TDMA WiFi implementation comparison

To test throughput, iperf utility under Ubuntu 12.04 is used.
Iperf is launched with settings to report throughput every 5 seconds.
To check throughput in UDP mode, bidirectional test is used with maximal bandwidth to have less than 0,1% drops and reordering
To check throughput in TCP mode, unidirectional test is used.
To align TCP throughput in CSMA/Ca mode to TDMA mode, the maximal uniderectional throughput divided with 2.

The command samples

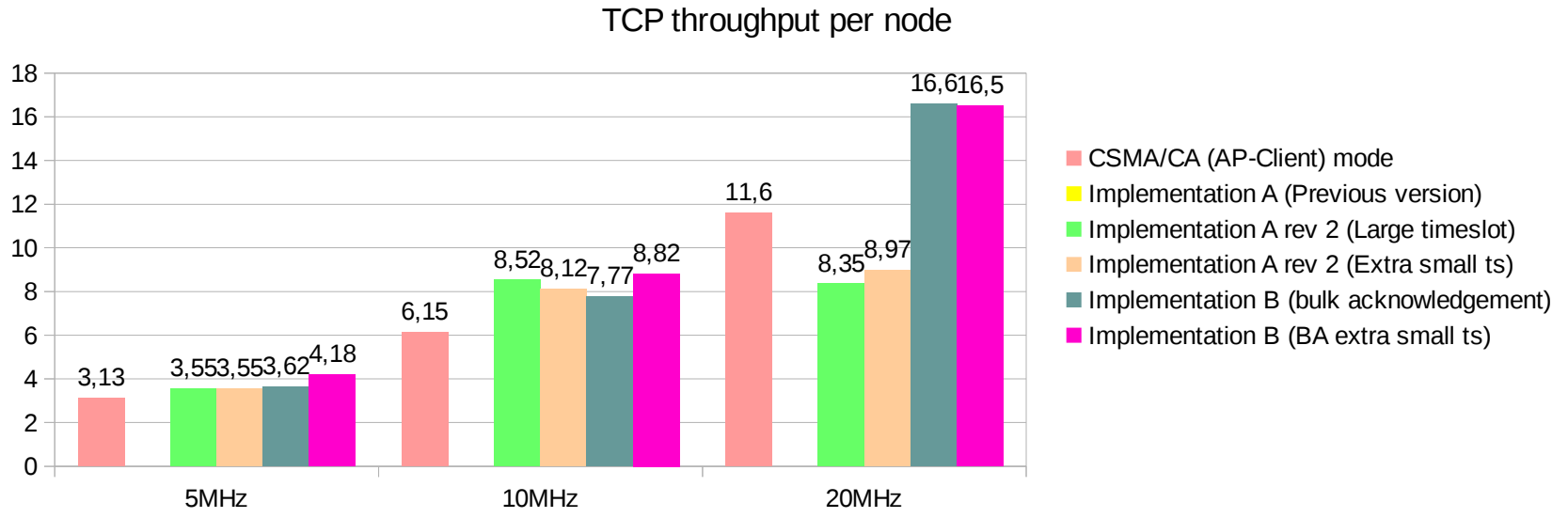
iperf -c SERVER_IP_ADDRESS -i5 -t50 -r
iperf -c SERVER_IP_ADDRESS -i5 -t50 -u -d -bBANDWIDTH_IN_MB

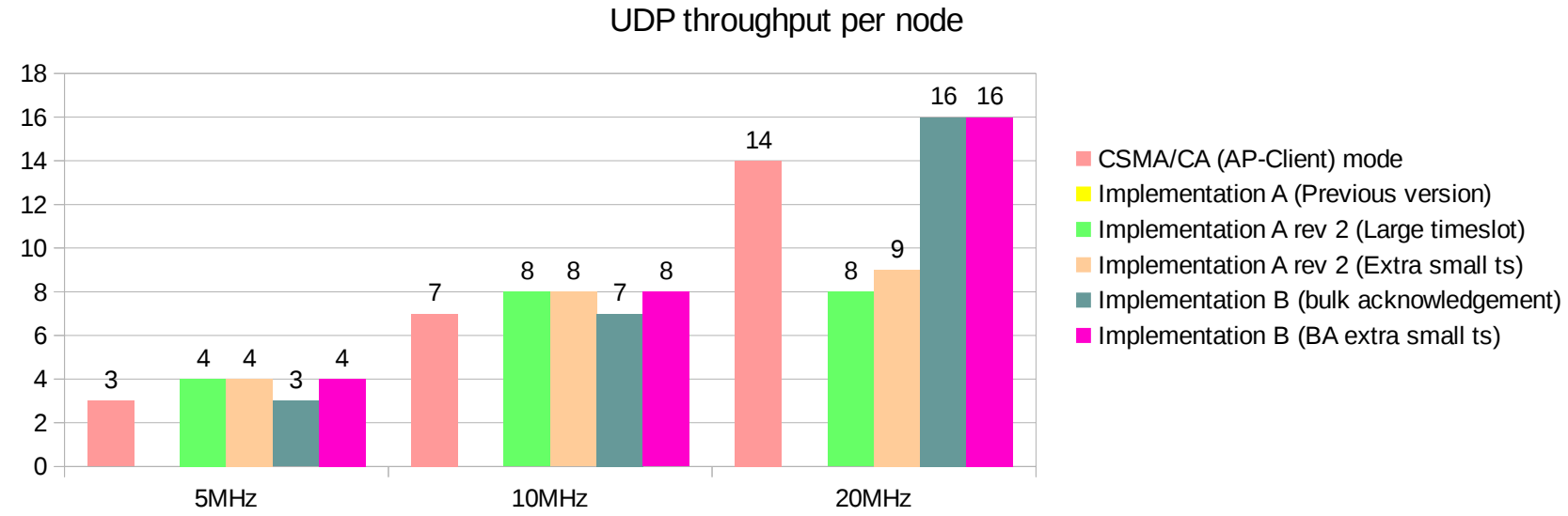
Testbed is configured for 2 nodes in the network.

