



City Research Online

City, University of London Institutional Repository

Citation: Algaith, A. (2017). Technical Report: Diversity with Intrusion Detection Systems: An Empirical Study. .

This is the published version of the paper.

This version of the publication may differ from the final published version.

Permanent repository link: <http://openaccess.city.ac.uk/18336/>

Link to published version:

Copyright and reuse: City Research Online aims to make research outputs of City, University of London available to a wider audience. Copyright and Moral Rights remain with the author(s) and/or copyright holders. URLs from City Research Online may be freely distributed and linked to.

City Research Online:

<http://openaccess.city.ac.uk/>

publications@city.ac.uk



Technical Report: Diversity with Intrusion Detection Systems: An Empirical Study

Areej Algaith

ABSTRACT

This report presents the analysis of the detection capabilities of intrusion detection systems when deployed in diverse, two-version, parallel defence-in-depth configurations. The configurations have been assessed in settings that favour detection of attacks (reducing false negatives), as well as settings that favour legitimate traffic

Table of Contents

1. INTRODUCTION	5
1.1 Basic Statistics	6
2. DIVERSITY RESULT	7
2.1 Analysis by type of IDS:	7
2.1.1 Summery Statistics	7
2.1.2 Averages	11
2.1.3 Diversity Analysis.	12
2.1.3.1 MyReferences	12
2.1.3.1.1 ROC	12
2.1.3.1.2 Accuracy	15
2.1.3.1.3 Specificity	17
2.1.3.1.4 Sensitivity	19
2.1.3.1.5 Improvement and deterioration in Sensitivity Specificity	21
2.1.3.2 PhpBB	22
2.1.3.2.1 ROC	22
2.1.3.2.2 Accuracy	25
2.1.3.2.3 Specificity	27
2.1.3.2.4 Sensitivity	29
2.1.3.2.5 Improvement and deterioration in Sensitivity Specificity	31
2.1.3.3 TikiWiki	32
2.1.3.3.1 ROC	32
2.1.3.3.2 Accuracy	35
2.1.3.3.3 Specificity	37
2.1.3.3.4 Sensitivity	39
2.1.3.3.5 Improvement and deterioration in Sensitivity Specificity	41
2.2 Analysis by type of attack:	42
2.2.1 Summery Statistics	42
2.2.2 Diversity Analysis.	49
2.2.2.1 MyReferences	49
2.2.2.1.1 ROC	49
2.2.2.1.2 Accuracy	51
2.2.2.1.3 Specificity	54
2.2.2.1.4 Sensitivity	58
2.2.2.2 PhpBB	62
2.2.2.2.1 ROC	62
2.2.2.2.2 Accuracy	64
2.2.2.2.3 Specificity	67
2.2.2.2.4 Sensitivity	70
2.2.2.3 TikiWiki	74
2.2.2.3.1 ROC	74
2.2.2.3.2 Accuracy	76
2.2.2.3.3 Specificity	80
2.2.2.3.4 Sensitivity	83

Table of Figures

FIGURE 1 THE ROC PLOT SHOWING THE INDIVIDUAL IDSS, 1002 AND 2002 CONFIGURATIONS FOR MYREFERENCES	12
FIGURE 2 THE ROC PLOT SHOWING THE INDIVIDUAL IDSS, 1002 AND 2002 CONFIGURATIONS . THE ROC FOR MYREFERENCES WHEN THE PAIRS WERE FUNCTIONALLY REDUNDANT	13
FIGURE 3 THE ROC PLOT SHOWING THE INDIVIDUAL IDSS, 1002 AND 2002 CONFIGURATIONS . THE ROC FOR MYREFERENCES WHEN THE PAIRS WERE FUNCTIONALLY DIVERSE	14
FIGURE 4 THE ACCURACY FOR A GIVEN SYSTEM A WHEN PAIRED WITH ANOTHER SYSTEM B FOR MYREFERENCES, THE CHART SHOWS THE INDIVIDUAL IDSS, 1002 AND 2002 CONFIGURATIONS	15
FIGURE 5 THE ACCURACY DIFFERENCE OF 1002 AND 2002 CONFIGURATIONS, COMAPRED WITH THE BEST SINGLE SYSTEM IN THE RESPECTIVE PAIR FOR MYREFERENCES	16
FIGURE 6 THE SPECIFICITY FOR A GIVEN SYSTEM A WHEN PAIRED WITH ANOTHER SYSTEM B FOR MYREFERENCES, THE CHART SHOWS THE INDIVIDUAL IDSS, 1002 AND 2002 CONFIGURATIONS	17
FIGURE 7 THE SPECIFICITY DIFFERENCE OF 1002 AND 2002 CONFIGURATIONS, COMAPRED WITH THE BEST SINGLE SYSTEM IN THE RESPECTIVE PAIR FOR MYREFERENCES	18
FIGURE 8 THE SENSITIVITY FOR A GIVEN SYSTEM A WHEN PAIRED WITH ANOTHER SYSTEM B FOR MYREFERENCES, THE CHART SHOWS THE INDIVIDUAL IDSS, 1002 AND 2002 CONFIGURATIONS	19
FIGURE 9 THE SENSITIVITY DIFFERENCE OF 1002 AND 2002 CONFIGURATIONS, COMAPRED WITH THE BEST SINGLE SYSTEM IN THE RESPECTIVE PAIR FOR MYREFERENCES	20
FIGURE 10 DIFFERENCES IN SENSITIVITY AND SPECIFICITY FOR A GIVEN SYSTEM A WHEN PAIRED WITH ANOTHER SYSTEM B FOR MYREFERENCES FOR A 1002 CONFIGURATION	21
FIGURE 11 DIFFERENCES IN SENSITIVITY AND SPECIFICITY FOR A GIVEN SYSTEM A WHEN PAIRED WITH ANOTHER SYSTEM B FOR MYREFERENCES FOR A 2002 CONFIGURATION	21
FIGURE 12 ROC PLOT SHOWING THE INDIVIDUAL IDSS, 1002 AND 2002 CONFIGURATIONS FOR PHPBB	22
FIGURE 13 THE ROC PLOT SHOWING THE INDIVIDUAL IDSS, 1002 AND 2002 CONFIGURATIONS . THE ROC FOR PHPBB WHEN THE PAIRS WERE FUNCTIONALLY REDUNDANT	23
FIGURE 14 THE ROC PLOT SHOWING THE INDIVIDUAL IDSS, 1002 AND 2002 CONFIGURATIONS . THE ROC FOR MYREFERENCES WHEN THE PAIRS WERE FUNCTIONALLY DIVERSE	24
FIGURE 15 THE ACCURACY FOR A GIVEN SYSTEM A WHEN PAIRED WITH ANOTHER SYSTEM B FOR PHPBB, THE CHART SHOWS THE INDIVIDUAL IDSS, 1002 AND 2002 CONFIGURATIONS	25
FIGURE 16 THE ACCURACY DIFFERENCE OF 1002 AND 2002 CONFIGURATIONS, COMAPRED WITH THE BEST SINGLE SYSTEM IN THE RESPECTIVE PAIR FOR PHPBB	26
FIGURE 17 THE SPECIFICITY FOR A GIVEN SYSTEM A WHEN PAIRED WITH ANOTHER SYSTEM B FOR PHPBB, THE CHART SHOWS THE INDIVIDUAL IDSS, 1002 AND 2002 CONFIGURATIONS	27
FIGURE 18 THE SPECIFICITY DIFFERENCE OF 1002 AND 2002 CONFIGURATIONS, COMAPRED WITH THE BEST SINGLE SYSTEM IN THE RESPECTIVE PAIR FOR PHPBB	28
FIGURE 19 THE SENSITIVITY FOR A GIVEN SYSTEM A WHEN PAIRED WITH ANOTHER SYSTEM B FOR PHPBB, THE CHART SHOWS THE INDIVIDUAL IDSS, 1002 AND 2002 CONFIGURATIONS	29
FIGURE 20 THE SENSITIVITY DIFFERENCE OF 1002 AND 2002 CONFIGURATIONS, COMAPRED WITH THE BEST SINGLE SYSTEM IN THE RESPECTIVE PAIR FOR PHPBB	30
FIGURE 21 DIFFERENCES IN SENSITIVITY AND SPECIFICITY FOR A GIVEN SYSTEM A WHEN PAIRED WITH ANOTHER SYSTEM B FOR PHPBB FOR A 1002 CONFIGURATION	31
FIGURE 22 DIFFERENCES IN SENSITIVITY AND SPECIFICITY FOR A GIVEN SYSTEM A WHEN PAIRED WITH ANOTHER SYSTEM B FOR PHPBB FOR A 2002 CONFIGURATION	31
FIGURE 23 THE ROC PLOT SHOWING THE INDIVIDUAL IDSS, 1002 AND 2002 CONFIGURATIONS FOR TIKIWIKI	32
FIGURE 24 THE ROC PLOT SHOWING THE INDIVIDUAL IDSS, 1002 AND 2002 CONFIGURATIONS . THE ROC FOR TIKIWIKI WHEN THE PAIRS WERE FUNCTIONALLY REDUNDANT	33
FIGURE 25 THE ROC PLOT SHOWING THE INDIVIDUAL IDSS, 1002 AND 2002 CONFIGURATIONS . THE ROC FOR TIKIWIKI WHEN THE PAIRS WERE FUNCTIONALLY DIVERSE	34
FIGURE 26 THE ACCURACY FOR A GIVEN SYSTEM A WHEN PAIRED WITH ANOTHER SYSTEM B FOR TIKIWIKI, THE CHART SHOWS THE INDIVIDUAL IDSS, 1002 AND 2002 CONFIGURATIONS	35
FIGURE 27 THE ACCURACY DIFFERENCE OF 1002 AND 2002 CONFIGURATIONS, COMAPRED WITH THE BEST SINGLE SYSTEM IN THE RESPECTIVE PAIR FOR TIKIWIKI	36

