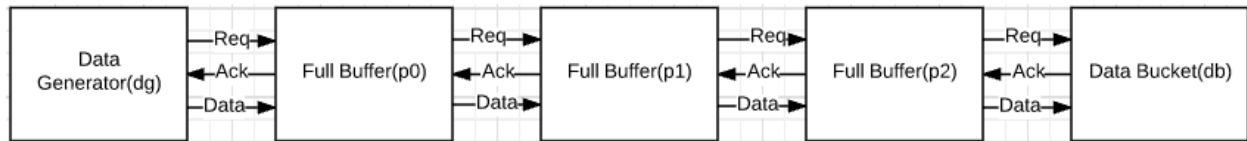


1. Linear Pipeline

a. Block Diagram



b.

#Execution cycle= 1000, Cycle Time= 10,

#Average CycleTime=9.996000, Average Throughput=0.100040

c. Start time of each always block

Blocks	Iteration 1	Iteration 2	Iteration 3	Iteration 4	Iteration 5
dg	0 ns	8ns	18ns	28ns	38ns
P0	0 ns	8ns	18ns	28ns	38ns
P1	0 ns	12ns	22ns	32ns	42ns
P2	0 ns	12ns	22ns	32ns	42ns
db	6 ns	16ns	26ns	36ns	46ns

d.

Simulation Time	Stalled Action	Waiting for	Stall Time
2ns	P1.receive	P0.send	2ns
4ns	P2.receive	P1.send	4ns
6ns	db.receive	P2.send	6ns
8ns	Dg.send	P1.receive	8ns
12ns	P1.receive	P0.send	2ns
14ns	P2.receive	P1.send	2ns
16ns	db.receive	P2.send	10ns
18ns	Dg.send	P1.receive	10ns
22ns	P1.receive	P0.send	2ns
24ns	P2.receive	P1.send	2ns
26ns	db.receive	P2.send	10ns

e. The cycle time of an asynchronous linear pipeline is equal to the maximum cycle time of all stages. (Pick from average, maximum, minimum).

2. Re-convergent Fan-out

fork_join_pipeline/dg/SendValue	8h09	8h81	8h09	8h63	8h0d	8h8d	8h65
fork_join_pipeline/cp/data	8h81	8h24	8h81	8h09	8h63	8h0d	8h8d
fork_join_pipeline/s0/data	8h81	8h24	8h81	8h09	8h63	8h0d	8h8d
fork_join_pipeline/s0/ndata	9h102	9h048	9h102	9h012	9h0c6	9h01a	9h11a
fork_join_pipeline/s1/data	9h048	9h048	9h102	9h012	9h0c6	9h01a	9h11a
fork_join_pipeline/s1/ndata	10h090	10h090	10h204	10h024	10h18c	10h034	10h034
fork_join_pipeline/s2/data	10h090	10h090	10h204	10h024	10h18c	10h034	10h034
fork_join_pipeline/s2/ndata	11h120	11h120	11h408	11h048	11h318	11h068	11h068
fork_join_pipeline/s3/data	8h81	8h24	8h81	8h09	8h63	8h0d	8h8d
fork_join_pipeline/s3/ndata	9h102	9h048	9h102	9h012	9h0c6	9h01a	9h11a
fork_join_pipeline/add1/a	11h120	11h120	11h408	11h048	11h318	11h068	11h068
fork_join_pipeline/add1/b	9h048	9h048	9h102	9h012	9h0c6	9h01a	9h11a
fork_join_pipeline/add1/ndata	12h168	12h168	12h50a	12h05a	12h3de	12h082	12h082
fork_join_pipeline/db/ReceiveValue	12h000	12h000	12h168	12h50a	12h05a	12h3de	12h082
fork_join_pipeline/db/cycleCounter	0	0	1	2	3	4	5
fork_join_pipeline/db/timeOfReceive	0	0	10	16	22	32	38
fork_join_pipeline/db/cycleTime	0	0	10	16	22	32	38
fork_join_pipeline/db/averageThroughput	0	0	0.1	0.125	0.136364	0.125	0.1
fork_join_pipeline/db/averageCycleTime	0	0	10	16	22	32	38
fork_join_pipeline/db/sumOfCycleTimes	0	0	10	16	22	32	38