AR7240 CPU based board with 32Mb of RAM. Frequency 5180MHz. Automatic power settings.

Channel width	RSSI	Timeslot size	TCP						UDP
			BS->CPE			CPE-BS			
			max	min	avg	max	min	avg	
5	40-46		3,46	2,94	3,13	3,15	3,08	3,1	3
10	44-51		6,6	6	6,15	6,15	6,05	6,1	7
20	48-56		12,05	11,45	11,6	11,65	11,55	11,6	14
5									
10	No data for tests with previous version								
20									
5	31-48	190	3,98	3,36	3,55	3,64	2,13	3,44	4
10	36-49	79	9,02	7,97	8,52	8,66	7,35	8,42	8
20	40-42	41	9,23	7,97	8,35	8,34	7,67	8,23	8
5	30-42	30	5,45	4,19	4,44	4,36	4,31	4,35	4
10	37-40	16	9,44	7,76	8,12	8,11	7,97	8,03	8
20	38-53	9	9,65	8,39	8,97	8,95	8,79	8,92	9
5	27-35	18	5,03	3,77	4,18	4,18	4,08	4,16	4
10	36-39	12	9,23	8,39	8,82	8,8	8,55	8,75	8
20	38-54	8	16,8	15,9	16,5	16,7	16,2	16,4	16
5	31-46	12	4,19	3,15	3,62	3,52	3,51	3,52	3
10	37-48	8	8,6	7,34	7,77	7,67	7,38	7,63	7
20	38-52	6	17,2	16,1	16,6	16,5	16,5	16,5	16

CSMA/CA (AP-Client) mode
Implementation A (Previous version)
Implementation A rev 2 (Large timeslot)
Implementation A rev 2 (Extra small ts)
Implementation B (bulk acknowledgement)
Implementation B (BA extra small ts)

