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CS451
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31 October 2019

Homework 3

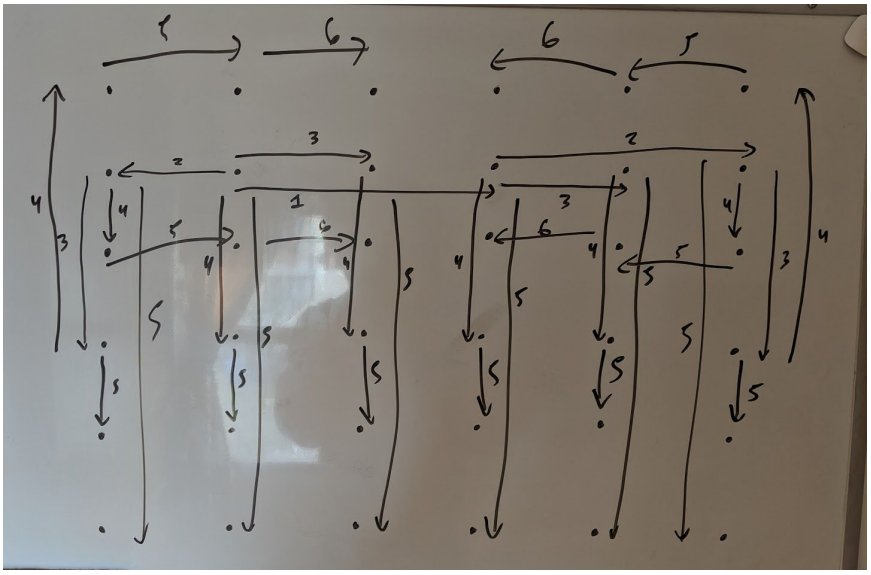
1. **6x6 2-Dimensional Torus** with **Cut-through Routing**
    a. One-To-All Broadcasting from node (2,2)
    b. Note that each step takes 10ms + 2ms + 500word(0.2ms/word) = 112ms
        i. Step 1 (timestamp: 112ms)
            1. (2,2) → (2,4)
        ii. Step 2 (timestamp: 224ms)
            1. (2,2) → (2,1)
            2. (2,4) → (2,6)
        iii. Step 3 (timestamp: 336ms)
            1. (2,2) → (2,3)
            2. (2,4) → (2,5)
            3. (2,1) → (4,1)
            4. (2,6) → (4,6)
        iv. Step 4 (timestamp: 448ms)
            1. (2,2) → (4,2)
            2. (2,4) → (4,4)
            3. (2,1) → (3,1)
            4. (2,6) → (3,6)
            5. (2,3) → (4,3)
            6. (2,5) → (4,5)
            7. (4,1) → (1,1)
            8. (4,6) → (1,6)
        v. Step 5 (timestamp: 560ms)
            1. (2,2) → (6,2)
            2. (2,4) → (6,4)
            3. (2,1) → (6,1)
            4. (2,6) → (6,6)
            5. (2,3) → (6,3)
            6. (2,5) → (6,5)
            7. (4,1) → (5,1)
            8. (4,6) → (5,6)
            9. (4,2) → (5,2)
            10. (4,4) → (5,4)
            11. (3,1) → (3,2)

12. (3,6) → (3,5)
13. (4,3) → (5,3)
14. (4,5) → (5,5)
15. (1,1) → (1,2)
16. (1,6) → (1,5)

vi. Step 6 (timestamp: 672ms)

1. (2,2)
2. (2,4)
3. (2,1)
4. (2,6)
5. (2,3)
6. (2,5)
7. (4,1)
8. (4,6)
9. (4,2)
10. (4,4)
11. (3,1)
12. (3,6)
13. (4,3)
14. (4,5)
15. (1,1)
16. (1,6)
17. (6,2)
18. (6,4)
19. (6,1)
20. (6,6)
21. (6,3)
22. (6,5)
23. (5,1)
24. (5,6)
25. (5,2)
26. (5,4)
27. (3,2) → (3,3)
28. (3,5) → (3,4)
29. (5,3)
30. (5,5)
31. (1,2) → (1,3)
32. (1,5) → (1,4)

vii. Diagram:

1. 

viii. Estimated Communtion Time

1. Knowns:
    a. t_s = 10 ms
    b. t_h =2 ms
    c. t_w = 0.2 ms/word
    d. m = 1000 bytes = 500 words
    e. p = 36
2. $t_{comm} = 2(log_2(\sqrt{p})(t_s + t_w m) + t_h(\sqrt{p} - 1))$
3. $t_{comm} = 2log_2(\sqrt{p})(t_s + t_w m) + 2t_h(\sqrt{p} - 1)$
4. $t_{comm} = 2log_2(\sqrt{36})(10ms + (0.2ms/word)(500words)) + 2(2ms)(\sqrt{36} - 1)$
5. $t_{comm} = 2log_2(\sqrt{36})(10ms + (0.2ms/word)(500words)) + 2(2ms)(\sqrt{36} - 1)$
6. $t_{comm} = 2log_2(6)(10ms + (0.2ms/word)(500words)) + 2(2ms)(6 - 1)$
7. $t_{comm} = 2log_2(6)(10ms + (0.2ms/word)(500words)) + 20ms$
8. $t_{comm} = 2log_2(6)(10ms + 100ms) + 20ms$
9. $t_{comm} = 2log_2(6)(110ms) + 20ms$
10. $t_{comm} = log_2(6)(220ms) + 20ms$
11. $t_{comm} = (2.58496250072)(220ms) + 20ms$
12. $t_{comm} = 588.69\ ms$

c. All-To-All Scatter

i. Steps: The steps of all to all scatter would be 36 times of the steps from one to all broadcast from 1b. The only differences would be have 36 nodes sending data instead of one and instead sending all data, it would be sending the next node half of the data.

ii. Estimated Communtion Time

1. Knowns:
    a. $t_s = 10$ ms
    b. $t_h = 2$ ms
    c. $t_w = 0.2$ ms/word
    d. m = 1000 bytes = 500 words
    e. p = 36
2. $t_{comm} = p(\sum_{i=1}^{\sqrt{p}} 2(log_2(\sqrt{p})(t_s + t_w \frac{m}{2*i}) + t_h(\sqrt{p} - 1)))$
3. $t_{comm} = 36(\sum_{i=1}^{\sqrt{36}} 2(log_2(\sqrt{36})(10ms + (0.2\ ms/word)\frac{500}{2*i}) + (\sqrt{36} - 1)))$
4. $t_{comm} = 36(\sum_{i=1}^{6} 2(log_2(6)(10ms + (0.2\ ms/word)\frac{500}{2*i}) + 5))$
5. $t_{comm} = 36((2(log_2(6)(10ms + (0.2\ ms/word)\frac{500}{2*1}) + 5)) +$
6. $(2(log_2(6)(10ms + (0.2\ ms/word)\frac{500}{2*2}) + 5)) +$
7. $(2(log_2(6)(10ms + (0.2\ ms/word)\frac{500}{2*3}) + 5)) +$
8. $(2(log_2(6)(10ms + (0.2\ ms/word)\frac{500}{2*4}) + 5)) +$
9. $(2(log_2(6)(10ms + (0.2\ ms/word)\frac{500}{2*5}) + 5)) +$
10. $(2(log_2(6)(10ms + (0.2\ ms/word)\frac{500}{2*6}) + 5)))$
11. $t_{comm} = 36(1003.51ms)$
12. $t_{comm} = 36126.36ms$