Report for Distribution system AS1

1.Main implementation choice

Basic node and network

For LCR using new objects Node which format similar to arraylist (each node has the address of next node) to simulate processor and Nodes which include a head Node to simulate the network. This data structure can make sure each node could find and only find the next node.

For HS add previous pointer to each Node to ensure the both direction communication.

Message send and store

In LCR use an integer variable to send ID, for the sender there is a variable save what to send, for the receiver there is a variable to save what received.

In HS send part there used a new object NodePackage which include ID, hopcount and status to record the message generator ID which used to judge by the receiver, the current pass distance which could ensure the package pass for only limited distance, the status include in and out to make the package generator to judge pass a package next or become leader.

In HS storage part, because for each node there may be more than 1 packages required to send, there used a Queue object to store packages need to send or received from other nodes.

2.Main functionality of simulator

Nodes ID generation

Generate n*a nodes then disrupt the order, then get 1 to n elements in the list as ID generate for each node. For clockwise and counter-clockwise generation there add a sort method to make the Ids in order needed.

Simulate run of each individual nodes

At first run the first round function for each algorithm. Then use loop to run read function for each node, each decision will be save in the storage of the node. Next use loop to run send function to each node to act as decision made in same round before. this structure could ensure each node can read and send message just as processing in parallel. In addition, for each read function there is all the main judgement of LCR and HS algorithm separately which ensure the execute of each leader election algorithm.

3.Experiments conduct set

There used several global variables in the Nodes class for network to record several important numbers, such as: the biggest ID in ID distribution, the leader ID elected, the number of message send in leader election process, the round/phases to elect the leader in LCR and HS, the total round of the simulator run for the network in step process include terminate process. There are also some functions to show the result and a print brief result which could simplify the gather of results. For graph part save all the experiment results in multidimensional array then use jfreechart outer package to support graph function.

4.Experiments findings

Analyze code run result:

DATA set:

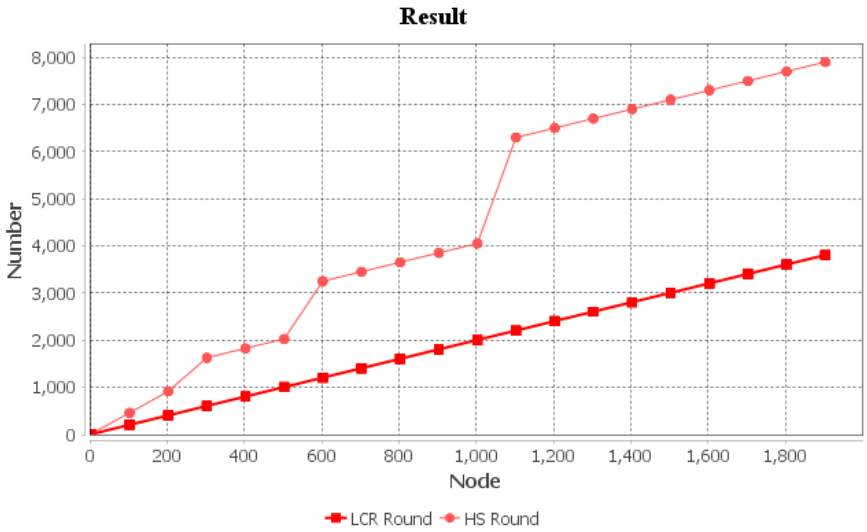
To get the time complexity and Communication complexity of each algorithm there chooses node number as X axis, Round and Message sent as Y axis.

