UNIVERSITY OF TARTU
Institute of Computer Science

LTAT.06.007 Distributed Systems

Practical Seminar 6

Farooq Ayoub
TEACHING ASSISTANT

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Recap

- Code Migration using java
  - Java Reflection Utility
  - Sockets
  - Code Offloading

Agenda

- **Goal:** Calculate timestamps in Vector Clock
- **Content:**
  - Happens before relation
  - Need for Vector Clocks
  - Causality Relation
  - Rules for calculating timestamps in vector clocks
  - Comparison of vector clock timestamps

- **Quiz**

After this lecture, you should be able to:

- Understand how to calculate vector clock timestamps

Session Content

Description

- The use of Vector clocks is an attempt to move away from the use of a physical clock for measuring ordering of events in a Distributed System.

Observation

Instructions to complete this practical session can be found in the course website: https://https://courses.cs.ut.ee/2021/ds/spring/Main/Instructions2

Vector Clocks

- **Definition:**
    - The vector clocks provide a sort of a **Logical Clock** that assigns a unique id to events in a Distributed System, such that it captures the casual order among events in a Distributed System.
    - The Distributed System can be viewed as a system where series of processes are executed. These Processes communicate with each other via messages

The Happens before Relation (<)

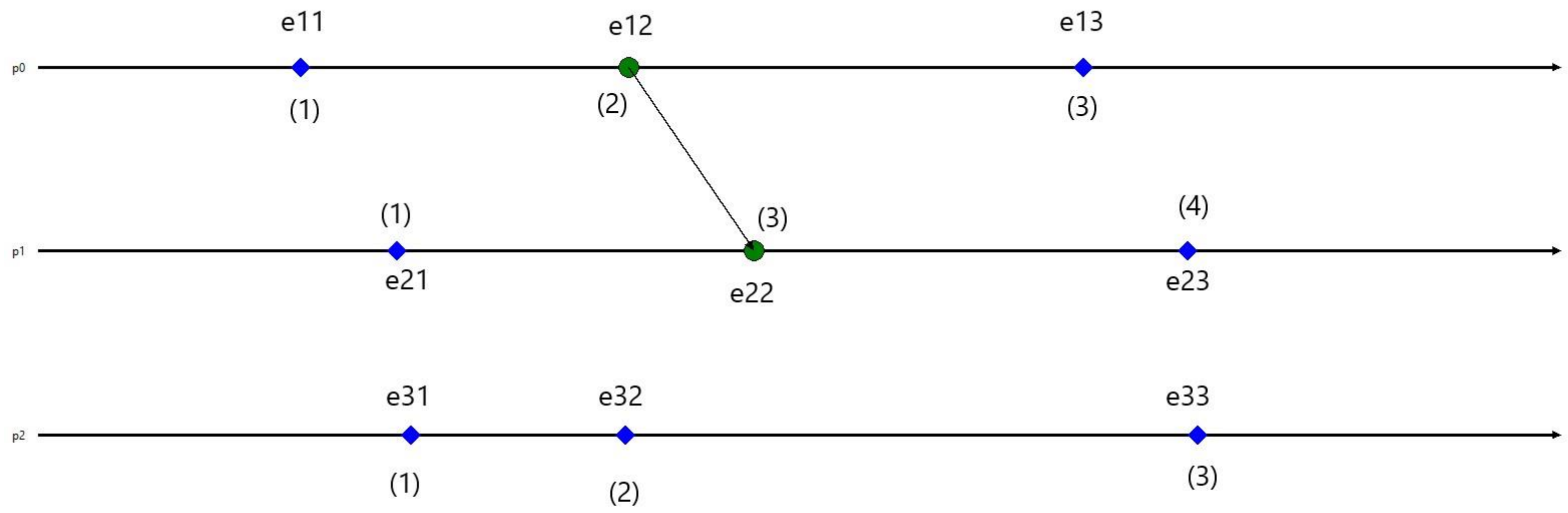
- If **a**, **b** are events in the same process, if **a** occurs before **b**, then **a < b**
- if **a** denotes sending of message in **process-a** and **b** denotes receipt of message in **process-b** then **a < b**
- The relation is **transitive**, **a < b and b < c => a < c**

Need for Vector Clocks

Eliminate limitations set by **Lamport's Logical Clock:**

- Looking at the Lamport's timestamps, we can not detect **Casual Relationship** in Lamport's logical clock and we can not conclude which events are casually related.
- Lamport's Logical Clock is a **Partial Order** of events.

Need for Vector Clocks



- **Consider the example:**
  - ➢ if **A -> B**, then it is true that **TS(A) < TS(B)**
  - ➢ But if **TS(A) < TS(B)**, then we can not conclude that **A -> B** (Not true for Concurrent Events)

➢ Even though C(e11) < C(e32), we can not say whether e11 happened before e32 or not. In other words, we cannot establish the casual relationship between these two events.

