy-Lamport Global Snapshot Algorithm

- **First, Initiator P*i* records its own state**
- **Initiator process creates special messages called "Marker" messages**
  - Not an application message, does not interfere with application messages

- **for *j=1 to N* except *i***

  P*i* sends out a Marker message on outgoing channel C_{ij}
  - (*N-1*) channels
- Starts recording the incoming messages on each of the incoming channels at P*i*: C_{ji} (for *j=1 to N* except *i*)

Chandy-Lamport Global Snapshot Algorithm (2)

Whenever a process P*i* receives a Marker message on an incoming channel C_{ki}

- **if** (this is the first Marker P*i* is seeing)
  - P*i* records its own state first
  - Marks the state of channel C_{ki} as "empty"
  - For *j=1 to N* except *i*
    - P*i* sends out a Marker message on outgoing channel C_{ij}
  - Starts recording the incoming messages on each of the incoming channels at P*i*: C_{ji} (for *j=1 to N* except *i* and *k*)
- **else // already seen a Marker message**
  - Mark the state of channel C_{ki} as all the messages that have arrived on it since recording was turned on for C_{ki}

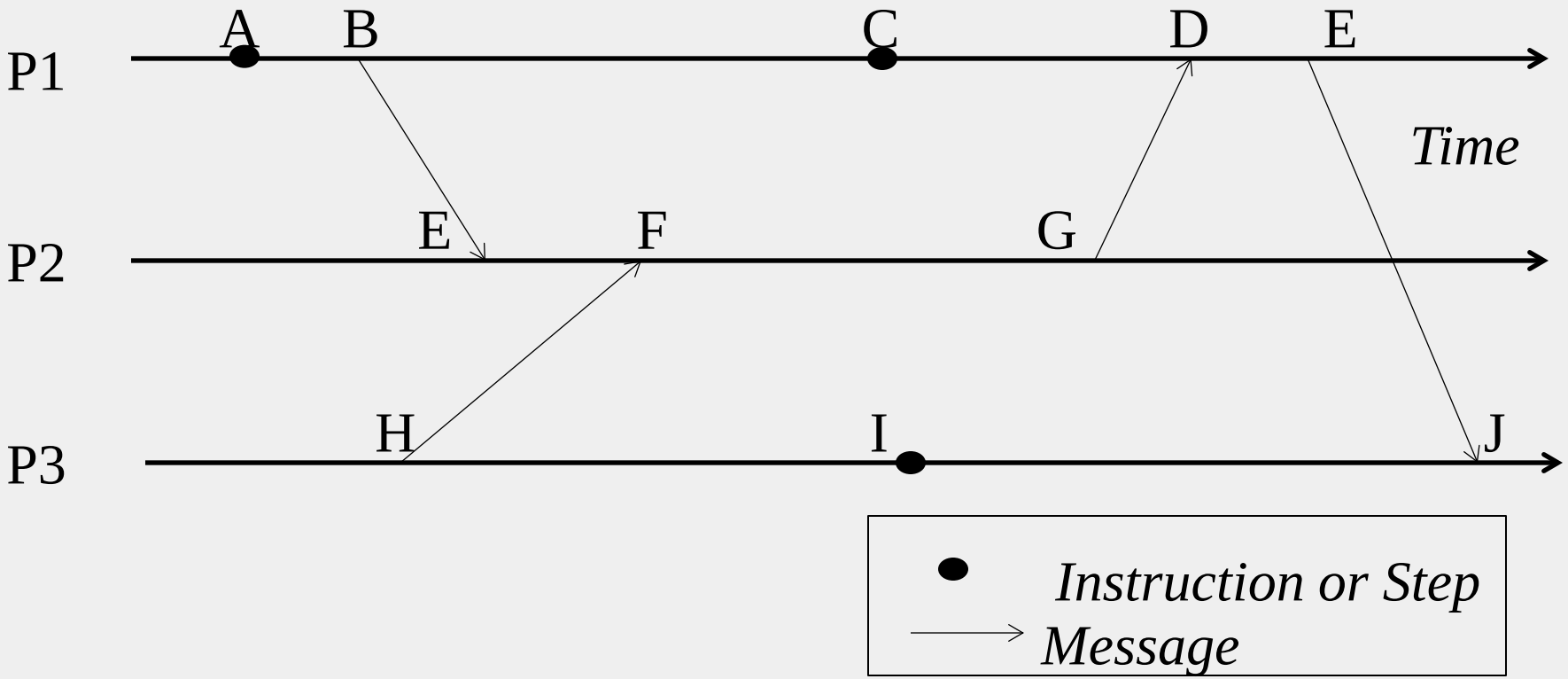
Chandy-Lamport Global Snapshot Algorithm (3)

The algorithm terminates when

- All processes have received a Marker
  - To record their own state
- All processes have received a Marker on all the (*N*-*1*) incoming channels at each
  - To record the state of all channels