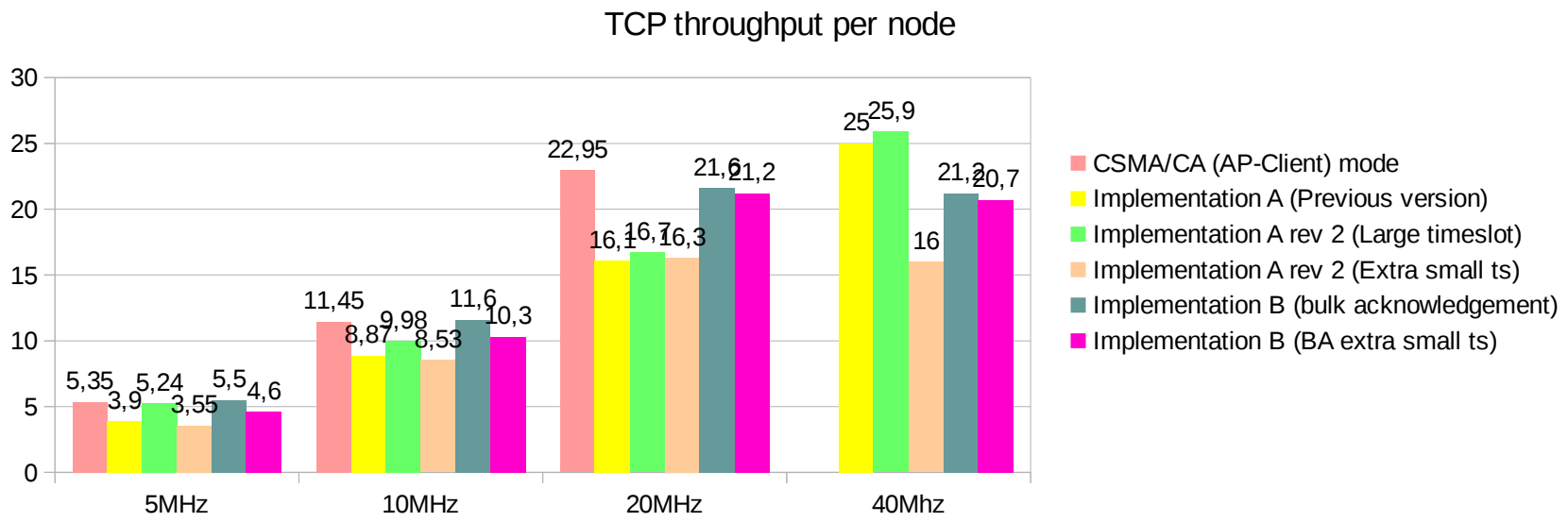

TCP throughput per node
18
16
14
12
10
8
6
4
2
0
3,13
3,55
3,55
3,62
4,18
6,15
8,52
8,12
7,77
8,82
11,6
8,35
8,97
16,6
16,5
5MHz
10MHz
20MHz
CSMA/CA (AP-Client) mode
Implementation A (Previous version)
Implementation A rev 2 (Large timeslot)
Implementation A rev 2 (Extra small ts)
Implementation B (bulk acknowledgement)
Implementation B (BA extra small ts)

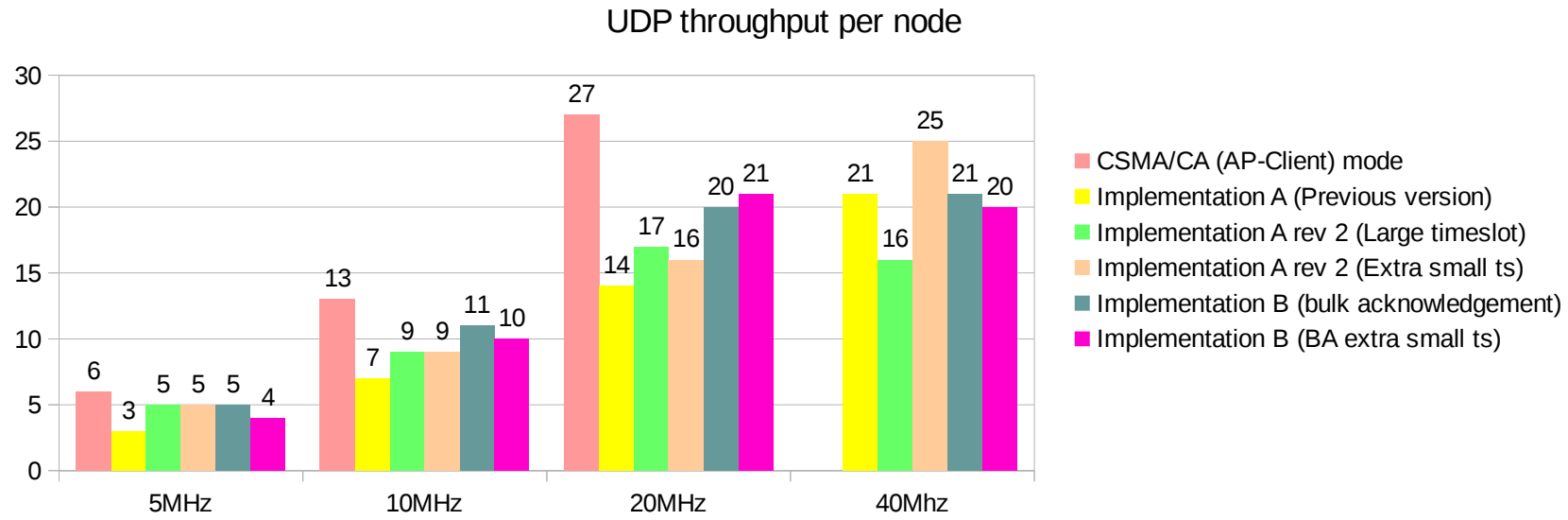

UDP throughput per node
18
16
14
12
10
8
6
4
2
0
3
4
4
3
4
7
8
8
7
8
14
8
9
16
16
5MHz
10MHz
20MHz
CSMA/CA (AP-Client) mode
Implementation A (Previous version)
Implementation A rev 2 (Large timeslot)
Implementation A rev 2 (Extra small ts)
Implementation B (bulk acknowledgement)
Implementation B (BA extra small ts)

Engenius 5XXX board with AR7240 CPU and 32Mb of RAM. MIMO-1. Frequency 5180MHz. Automatic power settings.