FIGURE 28 THE SPECIFICITY FOR A GIVEN SYSTEM A WHEN PAIRED WITH ANOTHER SYSTEM B FOR TIKIWIKI, THE CHART SHOWS THE INDIVIDUAL IDSS, 1002 AND 2002 CONFIGURATIONS	37
FIGURE 29 THE SPECIFICITY DIFFERENCE OF 1002 AND 2002 CONFIGURATIONS, COMPARED WITH THE BEST SINGLE SYSTEM IN THE RESPECTIVE PAIR FOR TIKIWIKI	38
FIGURE 30 THE SENSITIVITY FOR A GIVEN SYSTEM A WHEN PAIRED WITH ANOTHER SYSTEM B FOR TIKIWIKI, THE CHART SHOWS THE INDIVIDUAL IDSS, 1002 AND 2002 CONFIGURATIONS	39
FIGURE 31 THE SENSITIVITY DIFFERENCE OF 1002 AND 2002 CONFIGURATIONS, COMPARED WITH THE BEST SINGLE SYSTEM IN THE RESPECTIVE PAIR FOR TIKIWIKI	40
FIGURE 32 DIFFERENCES IN SENSITIVITY AND SPECIFICITY FOR A GIVEN SYSTEM A WHEN PAIRED WITH ANOTHER SYSTEM B FOR TIKIWIKI FOR A 1002 CONFIGURATION	41
FIGURE 33 DIFFERENCES IN SENSITIVITY AND SPECIFICITY FOR A GIVEN SYSTEM A WHEN PAIRED WITH ANOTHER SYSTEM B FOR TIKIWIKI FOR A 2002 CONFIGURATION	41
FIGURE 34 THE ROC PLOT SHOWING THE INDIVIDUAL IDSS, 1002 AND 2002 CONFIGURATIONS FOR MYREFERENCES WHEN ATTACKS WHERE READ (GET)	49
FIGURE 35 THE ROC PLOT SHOWING THE INDIVIDUAL IDSS, 1002 AND 2002 CONFIGURATIONS FOR MYREFERENCES WHEN ATTACKS WHERE WRITE (POST)	50
FIGURE 36 THE ACCURACY FOR A GIVEN SYSTEM A WHEN PAIRED WITH ANOTHER SYSTEM B FOR MYREFERENCES, THE CHART SHOWS THE INDIVIDUAL IDSS, 1002 AND 2002 CONFIGURATIONS WHEN ATTACKS WHERE READ (GET)	51
FIGURE 37 THE ACCURACY DIFFERENCE OF 1002 AND 2002 CONFIGURATIONS, COMPARED WITH THE BEST SINGLE SYSTEM IN THE RESPECTIVE PAIR FOR MYREFERENCES WHEN ATTACKS WHERE READ (GET)	51
FIGURE 38 THE ACCURACY DIFFERENCE OF 1002 AND 2002 CONFIGURATIONS, COMPARED WITH THE BEST SINGLE SYSTEM IN THE RESPECTIVE PAIR FOR MYREFERENCES WHEN ATTACKS WHERE WRITE (POST)	52
FIGURE 39 THE ACCURACY DIFFERENCE OF 1002 AND 2002 CONFIGURATIONS, COMPARED WITH THE BEST SINGLE SYSTEM IN THE RESPECTIVE PAIR FOR MYREFERENCES WHEN ATTACKS WHERE WRITE (POST)	53
FIGURE 40 THE SPECIFICITY FOR A GIVEN SYSTEM A WHEN PAIRED WITH ANOTHER SYSTEM B FOR MYREFERENCES, THE CHART SHOWS THE INDIVIDUAL IDSS, 1002 AND 2002 CONFIGURATIONS WHEN ATTACKS WHERE READ (GET)	54
FIGURE 41 THE SPECIFICITY DIFFERENCE OF 1002 AND 2002 CONFIGURATIONS, COMPARED WITH THE BEST SINGLE SYSTEM IN THE RESPECTIVE PAIR FOR MYREFERENCES WHEN ATTACKS WHERE READ (GET)	55
FIGURE 42 THE SPECIFICITY FOR A GIVEN SYSTEM A WHEN PAIRED WITH ANOTHER SYSTEM B FOR MYREFERENCES, THE CHART SHOWS THE INDIVIDUAL IDSS, 1002 AND 2002 CONFIGURATIONS WHEN ATTACKS WHERE WRITE (POST)	56
FIGURE 43 THE SPECIFICITY DIFFERENCE OF 1002 AND 2002 CONFIGURATIONS, COMPARED WITH THE BEST SINGLE SYSTEM IN THE RESPECTIVE PAIR FOR MYREFERENCES WHEN ATTACKS WHERE WRITE (POST)	57
FIGURE 44 THE SENSITIVITY FOR A GIVEN SYSTEM A WHEN PAIRED WITH ANOTHER SYSTEM B FOR MYREFERENCES, THE CHART SHOWS THE INDIVIDUAL IDSS, 1002 AND 2002 CONFIGURATIONS WHEN ATTACKS WHERE READ (GET)	58
FIGURE 45 THE SENSITIVITY DIFFERENCE OF 1002 AND 2002 CONFIGURATIONS, COMPARED WITH THE BEST SINGLE SYSTEM IN THE RESPECTIVE PAIR FOR MYREFERENCES WHEN ATTACKS WHERE READ (GET)	59
FIGURE 46 THE SENSITIVITY FOR A GIVEN SYSTEM A WHEN PAIRED WITH ANOTHER SYSTEM B FOR MYREFERENCES, THE CHART SHOWS THE INDIVIDUAL IDSS, 1002 AND 2002 CONFIGURATIONS WHEN ATTACKS WHERE WRITE (POST)	60
FIGURE 47 THE SENSITIVITY DIFFERENCE OF 1002 AND 2002 CONFIGURATIONS, COMPARED WITH THE BEST SINGLE SYSTEM IN THE RESPECTIVE PAIR FOR MYREFERENCES WHEN ATTACKS WHERE WRITE (POST)	61
FIGURE 48 THE ROC PLOT SHOWING THE INDIVIDUAL IDSS, 1002 AND 2002 CONFIGURATIONS FOR PHPBB WHEN ATTACKS WHERE READ (GET)	62
FIGURE 49 THE ROC PLOT SHOWING THE INDIVIDUAL IDSS, 1002 AND 2002 CONFIGURATIONS FOR PHPBB WHEN ATTACKS WHERE WRITE (POST)	63
FIGURE 50 THE ACCURACY FOR A GIVEN SYSTEM A WHEN PAIRED WITH ANOTHER SYSTEM B FOR PHPBB, THE CHART SHOWS THE INDIVIDUAL IDSS, 1002 AND 2002 CONFIGURATIONS WHEN ATTACKS WHERE READ (GET)	64
FIGURE 51 THE ACCURACY DIFFERENCE OF 1002 AND 2002 CONFIGURATIONS, COMPARED WITH THE BEST SINGLE SYSTEM IN THE RESPECTIVE PAIR FOR PHPBB WHEN ATTACKS WHERE READ (GET)	65
FIGURE 52 THE ACCURACY FOR A GIVEN SYSTEM A WHEN PAIRED WITH ANOTHER SYSTEM B FOR PHPBB, THE CHART SHOWS THE INDIVIDUAL IDSS, 1002 AND 2002 CONFIGURATIONS WHEN ATTACKS WHERE WRITE (POST)	65
FIGURE 53 THE ACCURACY DIFFERENCE OF 1002 AND 2002 CONFIGURATIONS, COMPARED WITH THE BEST SINGLE SYSTEM IN THE RESPECTIVE PAIR FOR PHPBB WHEN ATTACKS WHERE WRITE (POST)	66