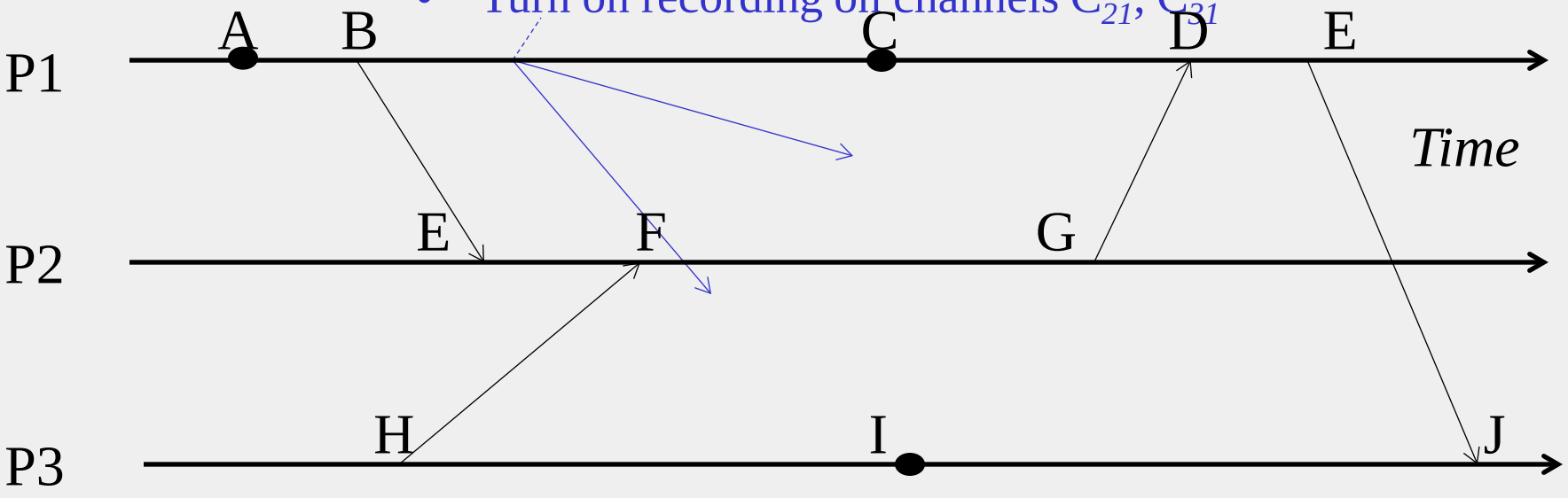
Then, (if needed), a central server collects all these partial state pieces to obtain the full global snapshot