Channel width	RSSI	Timeslot size	TCP						UDP
			BS->CPE			CPE-BS			
			max	min	avg	max	min	avg	
5	43-49		5,85	5,05	5,35	5,5	5,1	5,35	6
10	43-56		11,75	11,1	11,3	11,8	11,2	11,45	13
20	48-56		23,15	22,45	22,8	23,35	22,6	22,95	27
5	35-38	28	4,14	3,15	3,7	4,4	3,15	3,9	3
10	40-50	18	9,23	7,55	8,87	8,81	7,55	7,97	7
20	42-44	14	16,8	15,7	16,1	16,4	14,5	15,1	14
40	37-53	14	26,2	24,5	25	23,9	22,2	22,7	21
5	28-46	190	3,98	3,15	3,55	3,64	2,4	3,46	5
10	33-49	79	9,02	8,13	8,53	8,69	7,51	8,45	9
20	33-47	41	16,8	16,1	16,3	16,5	15,2	16,2	17
40	32-48	41	16,8	15,7	16,2	16,3	15	16	16
5	28-39	30	6,5	4,82	5,24	5,15	5,06	5,13	5
10	32-51	16	11,1	9,44	9,98	9,91	9,79	9,87	9
20	38-50	9	17,8	16,1	16,7	16,8	16,7	16,7	16
40	32-50	9	26,4	25	25,5	26,1	25,2	25,9	25
5	30-48	18	5,66	5,03	5,5	5,44	5,38	5,42	5
10	31-49	12	12,6	11,3	11,6	11,5	11,4	11,5	11
20	35-52	8	22,9	21,2	21,6	21,5	20,8	21,3	20
40	34-50	8	22	20,6	21,2	21,2	21,1	21,1	21
5	29-46	12	5,03	3,98	4,6	4,6	4,45	4,47	4
10	32-51	8	10,9	10,1	10,3	10,3	10	10,3	10
20	38-54	6	22,2	20,8	21,2	21,2	21	21,1	21
40	34-50	6	21,8	19,9	20,6	20,8	20,5	20,7	20

CSMA/CA (AP-Client) mode
Implementation A (Previous version)
Implementation A rev 2 (Large timeslot)
Implementation A rev 2 (Extra small ts)
Implementation B (bulk acknowledgement)
Implementation B (BA extra small ts)

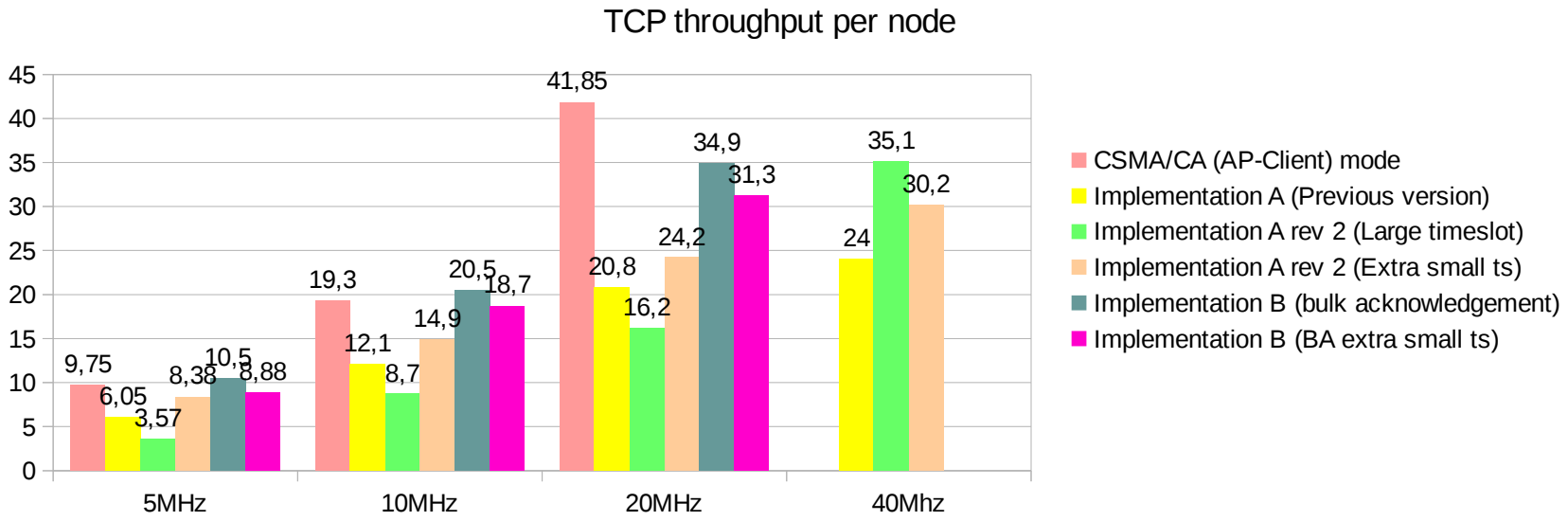

TCP throughput per node
30
25
20
15
10
5
0
5,35
3,9
5,24
3,55
5,5
4,6
11,45
8,87
9,98
8,53
11,6
10,3
22,95
16,1
16,7
16,3
21,6
21,2
25
25,9
16
21,2
20,7
5MHz
10MHz
20MHz
40Mhz
CSMA/CA (AP-Client) mode
Implementation A (Previous version)
Implementation A rev 2 (Large timeslot)
Implementation A rev 2 (Extra small ts)
Implementation B (bulk acknowledgement)
Implementation B (BA extra small ts)