FIGURE 54 THE SPECIFICITY FOR A GIVEN SYSTEM A WHEN PAIRED WITH ANOTHER SYSTEM B FOR PHPBB, THE CHART SHOWS THE INDIVIDUAL IDSS, 1002 AND 2002 CONFIGURATIONS WHEN ATTACKS WHERE READ (GET)	67
FIGURE 55 THE SPECIFICITY DIFFERENCE OF 1002 AND 2002 CONFIGURATIONS, COMAPRED WITH THE BEST SINGLE SYSTEM IN THE RESPECTIVE PAIR FOR PHPBB WHEN ATTACKS WHERE READ (GET)	68
FIGURE 56 THE SPECIFICITY FOR A GIVEN SYSTEM A WHEN PAIRED WITH ANOTHER SYSTEM B FOR PHPBB, THE CHART SHOWS THE INDIVIDUAL IDSS, 1002 AND 2002 CONFIGURATIONS WHEN ATTACKS WHERE WRITE (POST)	68
FIGURE 57 THE SPECIFICITY DIFFERENCE OF 1002 AND 2002 CONFIGURATIONS, COMAPRED WITH THE BEST SINGLE SYSTEM IN THE RESPECTIVE PAIR FOR PHPBB WHEN ATTACKS WHERE WRITE (POST)	69
FIGURE 58 THE SENSITIVITY FOR A GIVEN SYSTEM A WHEN PAIRED WITH ANOTHER SYSTEM B FOR PHPBB, THE CHART SHOWS THE INDIVIDUAL IDSS, 1002 AND 2002 CONFIGURATIONS WHEN ATTACKS WHERE READ (GET)	70
FIGURE 59 THE SENSITIVITY DIFFERENCE OF 1002 AND 2002 CONFIGURATIONS, COMAPRED WITH THE BEST SINGLE SYSTEM IN THE RESPECTIVE PAIR FOR PHPBB WHEN ATTACKS WHERE READ (GET)	71
FIGURE 60 THE SENSITIVITY FOR A GIVEN SYSTEM A WHEN PAIRED WITH ANOTHER SYSTEM B FOR PHPBB, THE CHART SHOWS THE INDIVIDUAL IDSS, 1002 AND 2002 CONFIGURATIONS WHEN ATTACKS WHERE WRITE (POST)	72
FIGURE 61 THE SENSITIVITY DIFFERENCE OF 1002 AND 2002 CONFIGURATIONS, COMAPRED WITH THE BEST SINGLE SYSTEM IN THE RESPECTIVE PAIR FOR PHPBB WHEN ATTACKS WHERE WRITE (POST)	73
FIGURE 62 THE ROC PLOT SHOWING THE INDIVIDUAL IDSS, 1002 AND 2002 CONFIGURATIONS FOR TIKIWIKI WHEN ATTACKS WHERE READ (GET)	74
FIGURE 63 THE ROC PLOT SHOWING THE INDIVIDUAL IDSS, 1002 AND 2002 CONFIGURATIONS FOR TIKIWIKI WHEN ATTACKS WHERE WRITE (POST)	75
FIGURE 64 THE ACCURACY FOR A GIVEN SYSTEM A WHEN PAIRED WITH ANOTHER SYSTEM B FOR TIKIWIKI, THE CHART SHOWS THE INDIVIDUAL IDSS, 1002 AND 2002 CONFIGURATIONS WHEN ATTACKS WHERE READ (GET)	76
FIGURE 65 THE ACCURACY DIFFERENCE OF 1002 AND 2002 CONFIGURATIONS, COMAPRED WITH THE BEST SINGLE SYSTEM IN THE RESPECTIVE PAIR FOR TIKIWIKI WHEN ATTACKS WHERE READ (GET)	77
FIGURE 66 THE ACCURACY FOR A GIVEN SYSTEM A WHEN PAIRED WITH ANOTHER SYSTEM B FOR TIKIWIKI, THE CHART SHOWS THE INDIVIDUAL IDSS, 1002 AND 2002 CONFIGURATIONS WHEN ATTACKS WHERE WRITE (POST)	78
FIGURE 67 THE ACCURACY DIFFERENCE OF 1002 AND 2002 CONFIGURATIONS, COMAPRED WITH THE BEST SINGLE SYSTEM IN THE RESPECTIVE PAIR FOR TIKIWIKI WHEN ATTACKS WHERE WRITE (POST)	79
FIGURE 68 THE SPECIFICITY FOR A GIVEN SYSTEM A WHEN PAIRED WITH ANOTHER SYSTEM B FOR TIKIWIKI, THE CHART SHOWS THE INDIVIDUAL IDSS, 1002 AND 2002 CONFIGURATIONS WHEN ATTACKS WHERE READ (GET)	80
FIGURE 69 THE SPECIFICITY DIFFERENCE OF 1002 AND 2002 CONFIGURATIONS, COMAPRED WITH THE BEST SINGLE SYSTEM IN THE RESPECTIVE PAIR FOR TIKIWIKI WHEN ATTACKS WHERE READ (GET)	81
FIGURE 70 THE SPECIFICITY FOR A GIVEN SYSTEM A WHEN PAIRED WITH ANOTHER SYSTEM B FOR TIKIWIKI, THE CHART SHOWS THE INDIVIDUAL IDSS, 1002 AND 2002 CONFIGURATIONS WHEN ATTACKS WHERE WRITE (POST)	81
FIGURE 71 THE SPECIFICITY DIFFERENCE OF 1002 AND 2002 CONFIGURATIONS, COMAPRED WITH THE BEST SINGLE SYSTEM IN THE RESPECTIVE PAIR FOR TIKIWIKI WHEN ATTACKS WHERE WRITE (POST)	82
FIGURE 72 THE SENSITIVITY FOR A GIVEN SYSTEM A WHEN PAIRED WITH ANOTHER SYSTEM B FOR TIKIWIKI, THE CHART SHOWS THE INDIVIDUAL IDSS, 1002 AND 2002 CONFIGURATIONS WHEN ATTACKS WHERE READ (GET)	83
FIGURE 73 THE SENSITIVITY DIFFERENCE OF 1002 AND 2002 CONFIGURATIONS, COMAPRED WITH THE BEST SINGLE SYSTEM IN THE RESPECTIVE PAIR FOR TIKIWIKI WHEN ATTACKS WHERE READ (GET)	84
FIGURE 74 THE SENSITIVITY FOR A GIVEN SYSTEM A WHEN PAIRED WITH ANOTHER SYSTEM B FOR TIKIWIKI, THE CHART SHOWS THE INDIVIDUAL IDSS, 1002 AND 2002 CONFIGURATIONS WHEN ATTACKS WHERE WRITE (POST)	85
FIGURE 75 THE SENSITIVITY DIFFERENCE OF 1002 AND 2002 CONFIGURATIONS, COMAPRED WITH THE BEST SINGLE SYSTEM IN THE RESPECTIVE PAIR FOR TIKIWIKI WHEN ATTACKS WHERE WRITE (POST)	86

