Distributed Algorithms

Assignment 3a Report

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Notes

- Gray colored rows mark the byzantine processes.
- In the tables there can be seen two values (0 and 1) and two letters (N and R). N means that no notification/proposal is sent by the byzantine process (based on random numbers). R means that a random value (0,1 or 2) is sent as notification/proposal (based on random numbers).
- If proposal is rejected in decision phase, the correct processes mark the value 2 at end of the round. The value 2 equals the ? symbol in pseudocode of algorithm in the lecture notes.
- Bottom row of table contains the maximum number of zeros or ones after the notification phase (to satisfy $(n + f)/2$ messages requirement)
- Normal cases are the ones that satisfy the $n > 5f$ requirement. Critical cases do not satisfy that requirement.

Testcase 1: **normal case with mostly values 1**

- This test case follows the requirement on the number of traitors: $n = 11 > 5f = 10$, meaning agreement and validity is guaranteed, and terminates with probability 1.
- 11 processes from which 2 are byzantine. 9 of them are initialized with value 1 and 2 of them will value 0. Byzantine nodes will discard this value and initialize it with a random 0, 1 or 2.
- Average number of rounds needed in 10 test runs is 1: 1, 1, 1, 1, 1, 1, 1, 1, 1, 1.
- For test case in table 1 consensus is reached within 1 round with value 1.

Testcase 2: **normal case with almost equal amount of ones and zeros**

- This test case follows the requirement on the number of traitors: $n = 11 > 5f = 10$, meaning agreement and validity is guaranteed, and terminates with probability 1.
- 11 processes from which 2 are byzantine. 5 of them are initialized with value 1 and 6 of them with value 0. Byzantine nodes will discard this value and initialize it with a random 0, 1 or 2.
- Average number of rounds needed in 10 test runs is 4.1: 4, 2, 2, 3, 5, 9, 6, 3, 4, 3.
- For test case in table 2 consensus is reached within 2 rounds with value 1.

Process ID	Predefined Value	Round 1	
		Start	End
0	1	N	1
1	1	1	1
2	1	N	1
3	1	1	1
4	1	1	1
5	1	1	1
6	1	1	1
7	1	1	1
8	1	1	1
9	0	0	1
10	0	0	1
Max(0,1) > 6.5		7	

Table 1: Results of test case 1

Process ID	Predefined Value	Round 1		Round 2	
		Start	End	Start	End
0	1	1	2	1	1
1	1	1	2	1	1
2	1	1	2	1	1
3	1	1	2	1	1
4	1	1	2	1	1
5	0	0	2	0	1
6	0	N	R=1	N	1
7	0	0	2	1	1
8	0	0	2	0	1
9	0	R=1	R=2	R=1	1
10	0	0	2	1	1
Max(0,1) > 6.5		6		7	

Table 2: Results of test case 2

Testcase 3: **critical case which might not terminate, same values as test case 2**

- This test case does not follow the requirement on the number of traitors: $n = 11 <= 5f = 15$, meaning agreement and validity is not guaranteed, and it might not terminate.
- 11 processes from which 3 are byzantine. 5 of them are initialized with value 1 and 6 of them with value 0. Byzantine nodes will discard this value and initialize it with a random 0, 1 or 2.
- Average number of rounds needed in 10 test runs is 24.5: 8, 12, 65, 10, 15, 12, 3, 16, 22, 82. All runs terminated.
- For test case in table 3 consensus is reached within 3 rounds with value 1.

Process ID	Predefined Value	Round 1		Round 2		Round 3	
		Start	End	Start	End	Start	End
0	1	1	2	0	2	1	1
1	1	N	R=2	R=1	R=1	N	R=1
2	1	1	2	1	2	0	1
3	1	1	2	1	2	1	1
4	1	1	2	0	2	1	1
5	0	R=1	R=1	N	2	R=1	R=1
6	0	0	2	1	2	1	1
7	0	0	2	1	2	1	1
8	0	0	2	1	2	1	1
9	0	0	2	0	2	1	1
10	0	R=1	R=0	N	2	N	R=2
Max(0,1) > 6.5		6		6		8	

Table 3: Results of test case 3

Testcase 4: **normal case with small number of processes which should terminate in 1 round**

- This test case follows the requirement on the number of traitors: $n = 5 > 5f = 0$, meaning agreement and validity is guaranteed, and terminates with probability 1.
- 5 processes from which 0 are byzantine. 3 of them are initialized with value 1 and 2 of them with value 0. Byzantine nodes will discard this value and initialize it with a random 0, 1 or 2.
- Average number of rounds needed in 10 test runs is 1: 1, 1, 1, 1, 1, 1, 1, 1, 1, 1.
- For test case in table 4 consensus is reached within 1 rounds with value 1.

Process ID	Predefined Value	Round 1	
		Start	End
0	1	1	1
1	1	1	1
2	1	1	1
3	0	0	1
4	0	0	1
Max(0,1) > 2.5		3	

Table 4: Results of test case 4

Testcase 5: **critical case with small number of processes**

- This test case does not follow the requirement on the number of traitors: $n = 5 <= 5f = 5$, meaning agreement and validity is not guaranteed, and it might not terminate.
- 5 processes from which 1 are byzantine. 3 of them are initialized with value 1 and 2 of them with value 0. Byzantine nodes will discard this value and initialize it with a random 0, 1 or 2.
- Average number of rounds needed in 10 test runs is 4.7: 6, 8, 3, 5, 4, 6, 7, 5, 2, 1. All runs terminated.
- For test case in table 5 consensus is reached within 3 rounds with value 0.