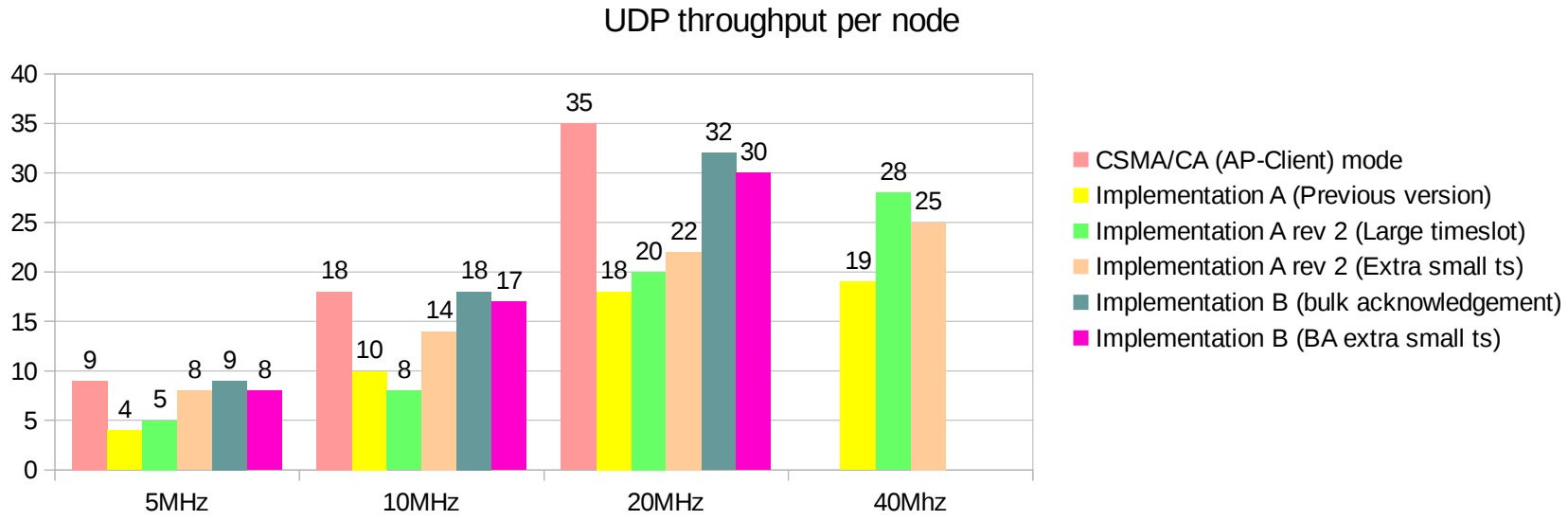

UDP throughput per node
30
25
20
15
10
5
0
6
3
5
5
5
4
13
7
9
9
11
10
27
14
17
16
20
21
21
16
25
21
20
5MHz
10MHz
20MHz
40Mhz
CSMA/CA (AP-Client) mode
Implementation A (Previous version)
Implementation A rev 2 (Large timeslot)
Implementation A rev 2 (Extra small ts)
Implementation B (bulk acknowledgement)
Implementation B (BA extra small ts)

ALFA N5 board with AR7240 CPU and 32Mb of RAM. MIMO-2. Frequency 5180MHz. Automatic power settings.

Channel width	RSSI	Timeslot size	TCP						UDP
			BS->CPE			CPE-BS			
			max	min	avg	max	min	avg	
5	20-29		10,4	9,4	9,75	10,4	9,4	9,75	9
10	24-31		20	18,95	19,3	20	18,95	19,3	18
20	28-35		42,3	40,75	41,85	42,3	40,75	41,85	35
5	34-40	28	7,13	5,03	5,79	7,13	5,45	6,05	4
10	37-44	18	13,6	10,1	11,5	13,4	10,1	12,1	10
20	35-45	14	22,6	19,5	20	22	20,1	20,8	18
40	36-42	14	25,8	21,8	24	24,7	21,8	23,1	19
5	25-33	190	3,64	2,12	3,45	3,98	3,15	3,57	5
10	23-32	79	9,02	7,3	8,7	8,69	7,54	8,45	8
20	34-41	41	16,3	14,9	16,1	16,6	15,9	16,2	20
40	24-35	41	36,9	30,4	35,1	35,5	29,8	34,7	28
5	23-30	30	8,29	8,07	8,21	9,23	7,76	8,38	8
10	22-31	16	15	14,8	14,9	15,3	13,8	14,4	14
20	31-43	9	24,3	23,7	24,2	24,1	23,9	24	22
40	25-37	9	30,6	27,3	29,2	30,4	30	30,2	25
5	22-30	18	10,8	10,1	10,5	11,1	10,1	10,4	9
10	24-35	12	21,6	17,8	20,1	20,7	19,8	20,5	18
20	41-33	8	35,9	33,1	34,9	35,7	31,2	34,9	32
40		8							
5	23-30	12	8,89	8,81	8,83	9,02	8,39	8,88	8
10	21-32	8	18,8	18,6	18,7	19	18,1	18,6	17
20	31-33	6	33,1	30,7	31,1	32,8	30,6	31,3	30
40	24-36	6							

CSMA/CA (AP-Client) mode
Implementation A (Previous version)
Implementation A rev 2 (Large timeslot)
Implementation A rev 2 (Extra small ts)
Implementation B (bulk acknowledgement)
Implementation B (BA extra small ts)