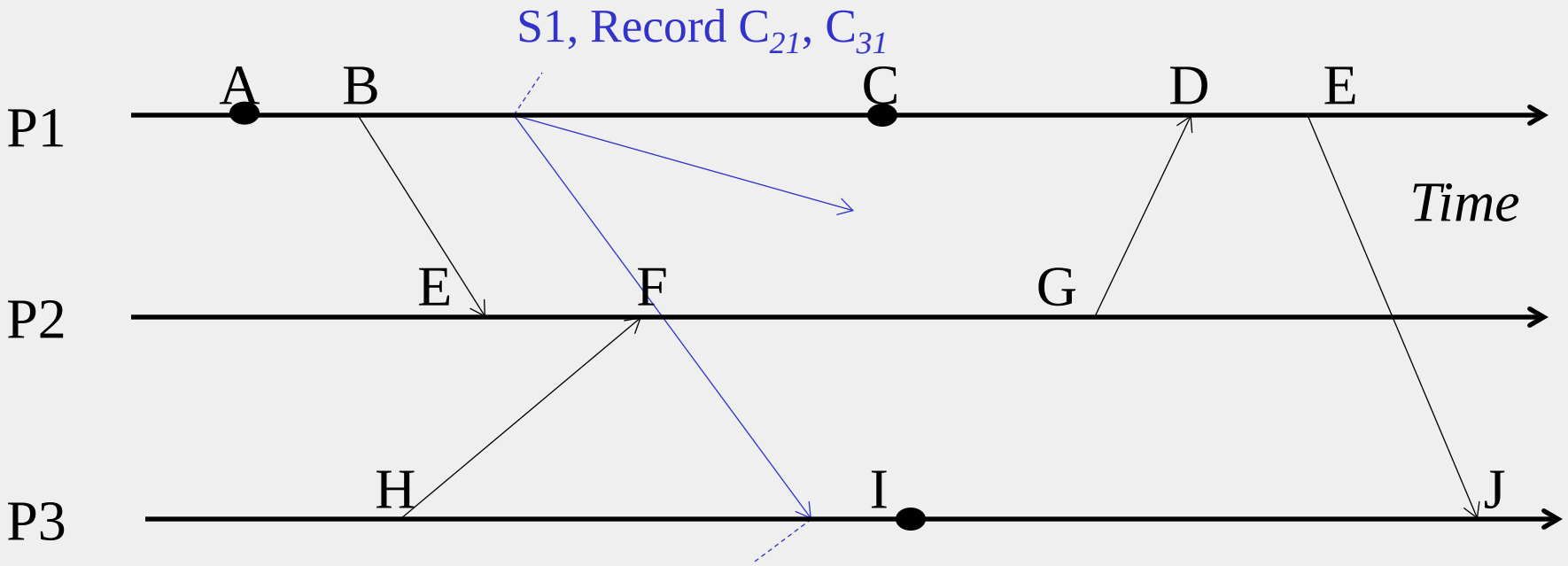
Example



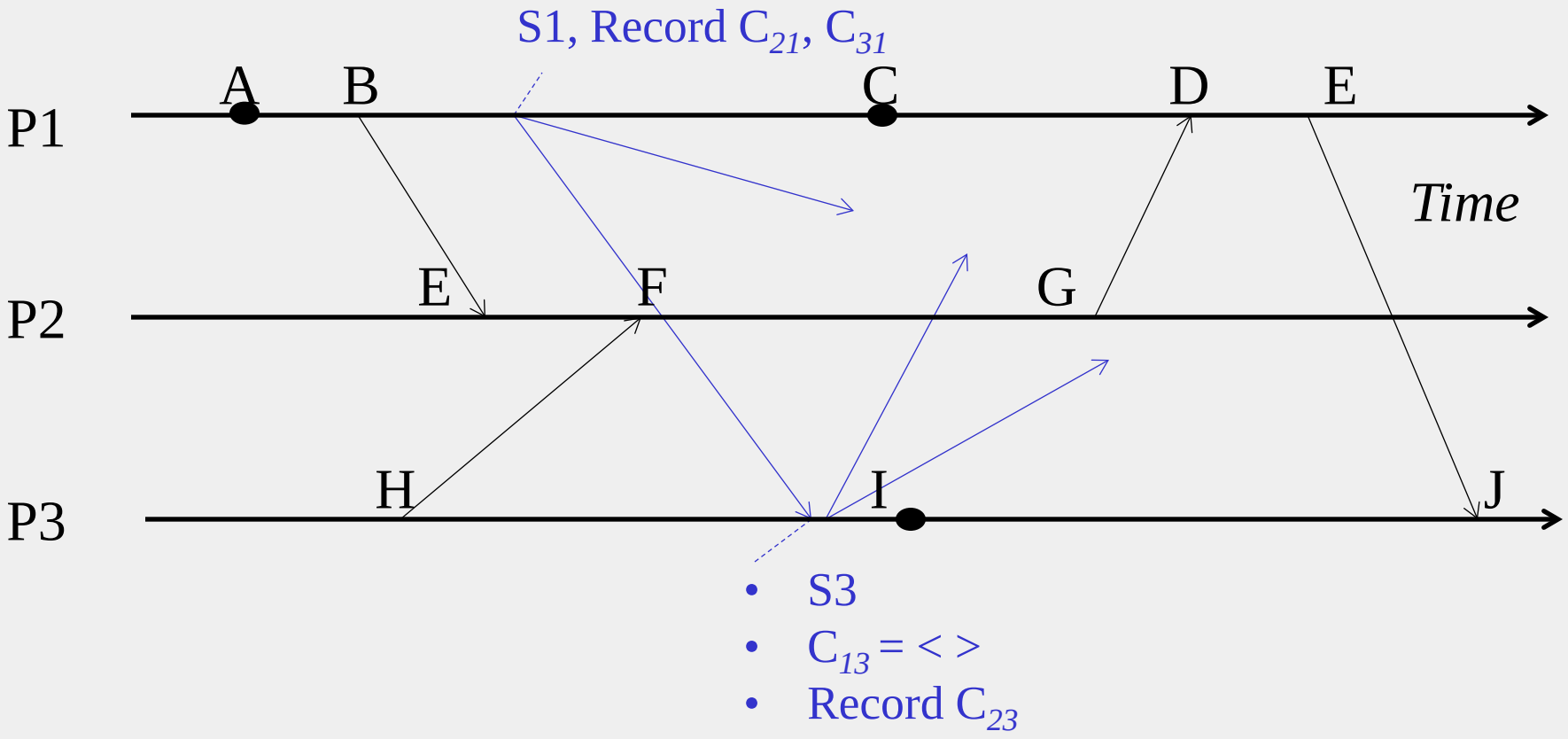
P1 is Initiator:

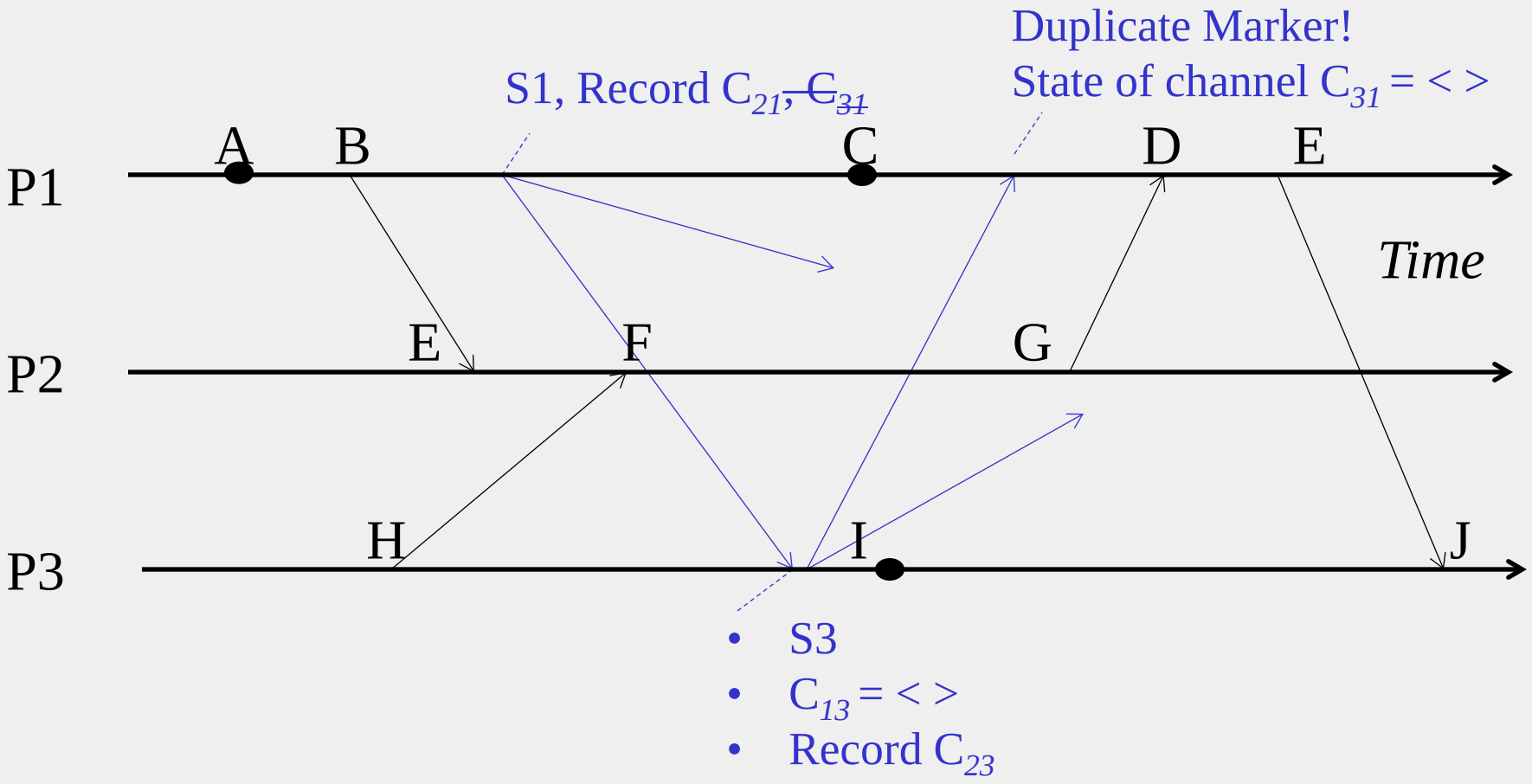
- Record local state S1
- Send out markers
- Turn on recording on channels C_{21}, C_{31}