1. Introduction

In this report, we present results of an empirical study to assess the detection capability of diverse Intrusion Detection Systems (IDSs) that operate at different system levels: Application, Database and Network, as shown in Table 1. The study used SQL Injection to test 9 IDSs in a setup based on three web applications of different sizes and complexities namely (TikiWiki, PhpBB, and MyReferences).

Table 1 Classification of the types of IDSs

IDS -Label	IDS	Architectural Level Monitored
1A	ACD1	Application
2A	ACD3	Application
3A	ACD10	Application
4A	ACD30	Application
5A	ACD100	Application
6D	GREENSQL	Database
7A	SCALP sqlia	Application
8N	SNORT 2.8	Network
9N	SNORT 2.8 Plus	Network

This empirical study used the same dataset of experiment that performed to test the effectiveness of security tools to detect SQL Injection attacks. The pervious experiment result highlighted the limitation of detection capabilities of the 9 IDSs, however in this study we investigate the effectiveness of diversity to help with the reliability of the detection tools.

This study achieves the benefits of diversity strategy through 2 configurations: 1oo2 and 2oo2

1-out-of-2 : 2 is the number of IDSs in a given configuration – the system raises an alarm/marks a demand as malicious as long as any one of the IDS has raised an alarm.

2-out-of-2 : 2 is the number of IDSs in a given configuration – the system raises an alarm/marks a demand as malicious only if both of the IDS raise an alarm.

Note that the attack injectors used two methods GET and POST, while the IDSs have different level of detections (application, network and database)

In this report we present results of diversity analysis we have performed. The results are structured into two main sections, depending on the level of detail we present:

- Overall summery results and analysis by type of IDS: 1-out-of-2 and 2-out-of-2 categorised by type of IDS (application, network or database level).
- Analysis by type of attack: 1-out-of-2 and 2-out-of-2 categorised by SQL injection attack method (GET (read) and POST (write)).

In all the cases above we present overall raw data analysis; and then the sensitivity, specificity, accuracy and ROC measures, as defined in the Table2 below.

Table 2 The formulas and definitions of four types of statistics sensitivity, specificity, accuracy and ROC

Statistical Measure	Equation	Definition
Sensitivity (True Positive Rate TPR)	$= TP / (TP+FN)$	The rate of detecting a legitimate attack
False Negative Rate FNR	$= FN / (FN+TP) = 1 - TPR$	The rate of failing to detect a legitimate attack
Specificity SPC (True Negative Rate TNR)	$= TN / (TN+FP)$	The rate of remaining silent with benign traffic
False positive Rate FPR	$= FP / (FP+TN) = 1 - SPC$	The rate of falsely detecting a benign traffic
Accuracy (ACC)	$= (TP+TN) / (TP+FP+FN+TN)$	The rate of detecting legitimate attack and Remain Silent with benign traffic

1.1 Basic Statistics

Table 3 reports the distribution of the analysis data of the empirical study.

Table 3 The counts of crawling actions traffic and successful attacks traffic per web application

Web Application	IDS	Crawling Actions	Successful Attack
MY REFERENCE	9	45	136
PHP BB	9	97	245
TIKIWIKI	9	80	76

2. Diversity Result

Since we have 9 different IDSs systems we can get ${}^9C_2 = 36$ combinations of 2-version systems.

2.1 Analysis by type of IDS:

1-out-of 2 and 2-out-of 2 with considering IDS function.

These IDSs have different functions and can be classified according to their level of detections (application, network and database). Table 4 shows The counts of IDS combinations according to the IDS function .

Taking into account the type of IDS we can apply diversity according to the IDS function:

- **Functionality Redundant.**
- **Functionality Diverse**

Table 4 The counts of IDS combinations according to the IDS function (level of detection: application, network and database)

Function Redundant	IDS COUNT	Function Diverse	IDS Count
Application, Application	15	Application, Network	12
Network, Network	1	Application, Database	6
-	-	Network, Database	2
Total	16	-	20

2.1.1 Summery Statistics

Table 5 presents the 9 configurations of the IDSs and the labels.

