UNIVERSITY OF TARTU
Institute of Computer Science

LTAT.06.007 Distributed Systems

Practical Seminar 7

Farooq Ayoub

TEACHING ASSISTANT

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Recap

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

Agenda

- **Goal:** To Understand Election Algorithms
- **Content:**
  - Basic Assumptions in Election Algorithms
  - Need for Election Algorithms
  - Types of Election Algorithms
  - Bully Algorithm
  - Bully Algorithm Explained

- **Quiz**

After this lecture, you should be able to:

- Understand and apply bullying algorithm to a set of processes

Session Content

Description

- To understand the concept behind **Election Algorithms**.
- Learn how to apply **election algorithm by bullying** to a system of processes
- In Election algorithms, We require some Processes to act as a **Coordinator**. The main issue here is to how to select this Coordinator dynamically.

Observation

Instructions to complete this practical session can be found in the course website: https://https://courses.cs.ut.ee/2021/ds/spring/Main/Instructions3

Basic Assumptions

- All processes have unique id’s
- All processes know id’s of all processes in the system (but not if they are up or down)
- Election means identifying the most suitable process based on different factors, e.g., highest id

INTRODUCTION

- In Election Algorithms, one process needs to act as a coordinator.
- The technique or algorithm here is to pick up a Unique Coordinator.
- The need to choose a Unique Coordinator arises in case of a failed process or when we need to pick a master in Berkeley Clock Synchronization Algorithm.
- Types of Election Algorithm:
  - Bully Algorithm
  - Ring Algorithm

ELECTION VIA BULLYING

- Each process has a Unique Numerical ID.
- Processes know the ID's and address of every other process.
- Communication is assumed to be reliable.
- The **key idea** as mentioned earlier is to **select process with highest ID**.
- Process initiates election if it just recovered from failure or if coordinator has just failed.
- Several Processes can initiate an election simultaneously.
- The messages required to be sent with **n** Processes is of the order of $\mathbf{O(n^2)}$

ALGORITHM STEPS

Consider N processes (P_0 …..P_{N-1}) and let id(P_K) = k. When a process P_K notices that the coordinator is no longer responding to requests, it initiates an election:

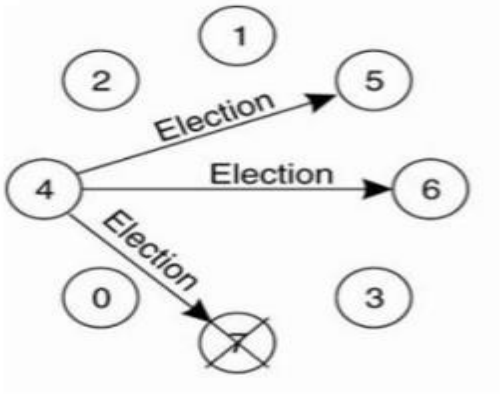
- P_K sends an ELECTION message to all processes with higher identifiers: P_{K+1}, P_{K+2} ..... P_{N-1}
- If no one responds, P_K wins the election and becomes coordinator.
- If one of the higher-ups answers, it takes over and P_K's job is done.

ALGORITHM EXPLAINED

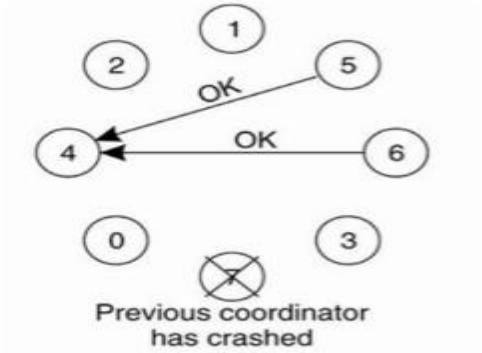
Suppose Process P sends a message to the coordinator:

- If Coordinator does not respond to the request within a time interval T, then it is assumed that the coordinator has failed.
- Now Process P sends **election** message to every process with high priority number.
- It waits for response, if no process responds in time interval T, then process P elects itself as Coordinator.
- Then it sends a message to all lower priority numbers that it is elected as their new coordinator.
- However, if an answer is received within time T from any other process Q:
  - Process P again waits for time interval T to receive another message from Q that it has been elected as Coordinator.
  - If Q doesn't respond within time interval T, Then it is assumed to have failed and the algorithm is restarted.

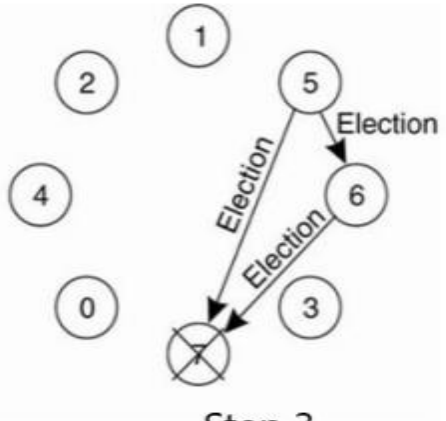
BULLY ALGORITHM: Example



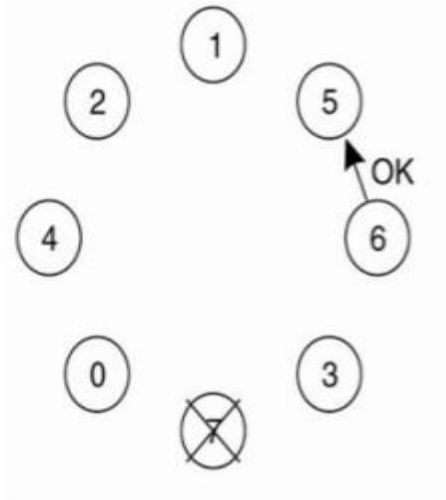
Step 1



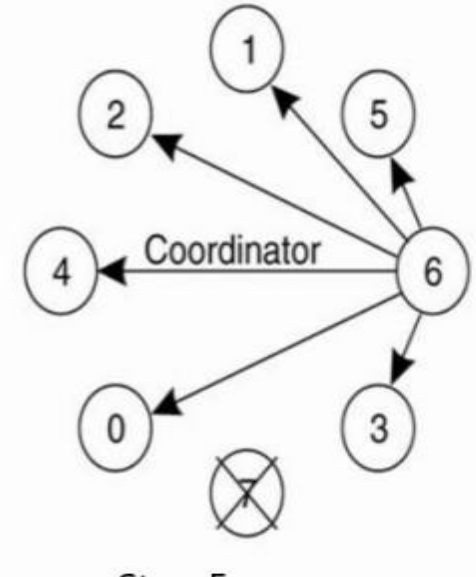
Step 2



Step 3



Step 4



Step 5

BULLY ALGORITHM: Example

In the example:

- Process 7 which was the Coordinator fails.
- Process P4 starts an election and a total of **15 messages** are required to elect a new coordinator.
- The number of messages required depends on which Process initiates the election:
  - If Process 0 starts an election, maximum number of messages will be required to elect a new coordinator (**Worst Case**).
  - If Process 6 initiates an election, minimum number of messages will be required to elect a new coordinator (**Best Case**).

Session Instructions at Course Page

Quiz

Content

- Lecture 7 (Mutual exclusion and election algorithms)
- 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