- a. True/False: The circuit can multiply a number by 10 at best every 6ns. Explain your choice.
If the multiplier is at the idle state, the time between first data send out and result received is 10ns. And follows by two 6ns delay of out but. The pattern is 10 6 6. The first number is always 10ns. And the best average cycle time is $(10+6+6)/3=7.33$. the first cycle time cannot be equal to 6ns. Therefore it cannot at best every 6ns.

- b. Average cycle time and throughput

Execution cycle= 1000, Cycle Time= 10,

Average CycleTime=7.336000, Average Throughput=0.136314

- c. stalls

Simulation Time	Stalled Action	Waiting for	Stall Time
2ns	S0.receive	Cp.send	2ns
2ns	S3.receive	Cp.send	2ns
4ns	S1.receive	S0.send	4ns
4ns	Add1.receive	S3.send	4ns
6ns	Dg.send	Cp.receive	6ns
6ns	S2.receive	S1.send	6ns
8ns	Add1.receive	S2.send	8ns
10ns	Db.receive	Add.send	10ns
12ns	Dg.send	Cp.receive	6ns
14ns	S3.send	Add1.receive	4ns
16ns	Db.receive	Add1.send	6ns
18ns	Cp.send	S3.receive	4ns
22ns	Dg.send	Cp.receive	10ns
22ns	Db.receive	Add1.send	6ns

- d. Look at the iteration start time of the shifter at the lower branch. Does the always block start iteration every 6ns? If not explain why.

The lower branch always block does not iteration every 6ns. Since it will need to wait for the upper branch stall. The copy module will wait until upper and lower both can receive data.

- e. Verified can be improved.

Execution cycle= 1000, Cycle Time= 6,

#Average CycleTime=6.004000, Average Throughput=0.166556

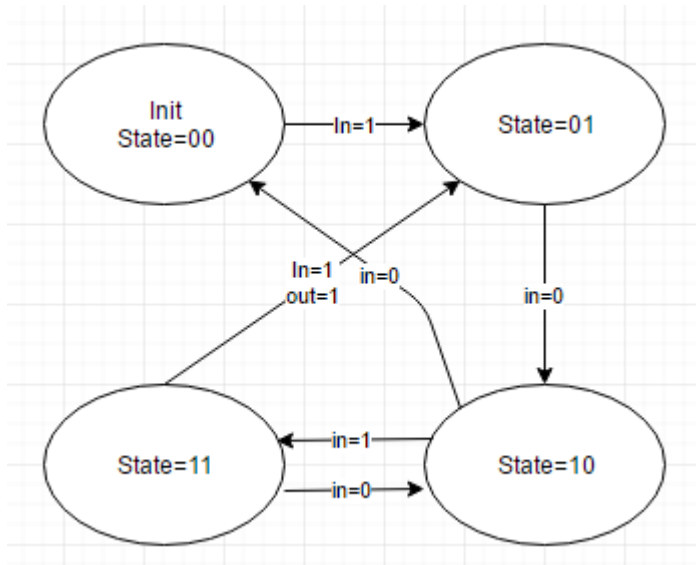
fork_join_pipeline/...	8h12	8h09	8h63	8h0d	8h8d	8h65	8h12
fork_join_pipeline/...	8h65	8h81	8h09	8h63	8h0d	8h8d	8h65
fork_join_pipeline/...	8h65	8h24	8h81	8h09	8h63	8h0d	8h8d
fork_join_pipeline/...	9h0ca	9h048	9h102	9h012	9h0c6	9h01a	9h11a
fork_join_pipeline/...	9h11a	9h048	9h102	9h012	9h0c6	9h01a	9h11a
fork_join_pipeline/...	10h234	10h090	10h204	10h024	10h18c	10h034	10h234
fork_join_pipeline/...	10h234	10h090	10h204	10h024	10h18c	10h034	10h234
fork_join_pipeline/...	11h468	11h120	11h408	11h048	11h318	11h068	11h468
fork_join_pipeline/...	8h65	8h24	8h81	8h09	8h63	8h0d	8h8d
fork_join_pipeline/...	9h0ca	9h048	9h102	9h012	9h0c6	9h01a	9h11a
fork_join_pipeline/...	9h11a	9h048	9h102	9h012	9h0c6	9h01a	9h11a
fork_join_pipeline/...	9h11a	9h048	9h102	9h012	9h0c6	9h01a	9h11a
fork_join_pipeline/...	11h468	11h120	11h408	11h048	11h318	11h068	11h468
fork_join_pipeline/...	9h11a	9h048	9h102	9h012	9h0c6	9h01a	9h11a
fork_join_pipeline/...	12h582	12h168	12h50a	12h05a	12h3de	12h082	12h582
fork_join_pipeline/...	12h082	12h000	12h168	12h50a	12h05a	12h3de	12h082
fork_join_pipeline/...	5	0	1	2	3	4	5
fork_join_pipeline/...	34	0	10	16	22	28	34
fork_join_pipeline/...	6	0	10	16	22	28	34
fork_join_pipeline/...	0.147059	0	0.1	0.125	0.136364	0.142857	0.147059
fork_join_pipeline/...	6.8	0	10	16	22	28	34
fork_join_pipeline/...	34	0	10	16	22	28	34