Table 5 The 9 Configurations of the IDSs

Label	IDS Name	MyReferencess		PhpBB		TikiWiki	
		Sensitivity	Specificity	Sensitivity	Specificity	Sensitivity	Specificity
1A	ACD1	0.89	0.76	0.93	0.37	0.49	0.48
2A	ACD3	0.61	0.84	0.22	0.68	0.24	0.75
3A	ACD10	0.35	1	0.07	0.99	0.20	0.99
4A	ACD30	0.27	1	0.04	1	0.20	1
5A	ACD100	0.10	1	0.02	1	0.00	1
6D	GREENSQL	0.12	1	0.63	1	1	1
7A	SCALP sqlia	0.25	0.91	0	1	0.21	1
8N	SNORT 2.8	0	1	0	1	0	1
9N	SNORT 2.8 plus CR	0.59	1	1	1	0.5000	1

Table 6 COUNTS OF DETECTIONS AND FAILURES FOR BENIGN TRAFFIC (FALSE POSITIVE AND TRUE NEGATIVE) AND FOR LEGITIMATE ATTACK (FALSE NEGATIVE AND TRUE POSITIVE) FOR EACH IDS AND FOR THE 36 COMBINATIONS OF 2-VERSION SYSTEMS 1002 AND 2002 FOR MYREFERENCES AND TAKING INTO ACCOUNT THE TYPE OF IDS

Combined System Label	A	B	FP				TN				FN				TP				Sensitivity		Specificity	
			FP (A)	FP (B)	FP 1002(A,B)	FP 2002 (A,B)	TN (A)	TN (B)	TN 1002 (A,B)	TN 2002 (A,B)	FN (A)	FN (B)	FN 1002 (A,B)	FN 2002 (A,B)	TP (A)	TP (B)	TP 1002 (A,B)	TP 2002 (A,B)	1002 (A,B)	2002 (A,B)	1002 (A,B)	2002 (A,B)
1-2 AA	1A	2A	11	7	15	3	34	38	30	42	15	53	15	53	121	83	121	83	0.89	0.61	0.67	0.93
1-3 AA	1A	3A	11	0	11	0	34	45	34	45	15	89	15	89	121	47	121	47	0.89	0.35	0.76	1
1-4 AA	1A	4A	11	0	11	0	34	45	34	45	15	99	15	99	121	37	121	37	0.89	0.27	0.76	1
1-5 AA	1A	5A	11	0	11	0	34	45	34	45	15	123	15	123	121	13	121	13	0.89	0.10	0.76	1
1-7 AA	1A	7A	11	4	13	2	34	41	32	43	15	102	8	109	121	34	128	27	0.94	0.20	0.71	0.96
2-3 AA	2A	3A	7	0	7	0	38	45	38	45	53	89	53	89	83	47	83	47	0.61	0.35	0.84	1
2-4 AA	2A	4A	7	0	7	0	38	45	38	45	53	99	53	99	83	37	83	37	0.61	0.27	0.84	1
2-5 AA	2A	5A	7	0	7	0	38	45	38	45	53	123	53	123	83	13	83	13	0.61	0.10	0.84	1
2-7 AA	2A	7A	7	4	11	0	38	41	34	45	53	102	46	109	83	34	90	27	0.66	0.20	0.76	1
3-4 AA	3A	4A	0	0	0	0	45	45	45	45	89	99	89	99	47	37	47	37	0.35	0.27	1	1
3-5 AA	3A	5A	0	0	0	0	45	45	45	45	89	123	89	123	47	13	47	13	0.35	0.10	1	1
3-7 AA	3A	7A	0	4	4	0	45	41	41	45	89	102	73	118	47	34	63	18	0.46	0.13	0.91	1
4-5 AA	4A	5A	0	0	0	0	45	45	45	45	99	123	99	123	37	13	37	13	0.27	0.10	1	1
4-7 AA	4A	7A	0	4	4	0	45	41	41	45	99	102	82	119	37	34	54	17	0.40	0.13	0.91	1
5-7 AA	5A	7A	0	4	4	0	45	41	41	45	123	102	89	136	13	34	47	0	0.35	0	0.91	1
8-9 NN	8N	9N	0	0	0	0	45	45	45	45	136	56	56	136	0	80	80	0	0.59	0	1	1
1-8 AN	1A	8N	11	0	11	0	34	45	34	45	15	136	15	136	121	0	121	0	0.89	0	0.76	1
1-9 AN	1A	9N	11	0	11	0	34	45	34	45	15	56	5	66	121	80	131	70	0.96	0.51	0.76	1
2-8 AN	2A	8N	7	0	7	0	38	45	38	45	53	136	53	136	83	0	83	0	0.61	0.00	0.84	1
2-9 AN	2A	9N	7	0	7	0	38	45	38	45	53	56	10	99	83	80	126	37	0.93	0.27	0.84	1
3-8 AN	3A	8N	0	0	0	0	45	45	45	45	89	136	89	136	47	0	47	0	0.35	0	1	1
3-9 AN	3A	9N	0	0	0	0	45	45	45	45	89	56	28	117	47	80	108	19	0.79	0.14	1	1
4-8 AN	4A	8N	0	0	0	0	45	45	45	45	99	136	99	136	37	0	37	0	0.27	0.00	1	1
4-9 AN	4A	9N	0	0	0	0	45	45	45	45	99	56	36	119	37	80	100	17	0.74	0.13	1	1
5-8 AN	5A	8N	0	0	0	0	45	45	45	45	123	136	123	136	13	0	13	0	0.10	0	1	1
5-9 AN	5A	9N	0	0	0	0	45	45	45	45	123	56	43	136	13	80	93	0	0.68	0	1	1
7-8 AN	7A	8N	4	0	4	0	41	45	41	45	102	136	102	136	34	0	34	0	0.25	0	0.91	1
7-9 AN	7A	9N	4	0	4	0	41	45	41	45	102	56	56	102	34	80	80	34	0.59	0.25	0.91	1
1-6 AD	1A	6D	11	0	11	0	34	45	34	45	15	120	12	123	121	16	124	13	0.91	0.10	0.76	1
2-6 AD	2A	6D	7	0	7	0	38	45	38	45	53	120	47	126	83	16	89	10	0.65	0.07	0.84	1
3-6 AD	3A	6D	0	0	0	0	45	45	45	45	89	120	73	136	47	16	63	0	0.46	0	1	1
4-6 AD	4A	6D	0	0	0	0	45	45	45	45	99	120	83	136	37	16	53	0	0.39	0	1	1
5-6 AD	5A	6D	0	0	0	0	45	45	45	45	123	120	107	136	13	16	29	0	0.21	0	1	1
6-7 DA	6D	7A	0	4	4	0	45	41	41	45	120	102	93	129	16	34	43	7	0.32	0.05	0.91	1
6-8 DN	6D	8N	0	0	0	0	45	45	45	45	120	136	120	136	16	0	16	0	0.12	0	1	1
6-9 DN	6D	9N	0	0	0	0	45	45	45	45	120	56	48	128	16	80	88	8	0.65	0.06	1	1

Table 7

COUNTS OF DETECTIONS AND FAILURES FOR BENIGN TRAFFIC (FALSE POSITIVE AND TRUE NEGATIVE) AND FOR LEGITIMATE ATTACK (FALSE NEGATIVE AND TRUE POSITIVE) FOR EACH IDS AND FOR THE 36 COMBINATIONS OF 2-VERSION SYSTEMS 1002 AND 2002 FOR PHPBB AND TAKING INTO ACCOUNT THE TYPE OF IDS