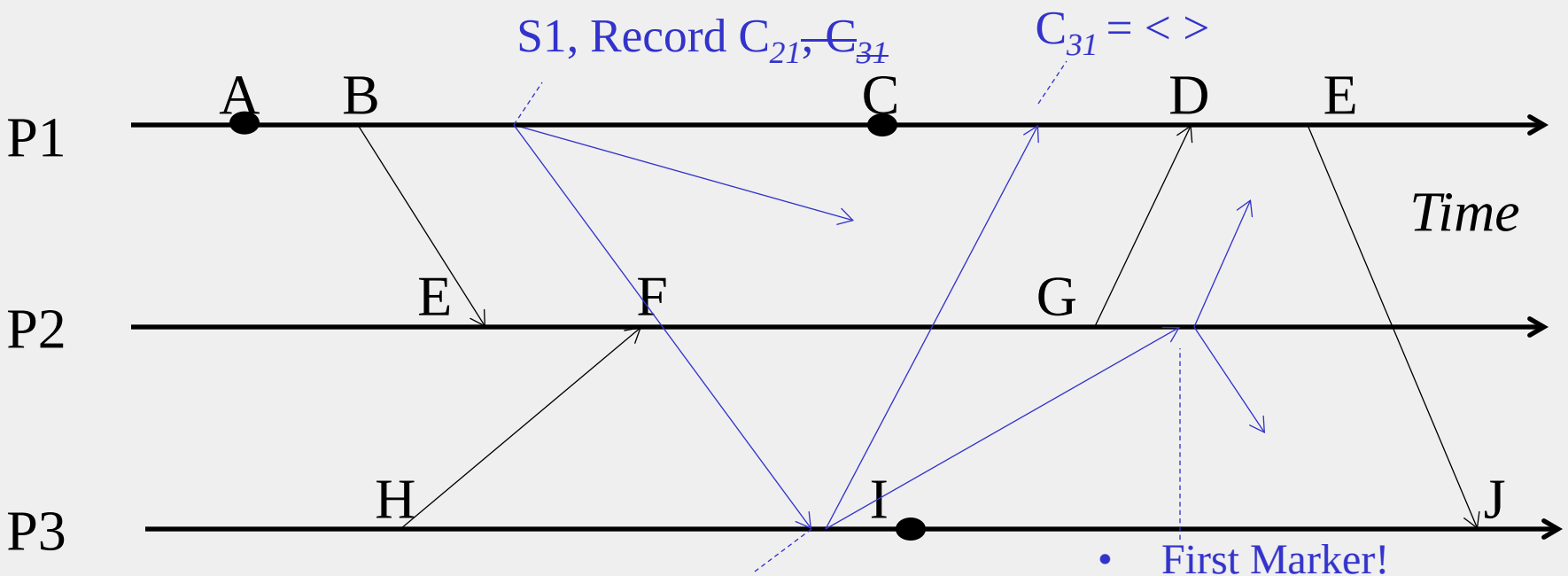




- First Marker!
- Record own state as S3
- Mark C_{13} state as empty
- Turn on recording on other incoming C_{23}
- Send out Markers