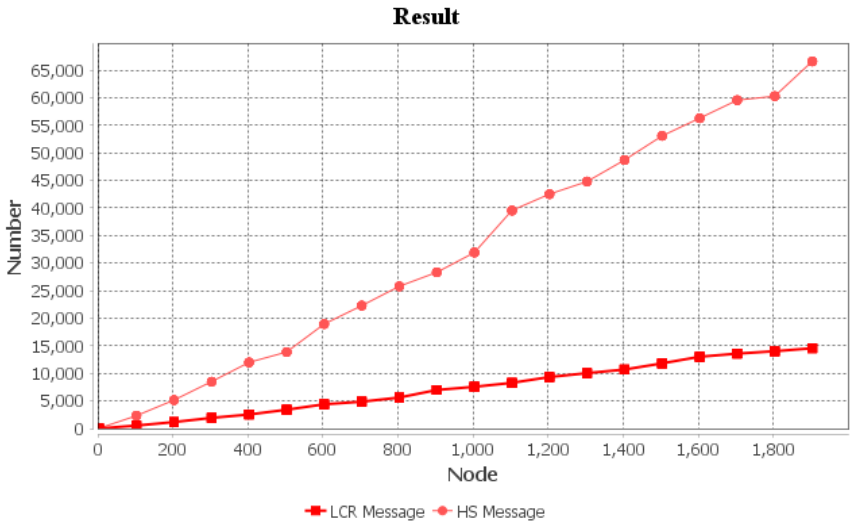
Round: calculate the round in total for each algorithm until terminate. The HS termination method in my simulation used same methods as LCR which could cause N/2 more rounds than terminate in both side.

Message: calculate the message number in total for each algorithm until elected the leader.

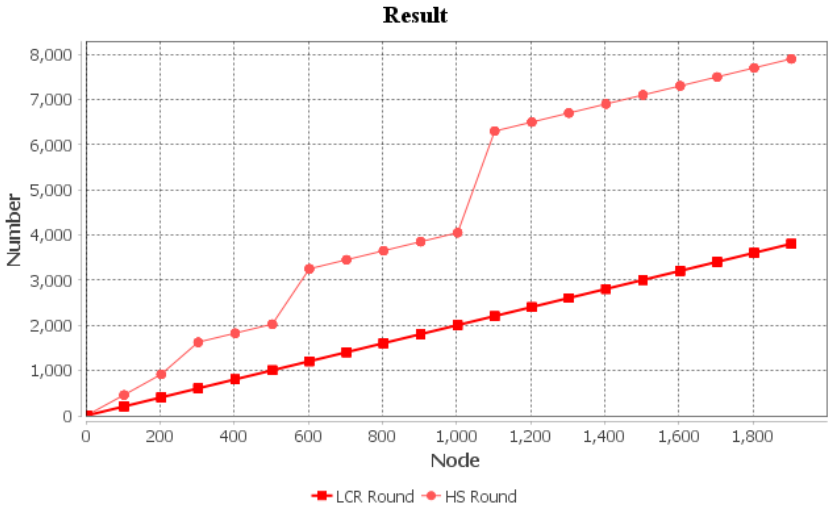
Results:

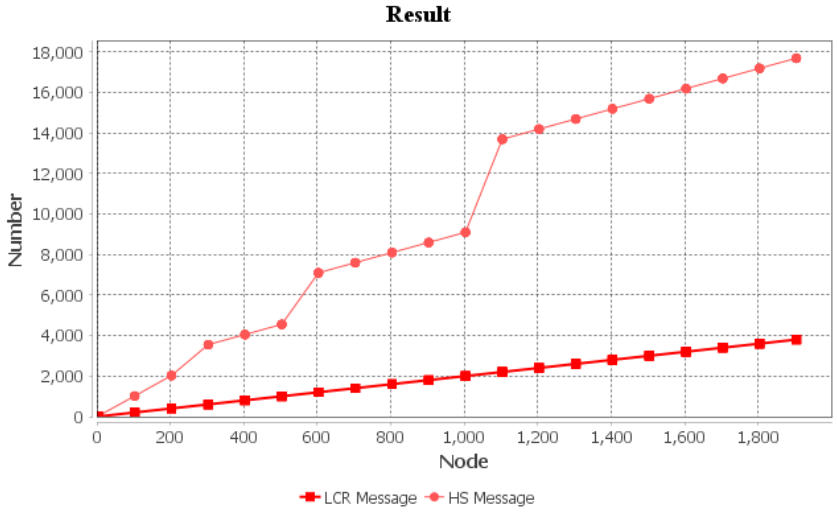
Random ID



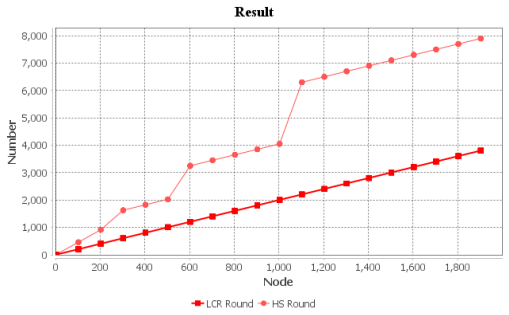


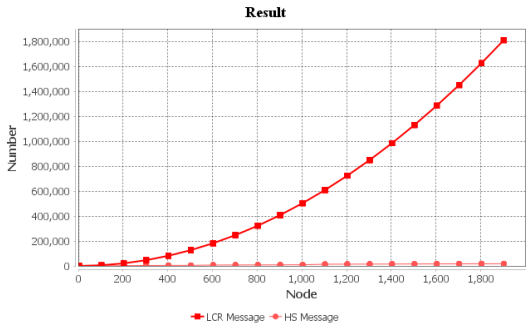
Clockwise ID

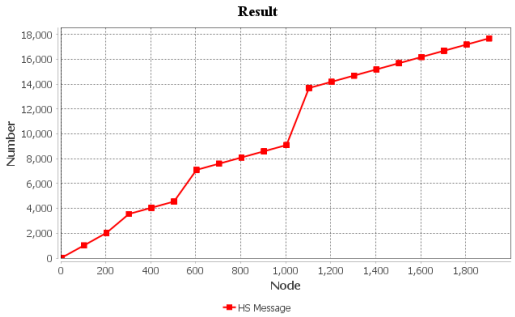




Counter-clockwise ID







LCR

Case: Clockwise is the best case, counter clockwise ID is the worst case.

Elect Rounds: there is always elect the leader at n+1 round in any ID situation. O(n)

Rounds: all node all terminate at 2n round in any ID situation. O(n)

Message number: clockwise ID has smallest message send about 2n O(n), counter clockwise ID has largest message send times (1+N) N/2 $O(n^2)$. random ID has O(n) message send times.

HS

For HS, counter clock wise and clock wise ID has no difference and is best case for message number which is about 18000 times for 2000 nodes.

Rounds: the rounds for HS to terminate is always about twice of LDR to terminate which is O(n) complexities.

Message: clockwise and counter clockwise ID has smallest message send O(n), random ID message number has lager message send times O(n). There is no $O(n^2)$ worst case for HS in any situation.

Moreover, the graphs of HS except normal ID arrangement message number, shows a sharp rise when node number over the power of 2 which according to realistic that in HS if node number more than 2^k (k is the phase number), there will be one more phase which could cause more round and message send to a higher level.

Compare

There is same terminate round in both worst and best situations of two methods each. And HS usually have about twice rounds of LDR to terminate.

LCR tend to have about 4 times fewer message than HS in normal and clockwise situation, but in worst situation the message number of LCR is O(n2) which is absolutely worse than HS O(n2).

5. Summary

Calculation

LCR: (N nodes)

- Round to elect: N+1
- Message to send until elect
  - Best: each non-leader node send number once and be blocked
    N-1(normal node ID pass) +N (leader ID pass) =2N-1
  - Worst: each non-leader node send number until blocked by the leader
    (1+N) N/2

HS: (N nodes)

- Phases to elect: SQUT(N)
- Message to send until elect
  - Best: each non-leader node message be blocked at phase 0
    2(N-1) (normal node) +(2+4+8+...2[$\log_2$(N)]) +2N

The experiment shows the calculation is right.

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NODE  Rounds  Counter  MessageNum
LCR random ID result: 1000 1001 2000 7765
LCR clockwise ID result: 1000 1001 2000 500500
LCR counterclockwise ID result: 1000 1001 2000 1999
HS random ID result: 1000 10 4046 31669
HS clockwise ID result: 1000 10 4046 9088
HS counterclockwise ID result: 1000 10 4046 9088
```

Comparison and results

Compare of the two algorithms:

LCR	Terminate Rounds (Time complexity)	Message send (Communication complexity)
BEST	O(n)	O(n)
WORST	O(n)	$O(n^2)$

Average	O(n)	O(n)

HS	Terminate Rounds (Time complexity)	Message send (Communication complexity)
BEST	O(n)	O(n)
WORST	O(n)	O(n)
Average	O(n)	O(n)

LCR always has fewer Time complexity than HS.

HS has more Communication complexity than HS normal case and best case, but for worth case, HS is much lower Communication complexity than LCR.

As a result, LCR has better performance in normal situation than HS, but HS shows higher robustness in all situation.