Combined System Label			FP				TN				FN				TP				Sensitivity		Specificity	
	A	B	FP (A)	FP (B)	FP 1002(A,B)	FP 2002 (A,B)	TN (A)	TN (B)	TN 1002 (A,B)	TN 2002 (A,B)	FN (A)	FN (B)	FN 1002 (A,B)	FN 2002 (A,B)	TP (A)	TP (B)	TP 1002 (A,B)	TP 2002 (A,B)	1002 (A,B)	2002 (A,B)	1002 (A,B)	2002 (A,B)
1-2 AA	1A	2A	61	31	61	31	36	66	36	66	16	192	16	192	229	53	229	53	0.93	0.22	0.37	0.68
1-3 AA	1A	3A	61	1	61	1	36	96	36	96	16	227	16	227	229	18	229	18	0.93	0.07	0.37	0.99
1-4 AA	1A	4A	61	0	61	0	36	97	36	97	16	234	16	234	229	11	229	11	0.93	0.04	0.37	1.00
1-5 AA	1A	5A	61	0	61	0	36	97	36	97	16	239	16	239	229	6	229	6	0.93	0.02	0.37	1.00
1-7 AA	1A	7A	61	0	61	0	36	97	36	97	16	245	16	245	229	0	229	0	0.93	0.00	0.37	1.00
2-3 AA	2A	3A	31	1	31	1	66	0	66	96	192	227	192	227	53	18	53	18	0.22	0.07	0.68	0.99
2-4 AA	2A	4A	31	0	31	0	66	0	66	97	192	234	192	234	53	11	53	11	0.22	0.04	0.68	1.00
2-5 AA	2A	5A	31	0	31	0	66	66	66	97	192	239	192	239	53	6	53	6	0.22	0.02	0.68	1.00
2-7 AA	2A	7A	31	0	31	0	66	96	66	97	192	245	192	245	53	0	53	0	0.22	0.00	0.68	1.00
3-4 AA	3A	4A	1	0	1	0	96	97	96	97	227	234	227	234	18	11	18	11	0.07	0.04	0.99	1.00
3-5 AA	3A	5A	1	0	1	0	96	97	96	97	227	239	227	239	18	6	18	6	0.07	0.02	0.99	1.00
3-7 AA	3A	7A	1	1	1	0	96	0	96	97	227	245	227	245	18	0	18	0	0.07	0.00	0.99	1.00
4-5 AA	4A	5A	0	0	0	0	97	66	97	97	234	239	234	239	11	6	11	6	0.04	0.02	1.00	1.00
4-7 AA	4A	7A	0	0	0	0	97	96	97	97	234	245	234	245	11	0	11	0	0.04	0.00	1.00	1.00
5-7 AA	5A	7A	0	0	0	0	97	97	97	97	239	245	239	245	6	0	6	0	0.02	0.00	1.00	1.00
8-9 NN	8N	9N	0	0	0	0	97	66	97	97	245	0	0	245	0	245	245	0	1.00	0.00	1.00	1.00
1-8 AN	1A	8N	61	0	61	0	36	97	36	97	16	245	16	245	229	0	229	0	0.93	0.00	0.37	1.00
1-9 AN	1A	9N	61	0	61	0	36	97	36	97	16	0	0	16	229	245	245	229	1.00	0.93	0.37	1.00
2-8 AN	2A	8N	31	0	31	0	66	0	66	97	192	245	192	245	53	0	53	0	0.22	0.00	0.68	1.00
2-9 AN	2A	9N	31	0	31	0	66	66	66	97	192	0	0	192	53	245	245	53	1.00	0.22	0.68	1.00
3-8 AN	3A	8N	1	0	1	0	96	97	96	97	227	245	227	245	18	0	18	0	0.07	0.00	0.99	1.00
3-9 AN	3A	9N	1	0	1	0	96	66	96	97	227	0	0	227	18	245	245	18	1.00	0.07	0.99	1.00
4-8 AN	4A	8N	0	0	0	0	97	97	97	97	234	245	234	245	11	0	11	0	0.04	0.00	1.00	1.00
4-9 AN	4A	9N	0	0	0	0	97	0	97	97	234	0	0	234	11	245	245	11	1.00	0.04	1.00	1.00
5-8 AN	5A	8N	0	0	0	0	97	97	97	97	239	245	239	245	6	0	6	0	0.02	0.00	1.00	1.00
5-9 AN	5A	9N	0	0	0	0	97	66	97	97	239	0	0	239	6	245	245	6	1.00	0.02	1.00	1.00
7-8 AN	7A	8N	0	0	0	0	97	0	97	97	245	245	245	245	0	0	0	0	0.00	0.00	1.00	1.00
7-9 AN	7A	9N	0	0	0	0	97	97	97	97	245	0	0	245	0	245	245	0	1.00	0.00	1.00	1.00
1-6 AD	1A	6D	61	0	61	0	36	97	36	97	16	91	16	91	229	154	229	154	0.93	0.63	0.37	1.00
2-6 AD	2A	6D	31	0	31	0	66	97	66	97	192	91	45	238	53	154	200	7	0.82	0.03	0.68	1.00
3-6 AD	3A	6D	1	0	1	0	96	97	96	97	227	91	80	238	18	154	165	7	0.67	0.03	0.99	1.00
4-6 AD	4A	6D	0	0	0	0	97	0	97	97	234	91	80	245	11	154	165	0	0.67	0.00	1.00	1.00
5-6 AD	5A	6D	0	0	0	0	97	97	97	97	239	91	85	245	6	154	160	0	0.65	0.00	1.00	1.00
6-7 DA	6D	7A	0	0	0	0	97	97	97	97	91	245	91	245	154	0	154	0	0.63	0.00	1.00	1.00
6-8 DN	6D	8N	0	0	0	0	97	0	97	97	91	245	91	245	154	0	154	0	0.63	0.00	1.00	1.00
6-9 DN	6D	9N	0	0	0	0	97	97	97	97	91	0	0	91	154	245	245	154	1.00	0.63	1.00	1.00

Table 8

COUNTS OF DETECTIONS AND FAILURES FOR BENIGN TRAFFIC (FALSE POSITIVE AND TRUE NEGATIVE) AND FOR LEGITIMATE ATTACK (FALSE NEGATIVE AND TRUE POSITIVE) FOR EACH IDS AND FOR THE 36 COMBINATIONS OF 2-VERSION SYSTEMS 1002 AND 2002 FOR TIKIWIKI AND TAKING INTO ACCOUNT THE TYPE OF IDS