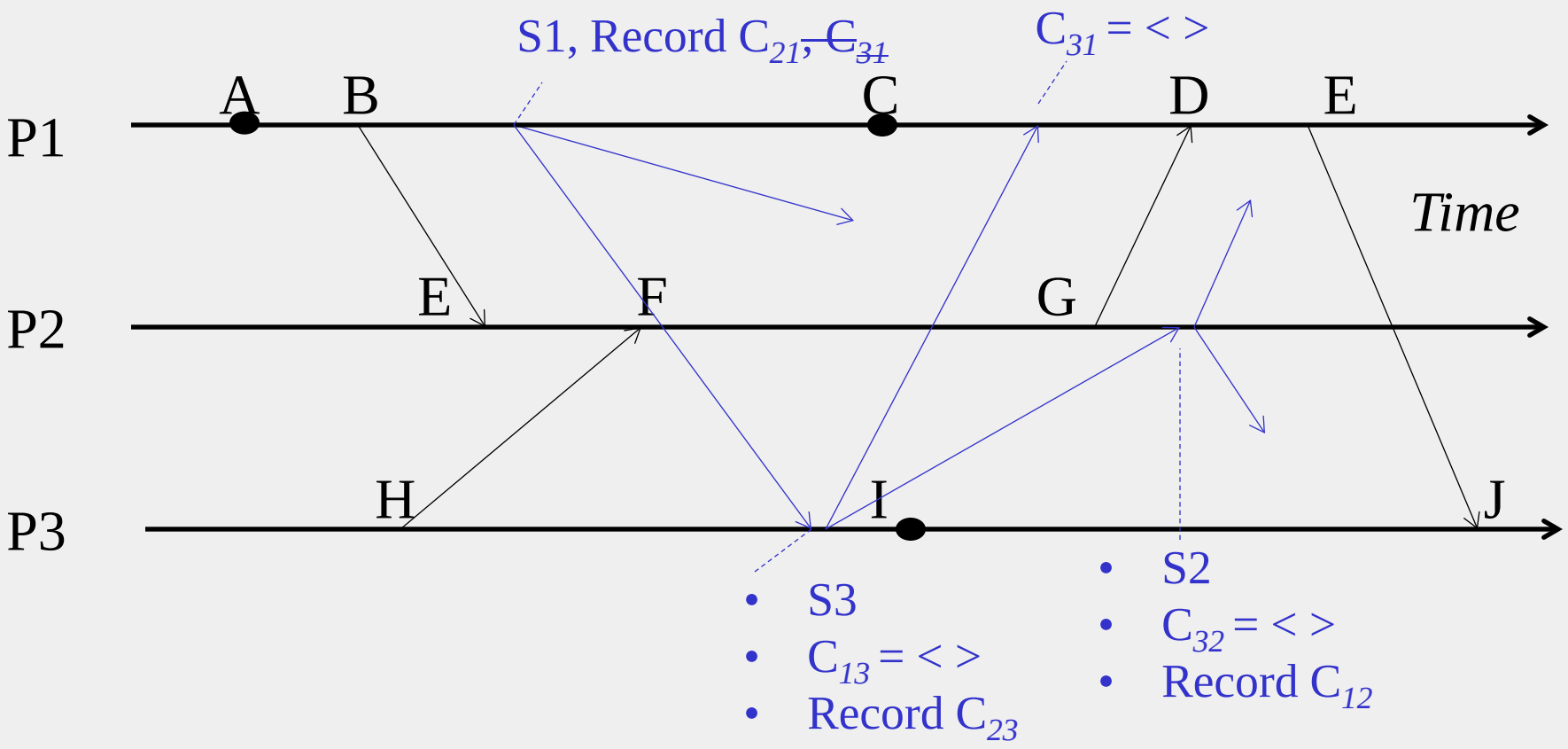

S1, Record C_{21}, C_{31}
A
B
C
D
E
P1
Time
E
F
G
P2
H
I
J
P3
S3
C_{13} = < >
Record C_{23}

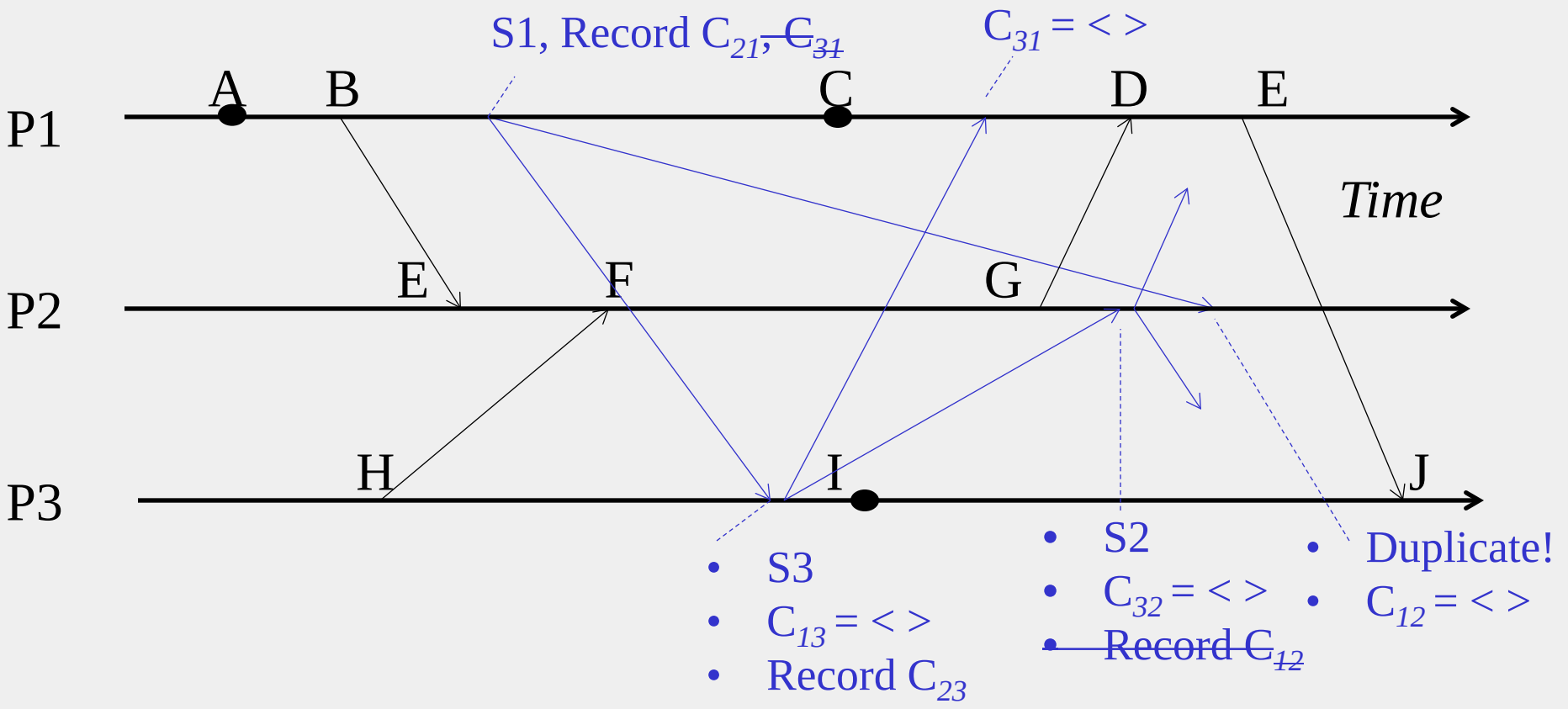

Duplicate Marker!
State of channel C_{31} = < >
S1, Record C_{21}, ~~C_{31}~~
A
B
C
D
E
P1
Time
E
F
G
P2
H
I
J
P3
• S3
• C_{13} = < >
• Record C_{23}