➢ The solution to this problem is to make use of **Vector Clock**

Casuality Relation:

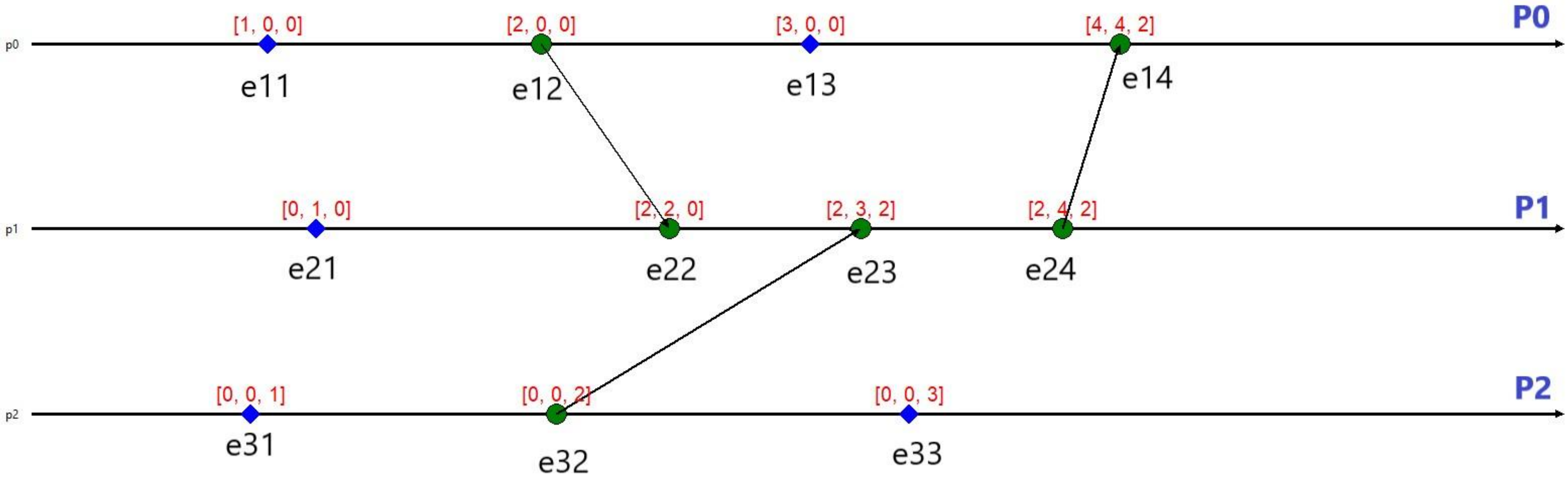
- It states: ***If an event e1 possibly influences the generation of event e2, then e1 < e2***
- The better way to establish such a relation is to rely on **message-passing** among the processes.
- Message passing establishes a ***happens before order*** on events based on the communication pattern.

Rules for Vector Clocks (Algorithm)

- Initially, all clocks are set to **0**
- $C_i[i] = C_i[i] + 1$, for two successive internal events at P_i
- At Process P_i , $C_i[j] = Max(C_i[j], tm[j])$, for all processes P_j ,

where **tm** is the vector timestamp borne by process **m** received by process P_i from some other process.

Vector Clocks (Example)



Comparison of Vector clock timestamps:

- **Equal:** $T_a = T_b$, iff for all processes P_i , $T_a[i] = T_b[i]$
  - For instance, (2,2,2) = (2,2,2)
- **Not Equal:** $T_a \neq T_b$, iff $T_a[i] \neq T_b[i]$ for atleast one P_i
  - For instance, (2,1,2) != (2,2,2)
- **Less than or Equal:** $T_a \leq T_b$, iff $T_a[i] \leq T_b[i]$ for all P_i
  - For instance, (2,1,2) ≤ (2,2,2)
- **Less than:** $T_a < T_b$, iff
  - for all P_i , $T_a[i] \leq T_b[i]$ and
  - there exists atleast one P_i , for which $T_a < T_b$
  - For instance, (2,1,2) < (2,2,2)
- **Concurrent:** $T_a \parallel T_b$, iff $T_a \not< T_b$ and $T_b \not< T_a$

Session Instructions at Course Page

Quiz

Content

- Lecture 6 (Clock synchronization for distributed processes)
- Two attempts
  - One in Seminar Session
  - Next available until Monday 23:50 (Deadline)
- Open Quiz in Moodle
- Total Quiz Points = 100

Observation

Quiz review is available after the quiz is closed

Questions?

E-mail: farooq.ayoub.dar@ut.ee