3. Merge

/merge_test/dg/SendValue	-No Data-	16h5e81	16hd609	16h566b	16h7b0d	16h998d
/merge_test/dg/sel	-No Data-	2h1	2h2	2h1	2h2	2h1
/merge_test/cp/data	-No Data-	8h24	8h5e	8h09	8h56	8h0d
/merge_test/cp/c	-No Data-	2h2	2h1	2h2	2h1	2h2
/merge_test/db/ReceiveValue	-No Data-	8h00	8h24	8h5e	8h09	8h56
/merge_test/db/cycleCounter	-No Data-	0	1	2	3	4
/merge_test/db/timeOfReceive	-No Data-	0	4	16	28	40
/merge_test/db/cycleTime	-No Data-	0	4	12		
/merge_test/db/averageThr...	-No Data-	0	0.25	0.125	0.107143	0.1
/merge_test/db/averageCyc...	-No Data-	0	4	8	9.33333	10
/merge_test/db/sumOfCycle...	-No Data-	0	4	16	28	40
						52

4. Finite State Machine

a. State machine



b. Next state logic

S=state ns=nextstate I=input

/next_state_logic_tb/dg/s	-No Data-	4h0	4h1	4h2	4h3	4h4
/next_state_logic_tb/dg/i	-No Data-	5h01	5h02	5h03	5h04	5h05
/next_state_logic_tb/dg/h	-No Data-	3h0	3h1	3h2	3h3	3h4
/next_state_logic_tb/h/s	-No Data-	3h0	3h1	3h2	3h3	3h4
/next_state_logic_tb/h/i	-No Data-	3h0	3h1	3h2	3h3	3h4
/next_state_logic_tb/db/ReceiveValue	-No Data-	1	2	3	4	5
/next_state_logic_tb/db/cycleCounter	-No Data-	2	12	22	32	42
/next_state_logic_tb/db/timeOfReceive	-No Data-	2	10			
/next_state_logic_tb/db/cycleTime	-No Data-	0.5	0.166667	0.136364	0.125	0.119048
/next_state_logic_tb/db/averageThrough...	-No Data-	2	6	7.33333	8	8.4
/next_state_logic_tb/db/averageCycleTime	-No Data-	2	12	22	32	42
/next_state_logic_tb/db/sumOfCycleTimes	-No Data-					