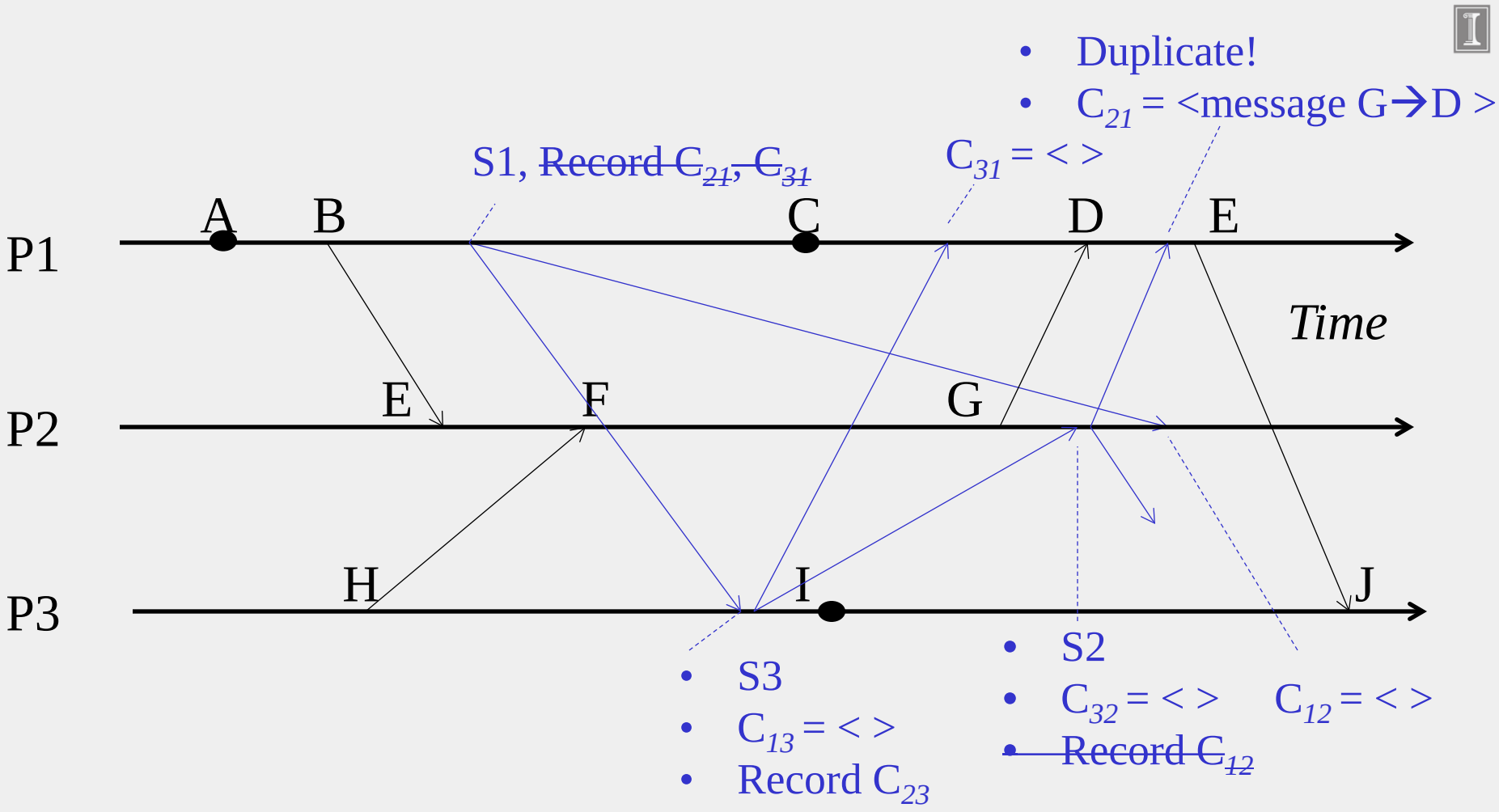


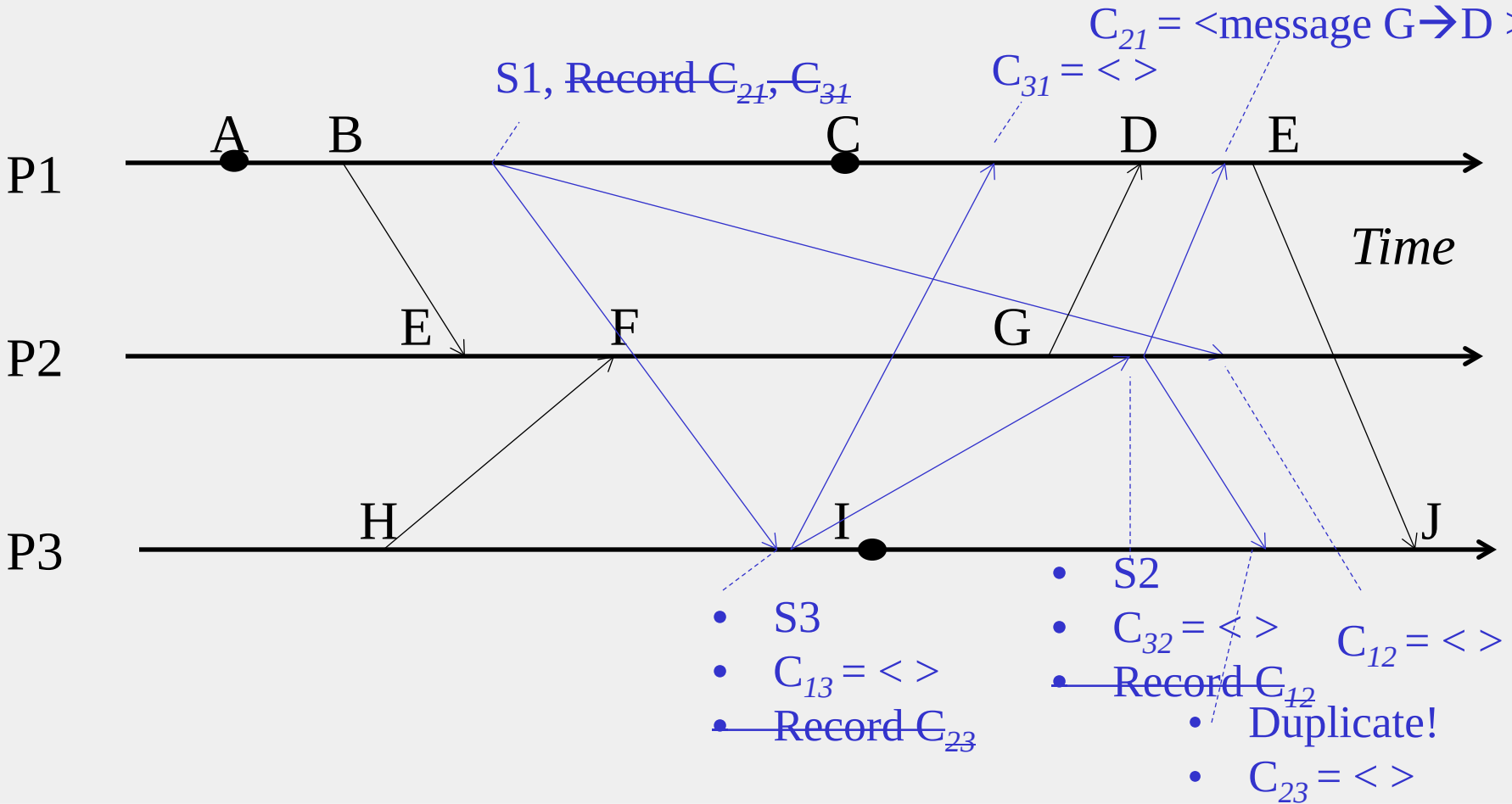
- S3
- C_{13} = < >
- Record C_{23}

- First Marker!
- Record own state as S2
- Mark C_{32} state as empty
- Turn on recording on C_{12}
