Improved Bully Election Algorithm for Distributed Systems

P Beaulah Soundarabai, Ritesh Sahai, Thriveni J, K R Venugopal, L M Patnaik

Department of Computer Science, Christ University, Bangalore 560 029 India,
Contact: beaulah.s@christuniversity.in

University Visvesvaraya College of Engineering, Bangalore University, Bangalore.

Honorary Professor, Indian Institute of Science, Bangalore.

ELECTING A LEADER IS A CLASSICAL PROBLEM IN DISTRIBUTED COMPUTING SYSTEM. SYNCHRONIZATION BETWEEN PROCESSES OFTEN REQUIRES ONE PROCESS ACTING AS A COORDINATOR. IF AN ELECTED LEADER NODE FAILS, THE OTHER NODES OF THE SYSTEM NEED TO ELECT ANOTHER LEADER WITHOUT MUCH WASTING OF TIME. THE BULLY ALGORITHM IS A CLASSICAL APPROACH FOR ELECTING A LEADER IN A SYNCHRONOUS DISTRIBUTED COMPUTING SYSTEM, WHICH IS USED TO DETERMINE THE PROCESS WITH HIGHEST PRIORITY NUMBER AS THE COORDINATOR. IN THIS PAPER, WE HAVE DISCUSSED THE LIMITATIONS OF BULLY ALGORITHM AND PROPOSED A SIMPLE AND EFFICIENT METHOD FOR THE BULLY ALGORITHM WHICH REDUCES THE NUMBER OF MESSAGES DURING THE ELECTION. OUR ANALYTICAL SIMULATION SHOWS THAT, OUR PROPOSED ALGORITHM IS MORE EFFICIENT THAN THE BULLY ALGORITHM WITH FEWER MESSAGES PASSING AND FEWER STAGES.

KEYWORDS: BULLY ALGORITHM, DISTRIBUTED SYSTEMS, LEADER ELECTION, SYNCHRONIZATION.

1. INTRODUCTION

DISTRIBUTED COMPUTING IS A DECENTRALIZED AND PARALLEL COMPUTING, USING TWO OR MORE COMPUTERS COMMUNICATING OVER A NETWORK TO ACCOMPLISH A COMMON TASK. CENTRALIZED CONTROL IN DISTRIBUTED SYSTEMS HELPS TO ACHIEVE SOME SPECIFIC GOALS SUCH AS MUTUAL EXCLUSION, SYNCHRONIZATION, LOAD BALANCING, AND TIME SCHEDULING. THIS TYPE OF DISTRIBUTED SYSTEM OFTEN REQUIRES A UNIQUE NODE TO PLAY THE ROLE OF LEADER OR COORDINATOR OF THE OTHER NODES TO TAKE CARE OF SYNCHRONIZATION. AS NODE CRASH FAILURE IS VERY COMMON IN DISTRIBUTED SYSTEMS. FAILURE OF A LEADER NODE REQUIRES SPECIAL ATTENTION AND NEEDS EXTRA TASKS TO ELECT ANOTHER ONE TO ACT AS LEADER.

THE COLLABORATING PROCESSES ARE OFTEN IDENTICAL. ONE OF THE CENTRAL PROBLEMS IS ELECTION OF A LEADER. GIVEN A NETWORK OF PROCESSES, EXACTLY ONE PROCESS SHOULD TAKE THE DECISION THAT IT IS THE LEADER. IT IS USUALLY REQUIRED THAT ALL NON-LEADER PROCESSES ARE INFORMED OR INVOLVED IN THE PROCESS OF THE LEADER ELECTION. A LEADER ELECTION ALGORITHM IS ONE OF THE BASIC ACTIVITIES OF DISTRIBUTED SYSTEMS, AS IT ACTS AS A BASIS FOR MORE COMPLEX AND HIGH LEVEL ALGORITHMS AND APPLICATIONS. AN IMPORTANT CHALLENGE IN DISTRIBUTED SYSTEMS IS THE ADOPTION OF SUITABLE AND EFFICIENT ALGORITHMS FOR COORDINATOR ELECTION. THE MAIN ROLE OF AN ELECTED COORDINATOR IS TO MANAGE THE USE OF A SHARED RESOURCE IN AN OPTIMAL MANNER WHICH IN TURN MAINTAINS THE COHERENCY OF THE SYSTEM EVEN DURING PARTIAL FAILURES.