c. Output Function Logic

S=state I=input o=output

/output_function_logic_tb/dg/s	-No Data-	2h0	2h1	2h2	2h3	2h0
/output_function_logic_tb/dg/i	-No Data-	3h1	3h2	3h3	3h4	3h5
/output_function_logic_tb/dg/h	-No Data-	2h0	2h1	2h2	2h3	2h0
/output_function_logic_tb/of/s	-No Data-	2h0	2h1	2h2	2h3	2h0
/output_function_logic_tb/of/i	-No Data-	2h0	2h1	2h2	2h3	2h0
/output_function_logic_tb/of/o	-No Data-	1	2	3	4	5
/output_function_logic_tb/db/...	-No Data-	2	12	22	32	42
/output_function_logic_tb/db/ti...	-No Data-	2	10			
/output_function_logic_tb/db/c...	-No Data-	0.5	0.166667	0.136364	0.125	0.119048
/output_function_logic_tb/db/a...	-No Data-	2	6	7.33333	8	8.4
/output_function_logic_tb/db/s...	-No Data-	2	12	22	32	42

d. Copy

/copy_tb/dg/SendValue	-No Data-	8'h81	8'h09	8'h63	8'h0d	8'h8d	8'h65	8'h12	8'h01	8'h0d	8'...
/copy_tb/cp/data	-No Data-	8'h24	8'h81	8'h09	8'h63	8'h0d	8'h8d	8'h65	8'h12	8'h01	8'...
/copy_tb/db1/ReceiveValue	-No Data-	8'h24	8'h81	8'h09	8'h63	8'h0d	8'h8d	8'h65	8'h12	8'h01	8'...
/copy_tb/db1/cycleCounter	-No Data-	1	2	3	4	5	6	7	8	9	
/copy_tb/db1/timeOfReceive	-No Data-	2	12	22	32	42	52	62	72	82	
/copy_tb/db1/cycleTime	-No Data-	2	10								
/copy_tb/db1/averageThroughput	-No Data-	0.5	0.166667	0.136364	0.125	0.119048	0.115385	0.112903	0.111111	0.109756	
/copy_tb/db1/averageCycleTime	-No Data-	2	6	7.333333	8	8.4	8.66667	8.85714	9	9.11111	
/copy_tb/db1/sumOfCycleTimes	-No Data-	2	12	22	32	42	52	62	72	82	
/copy_tb/db2/ReceiveValue	-No Data-	8'h24	8'h81	8'h09	8'h63	8'h0d	8'h8d	8'h65	8'h12	8'h01	8'...
/copy_tb/db2/cycleCounter	-No Data-	1	2	3	4	5	6	7	8	9	
/copy_tb/db2/timeOfReceive	-No Data-	2	12	22	32	42	52	62	72	82	
/copy_tb/db2/cycleTime	-No Data-	2	10								
/copy_tb/db2/averageThroughput	-No Data-	0.5	0.166667	0.136364	0.125	0.119048	0.115385	0.112903	0.111111	0.109756	
/copy_tb/db2/averageCycleTime	-No Data-	2	6	7.333333	8	8.4	8.66667	8.85714	9	9.11111	
/copy_tb/db2/sumOfCycleTimes	-No Data-	2	12	22	32	42	52	62	72	82	

e. State memory

/state_memory_tb/dg/SendValue	-No Data-	8'h81	8'h09	8'h63	8'h0d						
/state_memory_tb/sm/data	-No Data-	8'h24	8'h81	8'h09	8'h63						
/state_memory_tb/db1/ReceiveValue	-No Data-	8'...	8'h24	8'h81	8'h09	8'h63					
/state_memory_tb/db1/cycleCounter	-No Data-	0	1	2	3	4					
/state_memory_tb/db1/timeOfReceive	-No Data-	0	2	12	22	32					
/state_memory_tb/db1/cycleTime	-No Data-	0	2	10							
/state_memory_tb/db1/averageThroug...	-No Data-	0	0.5	0.166667	0.136364	0.125					
/state_memory_tb/db1/averageCycleTi...	-No Data-	0	2	6	7.333333	8					
/state_memory_tb/db1/sumOfCycleTimes	-No Data-	0	2	12	22	32					

f. FSM

The input sequence is 1011011001011. And there are three 1011 sequences. And the test bench shows there is 3 times output is 1.