- Send out Markers

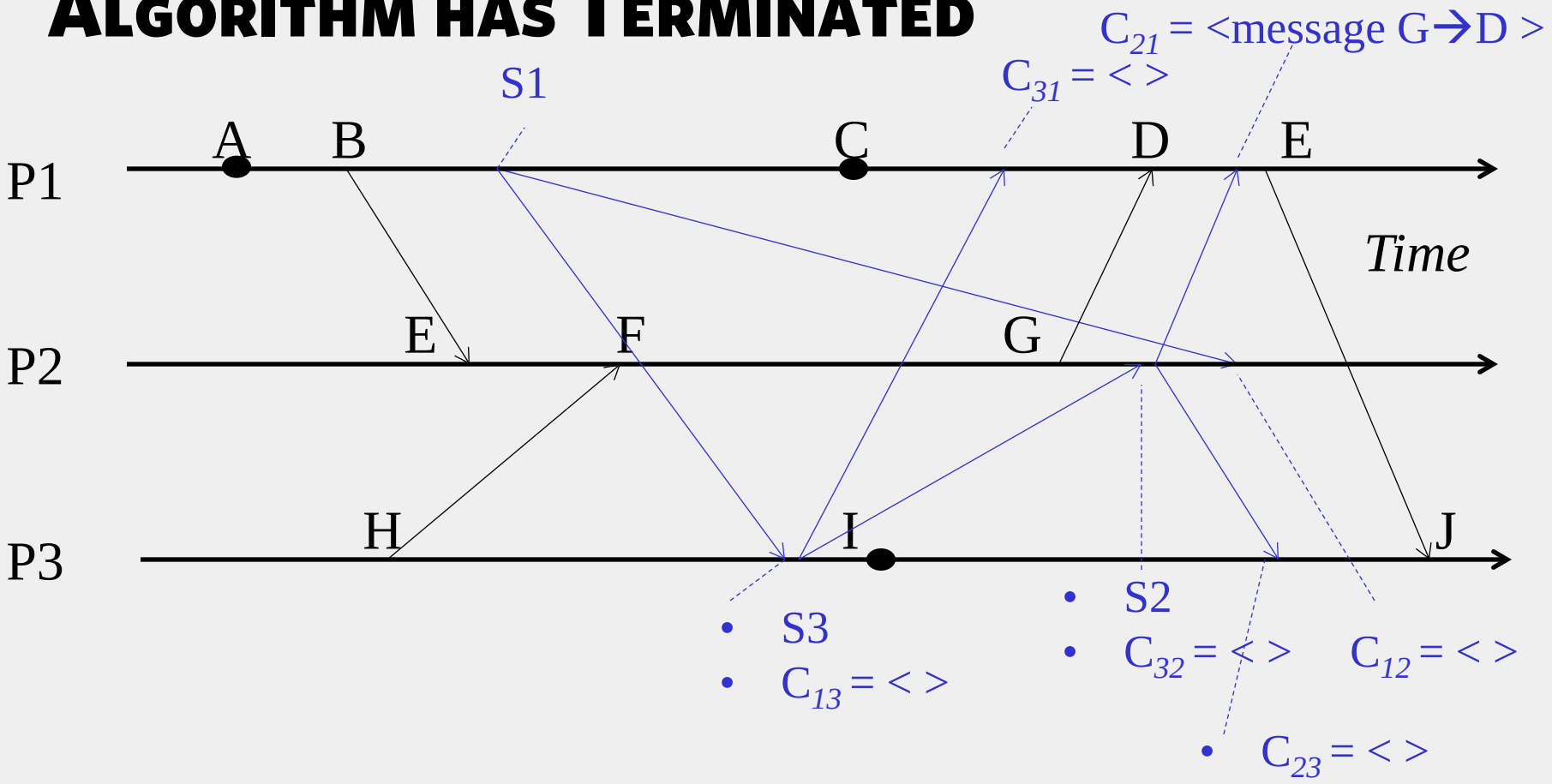

S1, Record C_{21}, ~~C_{31}~~
C_{31} = < >
A
B
C
D
E
P1
Time
E
F
G
P2
H
I
J
P3
• S3
• C_{13} = < >
• Record C_{23}
• S2
• C_{32} = < >
• Record C_{12}