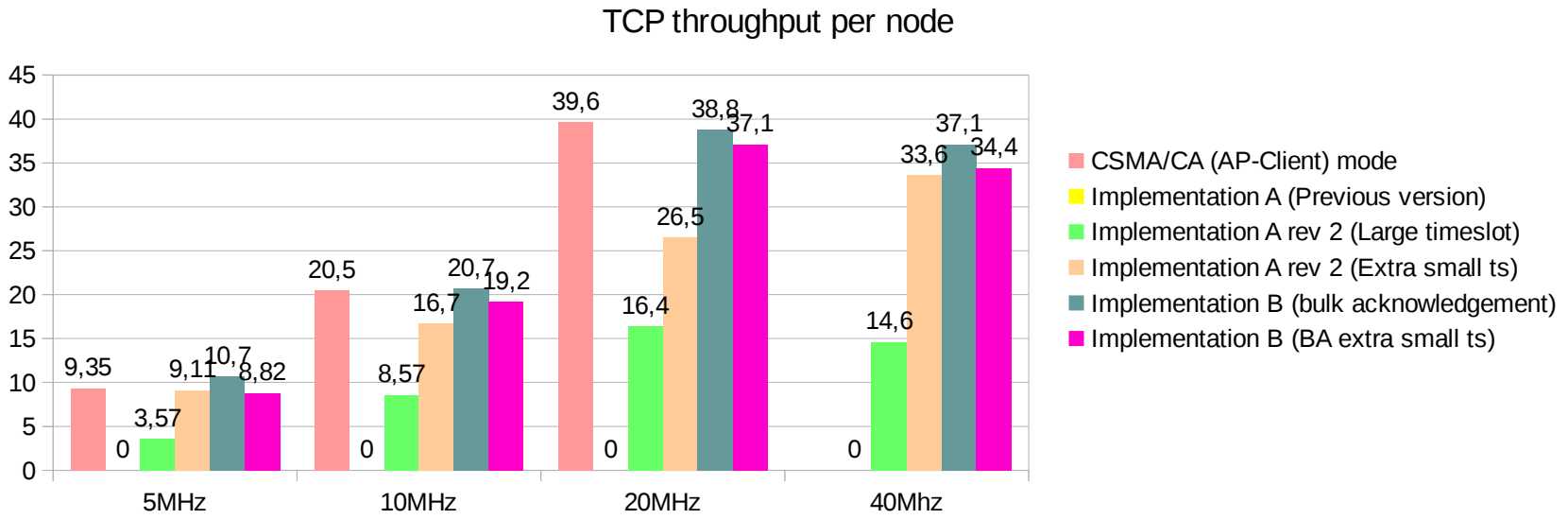

TCP throughput per node
45
40
35
30
25
20
15
10
5
0
9,75
6,05
3,57
8,38
10,5
8,88
19,3
12,1
8,7
14,9
20,5
18,7
41,85
20,8
16,2
24,2
34,9
31,3
24
35,1
30,2
5MHz
10MHz
20MHz
40Mhz
CSMA/CA (AP-Client) mode
Implementation A (Previous version)
Implementation A rev 2 (Large timeslot)
Implementation A rev 2 (Extra small ts)
Implementation B (bulk acknowledgement)
Implementation B (BA extra small ts)