1.1. Motivation

The main drawback of Bully algorithm is more number of message passing. As it is mentioned before the message passing has order O(n^2) that increases traffic in network. It also has five stages to decide the next leader which would waste a lot of time for the processes to resume their normal execution. Bully algorithm is a safe way for election; however its traffic is relatively high.

1.2. Contribution

In this paper, we have proposed a modified Bully algorithm which preserves all the advantages of the existing algorithm and at the same time eliminates the limitations of it by reducing...
Simplifying the above formula, we get
\[ T_m = \frac{n(n + 1)}{2} \]  
which is of \(O(n^2)\).

In our modified algorithm, considering worst case and assuming lowest process start election, then:

(i) Total number of election message sent to set \((S)\) of \(n\) processes \(\{(P_1, P_2, P_3, \ldots, P_n)\}\) are \((n - 1)\).

(ii) Total response message received is \((n - 1)\).

(iii) Informing to coordinator and coordinator to check with past coordinator involve two messages, and

(iv) Finally informing to every process by sending coordinator message is again \((n - 1)\) message.

The number of message passing between processes for performing election is obtained from the following formula:

\[ T_m = (n - 1) + (n - 1) + 1 + 1 + (n - 1), \text{ or} \]
\[ T_m = 3n - 1 \text{ or } 3n \]  
which is of \(O(n)\).

6. CONCLUSIONS

In this paper, we discussed the drawbacks of Bully algorithm and then we presented an optimized method for the Bully algorithm called modified bully algorithm. Modified Bully algorithm shows improved performance than the Bully algorithm. The additional advantages of modified Bully algorithm are that this algorithm is a very simple, having fail-safe mechanism, no parallel election, and reduced number of messages.

Our analytical simulation shows that our algorithm is more efficient rather than the Bully algorithm, in both number of message passing and the number of stages, and when only one process runs the algorithm message passing complexity decreased from \(O(n^2)\) to \(O(n)\).

In this analysis we consider the worst case in modified algorithm. Result of this analysis clearly shows that modified algorithm is better than bully algorithm with fewer message passing and the fewer stages.

REFERENCES


P Beaulah Soundarabai is presently an Assistant Professor in the Department of Computer Science in Christ University, Bangalore. She obtained her Bachelors, Masters Degrees in Computer Applications from Madurai Kamarai University, Madurai. She also has completed M. Phil. in Computer Science. Presently she is pursuing Ph.D in the field of Distributed Systems in Christ University.

Thriveni J has completed Bachelor of Engineering, Masters of Engineering and Doctoral Degree in Computer Science and Engineering. She has 4 years of industrial experience and 16 years of teaching experience. Currently she is an Associate Professor in the Department of Computer Science and Engineering, University Visvesvaraya College of Engineering, Bangalore. Her research interests include Networks, Data Mining and Biometrics.

Venugopal K R is currently the Principal, University Visvesvaraya College of Engineering, Bangalore University, Bangalore. He obtained his Bachelor of Engineering from University Visvesvaraya College of Engineering. He received his Masters degree in Computer Science and Automation from Indian Institute of Science Bangaluru. He was awarded Ph.D in Economics from Bangalore University and Ph.D in Computer Science from Indian Institute of Technology, Madras. He has a distinguished academic career and has degrees in Electronics, Economics, Law, Business Finance, Public Relations, Communications, Industrial Relations, Computer Science and Journalism. He has authored and edited 39 books on Computer Science and Economics, which include Petrodollar and the World Economy, C Aptitude, Mastering C, Microprocessor Programming, Mastering C++ and Digital Circuits and Systems etc. During his three decades of service at UVCE he has over 400 research papers to his credit. His research interests include Computer Networks, Wireless Sensor Networks, Parallel and Distributed Systems, Digital Signal Processing and Data Mining.

L M Patnaik is currently Honorary Professor, Indian Institute of Science, Bangalore, India. He was a Vice Chancellor, Defense Institute of Advanced Technology, Pune, India and was a Professor since 1986 with the Department of Computer Science and Automation, Indian Institute of Science, Bangalore. During the past 35 years of his service at the Institute he has over 700 research publications in refereed International Journals and refereed International Conference Proceedings. He is a Fellow of all the four leading Science and Engineering Academies in India; Fellow of the IEEE and the Academy of Science for the Developing World. He has received twenty national and international awards; notable among them is the IEEE Technical Achievement Award for his significant contributions to High Performance Computing and Soft Computing. His areas of research interest have been Parallel and Distributed Computing, Mobile Computing, CAD for VLSI circuits, Soft Computing and Computational Neuroscience.