Process ID	Predefined Value	Round 1		Round 2		Round 3	
		Start	End	Start	End	Start	End
0	1	1	2	1	2	0	0
1	1	N	N	R=2	N	R=0	R=1
2	1	1	2	1	2	1	0
3	0	0	2	0	2	0	0
4	0	0	2	0	2	0	0
Max(0,1) > 3		2		2		4	

Table 5: Results of test case 5

Testcase 6: **critical case that shouldn't be possible to decide**

- This test case does not follow the requirement on the number of traitors: $n = 5 <= 5f = 10$.
- 5 processes from which 2 are byzantine. 3 of them are initialized with value 1 and 2 of them with value 0. Byzantine nodes will discard this value and initialize it with a random 0, 1 or 2.
- No consensus is reached during execution (waited until somewhere round 2000 for a couple of runs). The condition for deciding on value 0 or 1 is that in the decision phase there exist more than $3f$ messages with the same proposal value. Since $3f = 6$ is larger than the total number of processes this is not possible.

Testcase 7: **normal case with large number of processes**

- This test case follows the requirement on the number of traitors: $n = 25 > 5f = 20$, meaning agreement and validity is guaranteed, and terminates with probability 1.
- 25 processes from which 4 are byzantine. 13 of them are initialized with value 1 and 12 of them with value 0. Byzantine nodes will discard this value and initialize it with a random 0, 1 or 2.
- Average number of rounds needed in 10 test runs is 7.2: 4, 2, 3, 2, 17, 17, 3, 2, 2, 20.
- For test case in table 6 consensus is reached within 4 rounds with value 0.

Testcase 8: **critical case with large number of processes**

- This test case does not follow the requirement on the number of traitors: $n = 25 <= 5f = 25$, meaning agreement and validity is not guaranteed, and it might not terminate.
- 25 processes from which 5 are byzantine. 13 of them are initialized with value 1 and 12 of them with value 0. Byzantine nodes will discard this value and initialize it with a random 0, 1 or 2.
- Average number of rounds needed in 10 test runs is 17.6: 16, 4, 10, 55, 23, 31, 13, 8, 7, 9. All runs terminated.
- For test case in table 7 consensus is reached within 6 rounds with value 0.

Process ID	Predefined Value	Round 1		Round 2		Round 3		Round 4	
		Start	End	Start	End	Start	End	Start	End
0	1	1	2	0	2	1	2	1	0
1	1	1	2	0	2	1	2	0	0
2	1	1	2	0	2	0	2	0	0
3	1	R=2	N	N	R=0	R=1	N	N	R=1
4	1	1	2	1	2	1	2	0	0
5	1	1	2	0	2	1	2	0	0
6	1	1	2	1	2	1	2	0	0
7	1	1	2	0	2	0	2	1	0
8	1	1	2	0	2	0	2	1	0
9	1	1	2	0	2	1	2	1	0
10	1	N	R=1	R=2	N	N	N	R=1	R=1
11	1	1	2	1	2	0	2	0	0
12	1	1	2	1	2	1	2	0	0
13	0	R=0	R=2	N	R=0	N	R=0	N	R=2
14	0	0	2	1	2	1	2	0	0
15	0	0	2	0	2	1	2	1	0
16	0	0	2	1	2	1	2	0	0
17	0	0	2	1	2	1	2	0	0
18	0	0	2	1	2	0	2	1	0
19	0	0	2	0	2	0	2	0	0
20	0	0	2	0	2	0	2	0	0
21	0	0	2	1	2	1	2	0	0
22	0	0	2	1	2	1	2	0	0
23	0	R=1	R=2	N	N	N	N	R=2	N
24	0	0	2	0	2	0	2	0	0
Max(0,1) > 14.5		12		12		14		15	

Table 6: Results of test case 7

Process ID	Predefined Value	Round 1		Round 2		Round 3		Round 4		Round 5		Round 6	
		Start	End	Start	End	Start	End	Start	End	Start	End	Start	End
0	1	1	2	1	2	1	2	0	2	0	2	1	0
1	1	1	2	0	2	1	2	0	2	0	2	1	0
2	1	1	2	1	2	1	2	1	2	0	2	0	0
3	1	1	2	1	2	1	2	1	2	0	2	1	0
4	1	1	2	0	2	0	2	0	2	0	2	0	0
5	1	1	2	1	2	0	2	0	2	1	2	1	0
6	1	1	2	1	2	0	2	0	2	0	2	0	0
7	1	1	2	0	2	0	2	1	2	0	2	0	0
8	1	1	2	0	2	1	2	0	2	1	2	0	0
9	1	1	2	1	2	0	2	0	2	0	2	0	0
10	1	1	2	0	2	1	2	1	2	0	2	1	0
11	1	R=1	N	N	N	R=1	N	N	R=2	N	N	R=0	R=1
12	1	N	N	N	N	R=1	R=1	N	N	R=1	N	R=0	R=1
13	0	R=0	N	N	R=1	R=1	N	R=15	R=2	R=2	R=2	N	R=1
14	0	0	2	0	2	0	2	0	2	0	2	0	0
15	0	0	2	1	2	0	2	1	2	1	2	0	0
16	0	0	2	0	2	0	2	1	2	1	2	0	0
17	0	0	2	1	2	0	2	1	2	0	2	0	0
18	0	0	2	0	2	1	2	0	2	0	2	0	0
19	0	0	2	0	2	1	2	0	2	0	2	0	0
20	0	R=1	R=1	R=2	N	R=1	N	R=2	R=2	R=1	R=2	N	N
21	0	0	2	1	2	1	2	0	2	0	2	0	0
22	0	0	2	1	2	1	2	0	2	0	2	0	0
23	0	R=1	R=0	N	R=1	N	N	R=2	R=1	N	N	R=0	R=1
24	0	0	2	1	2	1	2	1	2	1	2	1	0
Max(0,1) > 15		14		11		15		12		15		17	

Table 7: Results of test case 8