Combined System Label	A	B	FP				TN				FN				TP				Sensitivity		Specificity	
			FP (A)	FP (B)	FP 1002 (A,B)	FP 2002 (A,B)	TN (A)	TN (B)	TN 1002 (A,B)	TN 2002 (A,B)	FN (A)	FN (B)	FN 1002 (A,B)	FN 2002 (A,B)	TP (A)	TP (B)	TP 1002 (A,B)	TP 2002 (A,B)	1002 (A,B)	2002 (A,B)	1002 (A,B)	2002 (A,B)
1-2 AA	1A	2A	42	20	42	20	38	60	38	60	39	58	39	58	37	18	37	18	0.49	0.24	0.48	0.75
1-3 AA	1A	3A	42	1	42	1	38	79	38	79	39	61	39	61	37	15	37	15	0.49	0.20	0.48	0.99
1-4 AA	1A	4A	42	0	42	0	38	80	38	80	39	61	39	61	37	15	37	15	0.49	0.20	0.48	1.00
1-5 AA	1A	5A	42	0	42	0	38	80	38	80	39	70	39	70	37	6	37	6	0.49	0.08	0.48	1.00
1-7 AA	1A	7A	42	0	42	0	38	80	38	80	39	60	34	65	37	16	42	11	0.55	0.14	0.48	1.00
2-3 AA	2A	3A	20	1	20	1	60	79	60	79	58	61	58	61	18	15	18	15	0.24	0.20	0.75	0.99
2-4 AA	2A	4A	20	0	20	0	60	80	60	80	58	61	58	61	18	15	18	15	0.24	0.20	0.75	1.00
2-5 AA	2A	5A	20	0	20	0	60	80	60	80	58	70	58	70	18	6	18	6	0.24	0.08	0.75	1.00
2-7 AA	2A	7A	20	0	20	0	60	80	60	80	58	60	52	66	18	16	24	10	0.32	0.13	0.75	1.00
3-4 AA	3A	4A	1	0	1	0	79	80	79	80	61	61	61	61	15	15	15	15	0.20	0.20	0.99	1.00
3-5 AA	3A	5A	1	0	1	0	79	80	79	80	61	70	61	70	15	6	15	6	0.20	0.08	0.99	1.00
3-7 AA	3A	7A	1	0	1	0	79	80	79	80	61	60	53	68	15	16	23	8	0.30	0.11	0.99	1.00
4-5 AA	4A	5A	0	0	0	0	80	80	80	80	61	70	61	70	15	6	15	6	0.20	0.08	1.00	1.00
4-7 AA	4A	7A	0	0	0	0	80	80	80	80	61	60	53	68	15	16	23	8	0.30	0.11	1.00	1.00
5-7 AA	5A	7A	0	0	0	0	80	80	80	80	70	60	56	74	6	16	20	2	0.26	0.03	1.00	1.00
8-9 NN	8N	9N	0	0	0	0	80	80	80	80	76	38	38	76	0	0	38	0	0.50	0.00	1.00	1.00
1-8 AN	1A	8N	42	0	42	0	38	80	38	80	39	76	39	76	37	0	37	0	0.49	0.00	0.48	1.00
1-9 AN	1A	9N	42	0	42	0	38	80	38	80	39	38	20	57	37	38	56	19	0.74	0.25	0.48	1.00
2-8 AN	2A	8N	20	0	20	0	60	80	60	80	58	76	58	76	18	0	18	0	0.24	0.00	0.75	1.00
2-9 AN	2A	9N	20	0	20	0	60	80	60	80	58	38	31	65	18	38	45	11	0.59	0.14	0.75	1.00
3-8 AN	3A	8N	1	0	1	0	79	80	79	80	61	76	61	76	15	0	15	0	0.20	0.00	0.99	1.00
3-9 AN	3A	9N	1	0	1	0	79	80	79	80	61	38	31	68	15	38	45	8	0.59	0.11	0.99	1.00
4-8 AN	4A	8N	0	0	0	0	80	80	80	80	61	76	61	76	15	0	15	0	0.20	0.00	1.00	1.00
4-9 AN	4A	9N	0	0	0	0	80	80	80	80	61	38	31	68	15	38	45	8	0.59	0.11	1.00	1.00
5-8 AN	5A	8N	0	0	0	0	80	80	80	80	70	76	70	76	6	0	6	0	0.08	0.00	1.00	1.00
5-9 AN	5A	9N	0	0	0	0	80	80	80	80	70	38	34	74	6	38	42	2	0.55	0.03	1.00	1.00
7-8 AN	7A	8N	0	0	0	0	80	80	80	80	60	76	60	76	16	0	16	0	0.21	0.00	1.00	1.00
7-9 AN	7A	9N	0	0	0	0	80	80	80	80	60	38	38	60	16	38	38	16	0.50	0.21	1.00	1.00
1-6 AD	1A	6D	42	0	42	0	38	80	38	80	39	0	0	39	37	76	76	37	1.00	0.49	0.48	1.00
2-6 AD	2A	6D	20	0	20	0	60	80	60	80	58	0	0	58	18	76	76	18	1.00	0.24	0.75	1.00
3-6 AD	3A	6D	1	0	1	0	79	80	79	80	61	0	0	61	15	76	76	15	1.00	0.20	0.99	1.00
4-6 AD	4A	6D	0	0	0	0	80	80	80	80	61	0	0	61	15	76	76	15	1.00	0.20	1.00	1.00
5-6 AD	5A	6D	0	0	0	0	80	80	80	80	70	0	0	70	6	76	76	6	1.00	0.08	1.00	1.00
6-7 DA	6D	7A	0	0	0	0	80	80	80	80	0	60	0	60	76	16	76	16	1.00	0.21	1.00	1.00
6-8 DN	6D	8N	0	0	0	0	80	80	80	80	0	76	0	76	76	0	76	0	1.00	0.00	1.00	1.00
6-9 DN	6D	9N	0	0	0	0	80	80	80	80	0	38	0	38	76	38	76	38	1.00	0.50	1.00	1.00

2.1.2 Averages

Table 9 The Average Sensitivity, Specificity and Accuracy for Single IDS and the 1002 and 2002 pairs, per type and per web application

Averages		MyReferences			PhpBB			TikiWiki		
		Sensitivity	Specificity	Accuracy	Sensitivity	Specificity	Accuracy	Sensitivity	Specificity	Accuracy
Single System		0.32	0.91	0.63	0.32	0.89	0.49	0.32	0.91	0.63
Overall 1002		0.51	0.83	0.68	0.56	0.80	0.63	0.51	0.83	0.68
	<i>Application-only</i>	0.33	0.76	0.55	0.39	0.70	0.48	0.33	0.76	0.55
	<i>Network-only</i>	0.50	1	0.76	1	1	1	0.50	1	0.76
	<i>Application & Network</i>	0.41	0.87	0.65	0.61	0.84	0.67	0.41	0.87	0.65
	<i>Application & Database</i>	1	0.87	0.93	0.73	0.84	0.76	1	0.87	0.93
	<i>Network & Database</i>	1	1	1	0.81	1	0.87	1	1	1
Overall 2002		0.13	0.99	0.57	0.09	0.99	0.34	0.13	0.99	0.57
	<i>Application-only</i>	0.13	0.98	0.57	0.04	0.98	0.31	0.13	0.98	0.57
	<i>Network-only</i>	0	1	0.51	0	1	0.28	0	1	0.51
	<i>Application & Network</i>	0.07	1	0.55	0.11	1	0.36	0.07	1	0.55
	<i>Application & Database</i>	0.23	1	0.63	0.11	1	0.37	0.23	1	0.63
	<i>Network & Database</i>	0.25	1	0.63	0.31	1	0.51	0.25	1	0.63