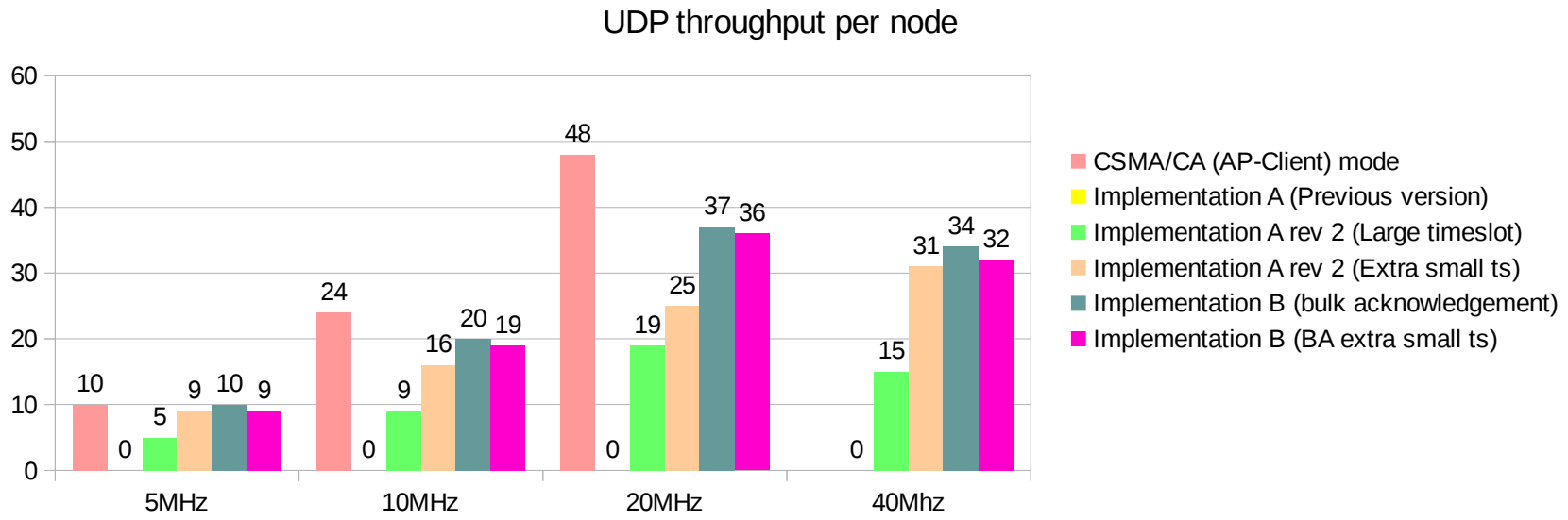

UDP throughput per node
40
35
30
25
20
15
10
5
0
9
4
5
8
9
8
18
10
8
14
18
17
35
18
20
22
32
30
19
28
25
5MHz
10MHz
20MHz
40Mhz
CSMA/CA (AP-Client) mode
Implementation A (Previous version)
Implementation A rev 2 (Large timeslot)
Implementation A rev 2 (Extra small ts)
Implementation B (bulk acknowledgement)
Implementation B (BA extra small ts)

JjPlus JWAP-603 board with AR9342 CPU and 64Mb of RAM. MIMO-2. Frequency 5180MHz. Automatic power settings.

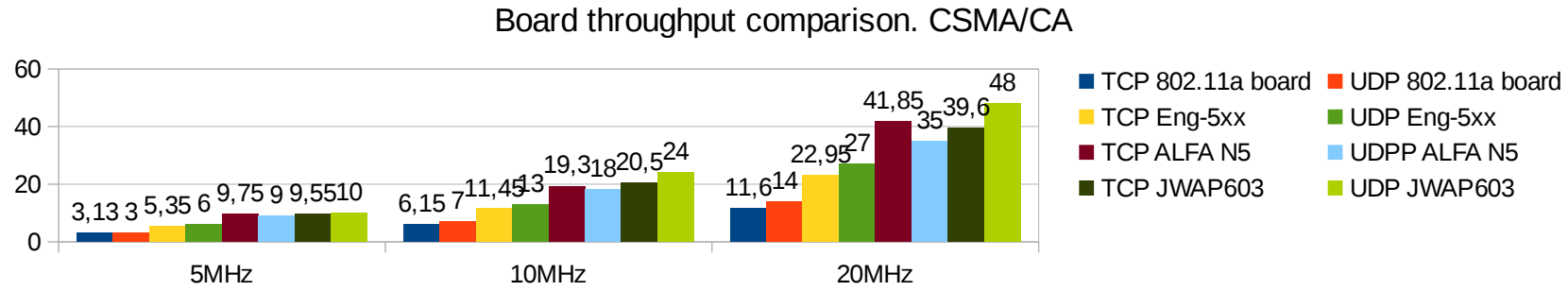
Channel width	RSSI	Timeslot size	TCP						UDP
			BS->CPE			CPE-BS			
			max	min	avg	max	min	avg	
5	17-19		10,1	8,85	9,35	9,85	9,25	9,55	10
10	20-23		20,85	19,9	20,5	21,3	20,05	20,5	24
20	22-25		38,85	37,55	38,4	40,35	38,9	39,6	48
5									
10									
20									
40									
5	24-28	190	4,19	3,15	3,57	3,64	2,52	3,41	5
10	25-28	79	9,02	8,18	8,57	8,68	7,17	8,27	9
20	22-25	41	17,2	15,9	16,4	16,5	14,8	16,1	19
40	25-29	41	15,1	13,4	14,5	15	13,8	14,6	15
5	25-29	30	9,44	8,18	9,11	9,12	7,64	8,9	9
10	24-28	16	17,2	16,4	16,7	16,6	16,2	16,5	16
20	22-25	9	27,9	26,8	27,1	26,8	26,2	26,5	25
40	24-27	9	34,2	32,9	33,6	34	32,5	33,6	31
5	25-29	18	11,4	10,5	10,7	10,7	9,28	10,5	10
10	24-28	12	21,4	17,8	20,7	20,9	20,5	20,8	20
20	22-25	8	39	38,2	38,8	38,9	37,8	38,5	37
40	27-31	8	38	36,5	37,1	36,8	35,5	36,2	34
5	25-29	12	9,23	8,6	8,82	8,86	7,35	8,24	9
10	25-28	8	19,7	19,1	19,2	19,3	19	19,2	19
20	22-26	6	37,5	36,9	37,1	36,9	35,2	36,3	36
40	26-32	6	35,7	34,4	35	34,8	33,7	34,4	32