/fsm_tb/dg/SendValue	-No Data-	1...	13h0...	13...	13h...	13...	13h...	13...	13h0...	1...	13h0...	13...	13h...	13h0000		
/fsm_tb/mfsm/cpin/data	-No Data-	2h1	2h0	2h1	2h0	2h1	2h0	2h1	2h0	2h1	2h0	2h1	2h0	2h1	2h0	
/fsm_tb/mfsm/sm/data	-No Data-	2h1	2h2	2h3	2h1	2h2	2h3	2h1	2h2	2h3	2h1	2h2	2h3	2h1	2h2	2h0
/fsm_tb/mfsm/cpsd/data	-No Data-	2h0	2h1	2h2	2h3	2h1	2h2	2h3	2h1	2h2	2h3	2h1	2h2	2h3	2h1	2h2
/fsm_tb/mfsm/of/s	-No Data-	2h0	2h1	2h2	2h3	2h1	2h2	2h3	2h1	2h2	2h3	2h1	2h2	2h3	2h1	2h2
/fsm_tb/mfsm/of/i	-No Data-															
/fsm_tb/mfsm/of/o	-No Data-															
/fsm_tb/mfsm/ns/s	-No Data-	2h0	2h1	2h2	2h3	2h1	2h2	2h3	2h1	2h2	2h3	2h1	2h2	2h3	2h1	2h2
/fsm_tb/mfsm/ns/ns	-No Data-	2h1	2h2	2h3	2h1	2h2	2h3	2h1	2h2	2h3	2h1	2h2	2h3	2h1	2h2	2h0
/fsm_tb/mfsm/ns/i	-No Data-															
/fsm_tb/db/ReceiveValue	-No Data-															
/fsm_tb/db/cycleCounter	-No Data-	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
/fsm_tb/db/timeOfReceive	-No Data-	4	14	28	38	52	62	76	86	100	110	124	134	148	158	172
/fsm_tb/db/cycleTime	-No Data-	4	10	14	10	14	10	14	10	14	10	14	10	14	10	14
/fsm_tb/db/averageThroughput	-No Data-	0.25	0.14...	0.0...	0.10...	0.0...	0.09...	0.10...	0.09...	0.09...	0.09...	0.0...	0.08...	0.0...	0.08...	0.08...
/fsm_tb/db/averageCycleTime	-No Data-	4	7	9...	9.5	10.4	10.3...	10...	10.75	11...	11	11...	11.1...	1...	11.2...	11...
/fsm_tb/db/sumOfCycleTimes	-No Data-	4	14	28	38	52	62	76	86	100	110	124	134	148	158	172

5. Palindrome Detector

The P1 module is the first pcell. P initially to be 1. And when S=1, first data feed in the P is still 1. Then when input is 4aa4 P is 1. Then b inserted, the P is 0. In the second sequence when the first item inserted the P is 1 and when the last item is inserted the P is 1. For the third sequence, the P is 1 at all times.