S1, Record C_{21}, ~~C_{31}~~
C_{31} = < >
A
B
C
D
E
P1
Time
E
F
G
P2
H
I
J
P3
• S3
• C_{13} = < >
• Record C_{23}
• S2
• C_{32} = < >
• ~~Record C_{12}~~
• Duplicate!
• C_{12} = < >

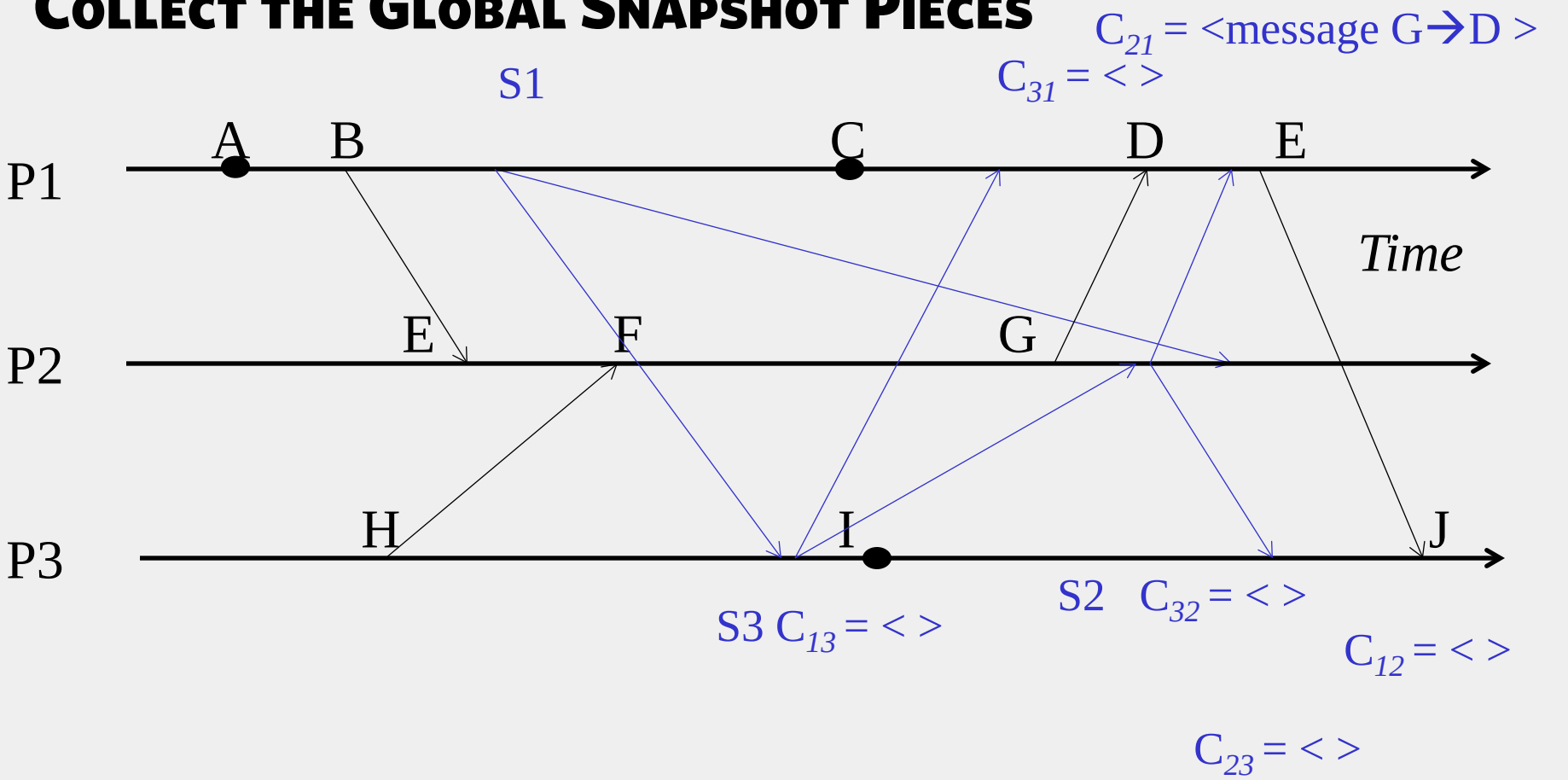

P1
P2
P3
A
B
C
D
E
E
F
G
H
I
J
Time
S1, ~~Record C_{21}, C_{31}~~
C_{31} = < >
• Duplicate!
• C_{21} = <message G→D >
• S3
• C_{13} = < >
• Record C_{23}
• S2
• C_{32} = < >
• ~~Record C_{12}~~
C_{12} = < >


P1
P2
P3
A
B
C
D
E
E
F
G
H
I
J
Time
S1, Record C_{21}, C_{31}
C_{31} = < >
C_{21} = <message G→D >
• S3
• C_{13} = < >
• Record C_{23}
• S2
• C_{32} = < >
• Record C_{12}
C_{12} = < >
• Duplicate!
• C_{23} = < >

Algorithm has Terminated



Collect the Global Snapshot Pieces



Next

- **Global Snapshot calculated by Chandy-Lamport algorithm is causally correct**
  - What?