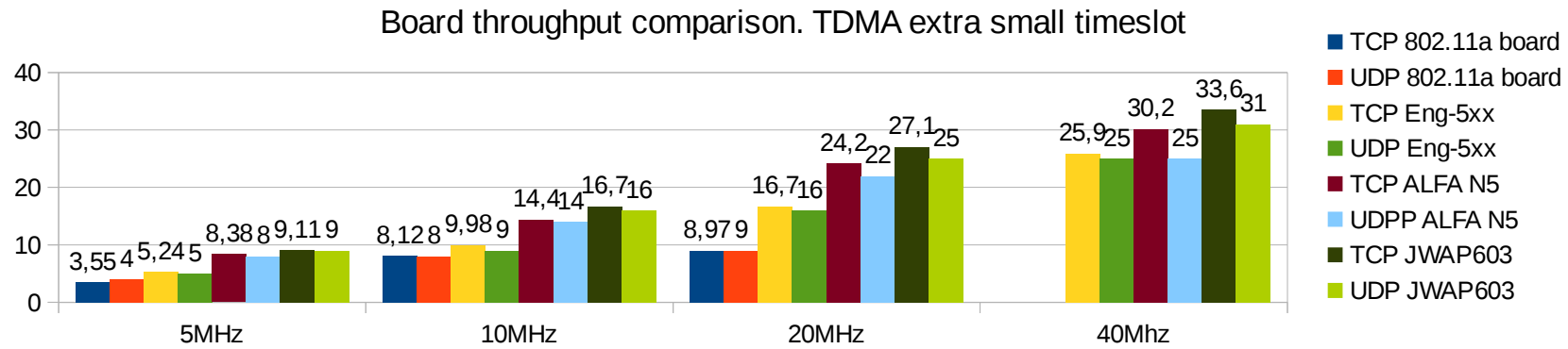
CSMA/CA (AP-Client) mode
Implementation A (Previous version)
Implementation A rev 2 (Large timeslot)
Implementation A rev 2 (Extra small ts)
Implementation B (bulk acknowledgement)
Implementation B (BA extra small ts)

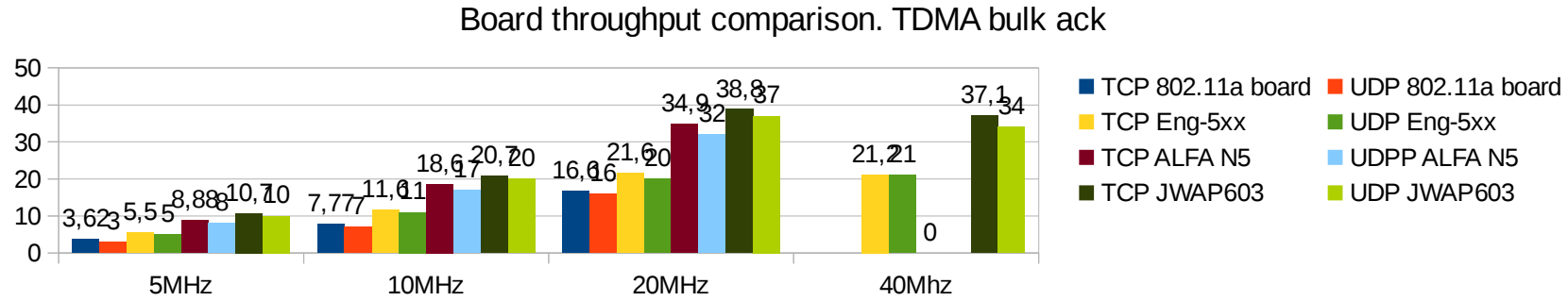

TCP throughput per node
45
40
35
30
25
20
15
10
5
0
9,35
0
3,57
9,11
10,7
8,82
20,5
0
8,57
16,7
20,7
19,2
39,6
0
16,4
26,5
38,8
37,1
0
14,6
33,6
37,1
34,4
5MHz
10MHz
20MHz
40Mhz
CSMA/CA (AP-Client) mode
Implementation A (Previous version)
Implementation A rev 2 (Large timeslot)
Implementation A rev 2 (Extra small ts)
Implementation B (bulk acknowledgement)
Implementation B (BA extra small ts)


UDP throughput per node
60
50
40
30
20
10
0
10
0
5
9
10
9
24
0
9
16
20
19
48
0
19
25
37
36
0
15
31
34
32
5MHz
10MHz
20MHz
40Mhz
CSMA/CA (AP-Client) mode
Implementation A (Previous version)
Implementation A rev 2 (Large timeslot)
Implementation A rev 2 (Extra small ts)
Implementation B (bulk acknowledgement)
Implementation B (BA extra small ts)

Board's comparison







Conclusion

The tests show throughput enchancement in 15-50 percents between implementations without latency increasion for the Similar hardware platforms.

Throughput for the TDMA mode with bulk acknowledgements is close to the maximal throughput in CSMA/CA mode.

TDMA enabled wireless stack is useful to improve throughput for old systems (ath5k based).

The tests show that the combination of AR7240 class CPU with 32Mb of RAM could not utilize all possible throughput For MIMO-2 modes with 20 and 40MHz channel widths.
Also, the system based on low end CPUs may have troubles in work with 6ms timeslot size.
To utilize possible throughput and to use 6ms timeslot size AR726x/AR934x class CPU with 64Mb of RAM should be used.

'Large timeslot size' without bulk acknowledgement shows poor results. For what this settings are implemented?
'Large timeslot size' is kept for next cases:
- Very long distance links;
- Very noised environment;
-Full compatibility with 2.4GHz band.