/tb_palindrome/pTester/p1/y	4'h0	4'h0	4'h4	4'ha	4'hb	4'ha	4'h0	4'ha	4'h0	4'hb	4'ha					
/tb_palindrome/pTester/p1/h	4'h0	4'h0	4'ha	4'h4	4'hb	4'ha	4'h0	4'ha	4'h0	4'hb	4'ha					
/tb_palindrome/pTester/p1/p	1'h1	1'h1	1'hx	1'hx	1'hx	1'hx	1'hx	1'hx	1'hx	1'hx	1'hx					
/tb_palindrome/pTester/p1/s	1'hx	1'hx	1'hx	1'hx	1'hx	1'hx	1'hx	1'hx	1'hx	1'hx	1'hx					
/tb_palindrome/pTester/p1/s_	1'hx	1'hx	1'hx	1'hx	1'hx	1'hx	1'hx	1'hx	1'hx	1'hx	1'hx					
/tb_palindrome/pTester/p1/nw	1'hx	1'hx	1'hx	1'hx	1'hx	1'hx	1'hx	1'hx	1'hx	1'hx	1'hx					
/tb_palindrome/pTester/genblk1[0]/pp/y	4'h0	4'h0	4'ha	4'h4	4'hb	4'ha	4'h0	4'ha	4'h0	4'hb	4'ha					
/tb_palindrome/pTester/genblk1[0]/pp/h	4'h0	4'h0	4'ha	4'h4	4'hb	4'ha	4'h0	4'ha	4'h0	4'hb	4'ha					
/tb_palindrome/pTester/genblk1[0]/pp/p	1'h1	1'h1	1'hx	1'hx	1'hx	1'hx	1'hx	1'hx	1'hx	1'hx	1'hx					
/tb_palindrome/pTester/genblk1[0]/pp/s	1'hx	1'hx	1'hx	1'hx	1'hx	1'hx	1'hx	1'hx	1'hx	1'hx	1'hx					
/tb_palindrome/pTester/genblk1[0]/pp/s_	1'hx	1'hx	1'hx	1'hx	1'hx	1'hx	1'hx	1'hx	1'hx	1'hx	1'hx					
/tb_palindrome/pTester/genblk1[0]/pp/nw	1'hx	1'hx	1'hx	1'hx	1'hx	1'hx	1'hx	1'hx	1'hx	1'hx	1'hx					
/tb_palindrome/pTester/genblk1[1]/pp/y	4'h0	4'h0	4'ha	4'h4	4'hb	4'ha	4'h0	4'ha	4'h0	4'hb	4'ha					
/tb_palindrome/pTester/genblk1[1]/pp/h	4'h0	4'h0	4'ha	4'h4	4'hb	4'ha	4'h0	4'ha	4'h0	4'hb	4'ha					
/tb_palindrome/pTester/genblk1[1]/pp/p	1'h1	1'h1	1'hx	1'hx	1'hx	1'hx	1'hx	1'hx	1'hx	1'hx	1'hx					
/tb_palindrome/pTester/genblk1[1]/pp/s	1'hx	1'hx	1'hx	1'hx	1'hx	1'hx	1'hx	1'hx	1'hx	1'hx	1'hx					
/tb_palindrome/pTester/genblk1[1]/pp/s_	1'hx	1'hx	1'hx	1'hx	1'hx	1'hx	1'hx	1'hx	1'hx	1'hx	1'hx					
/tb_palindrome/pTester/genblk1[1]/pp/nw	1'hx	1'hx	1'hx	1'hx	1'hx	1'hx	1'hx	1'hx	1'hx	1'hx	1'hx					
/tb_palindrome/pTester/genblk1[2]/pp/y	4'h0	4'h0	4'ha	4'h4	4'hb	4'ha	4'h0	4'ha	4'h0	4'hb	4'ha					
/tb_palindrome/pTester/genblk1[2]/pp/h	4'h0	4'h0	4'ha	4'h4	4'hb	4'ha	4'h0	4'ha	4'h0	4'hb	4'ha					
/tb_palindrome/pTester/genblk1[2]/pp/p	1'h1	1'h1	1'hx	1'hx	1'hx	1'hx	1'hx	1'hx	1'hx	1'hx	1'hx					
/tb_palindrome/pTester/genblk1[2]/pp/s	1'hx	1'hx	1'hx	1'hx	1'hx	1'hx	1'hx	1'hx	1'hx	1'hx	1'hx					
/tb_palindrome/pTester/genblk1[2]/pp/s_	1'hx	1'hx	1'hx	1'hx	1'hx	1'hx	1'hx	1'hx	1'hx	1'hx	1'hx					
/tb_palindrome/pTester/genblk1[2]/pp/nw	1'hx	1'hx	1'hx	1'hx	1'hx	1'hx	1'hx	1'hx	1'hx	1'hx	1'hx					