2.1.3 Diversity Analysis.

2.1.3.1 MyReferences

2.1.3.1.1 ROC

Figure 1 THE ROC PLOT SHOWING THE INDIVIDUAL IDSs, 1002 AND 2002 CONFIGURATIONS FOR MYREFERENCES

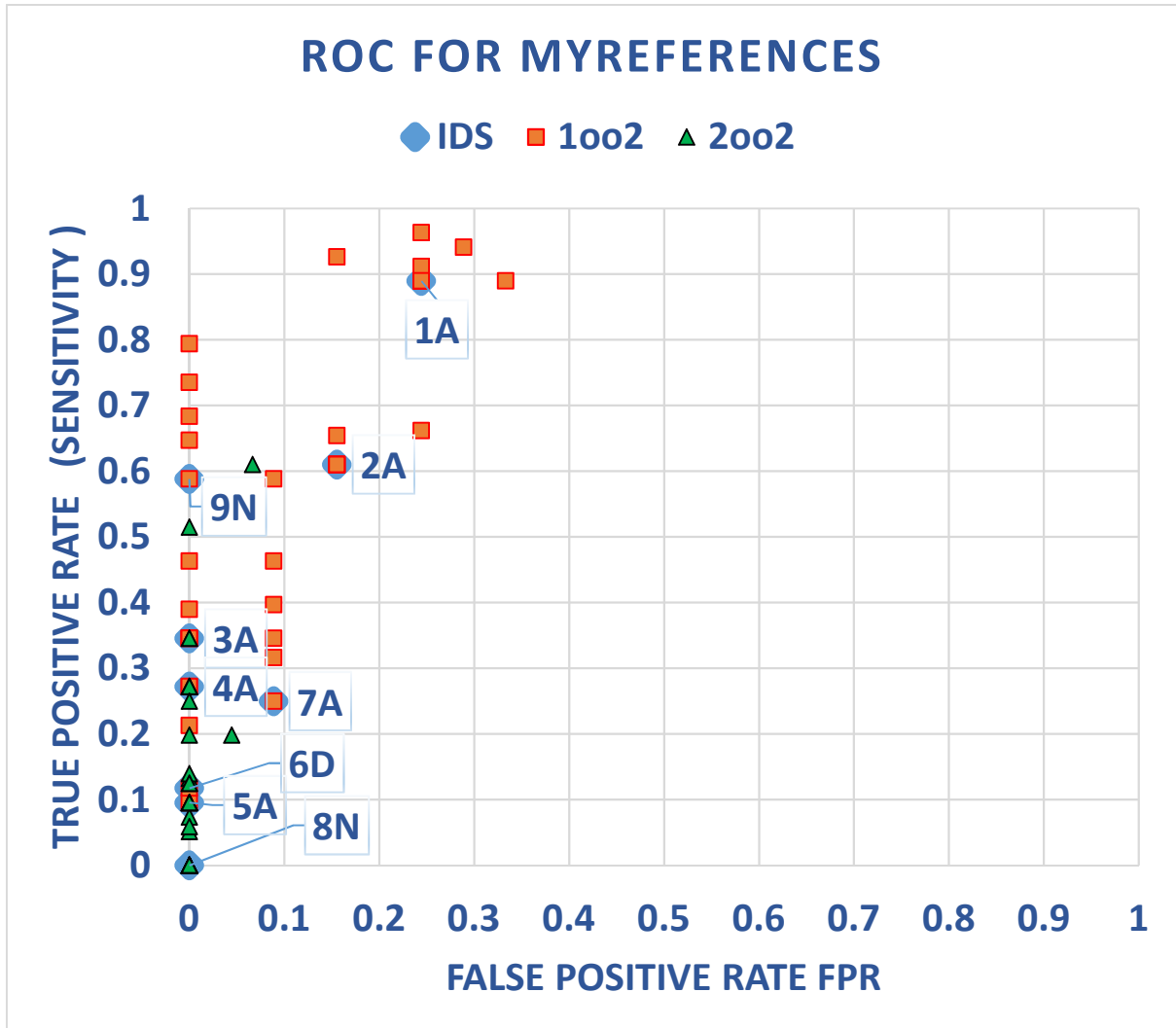


Figure 2 THE ROC PLOT SHOWING THE INDIVIDUAL IDSs, 1002 AND 2002 CONFIGURATIONS . THE ROC FOR MYREFERENCES WHEN THE PAIRS WERE FUNCTIONALLY REDUNDANT

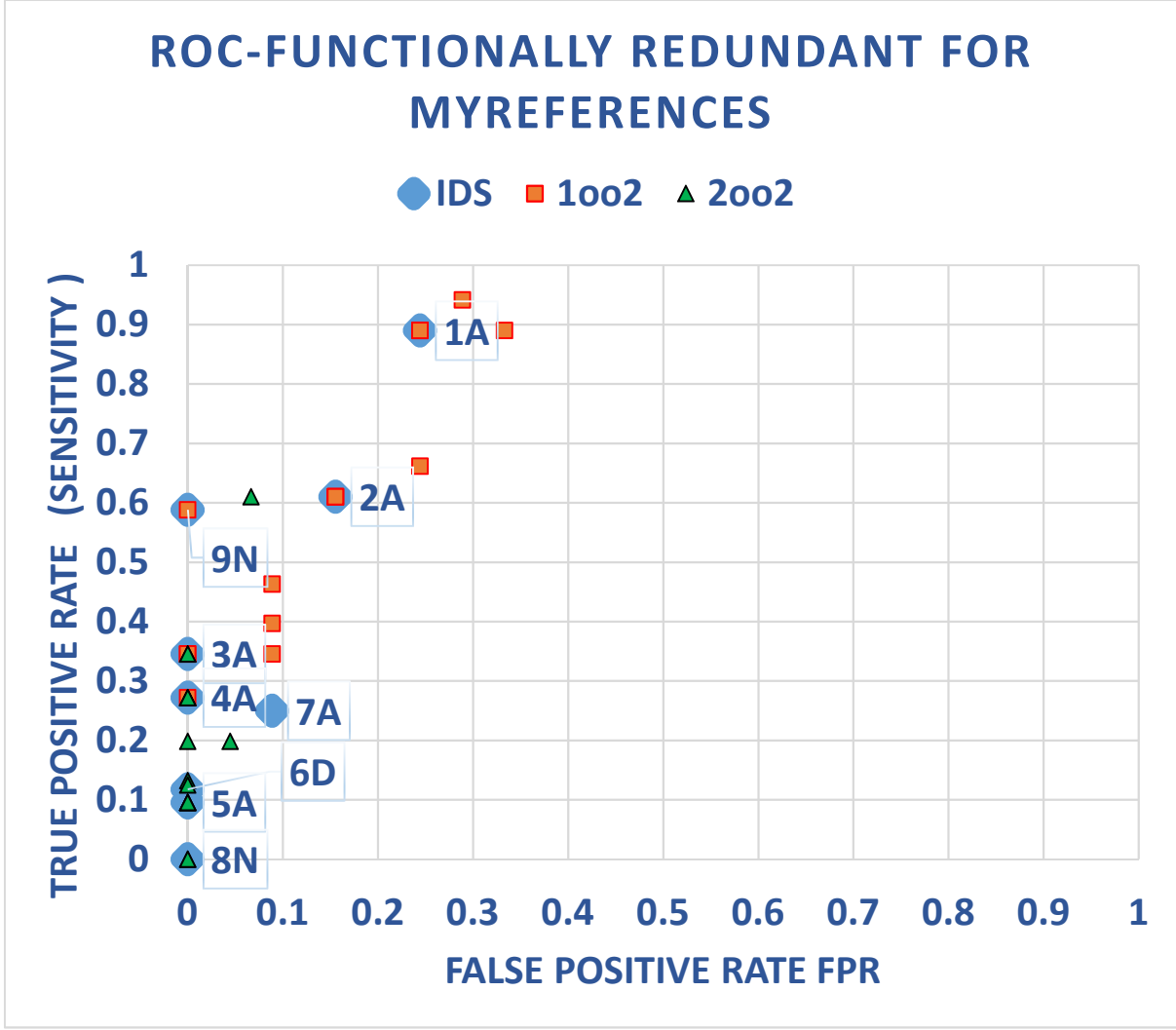
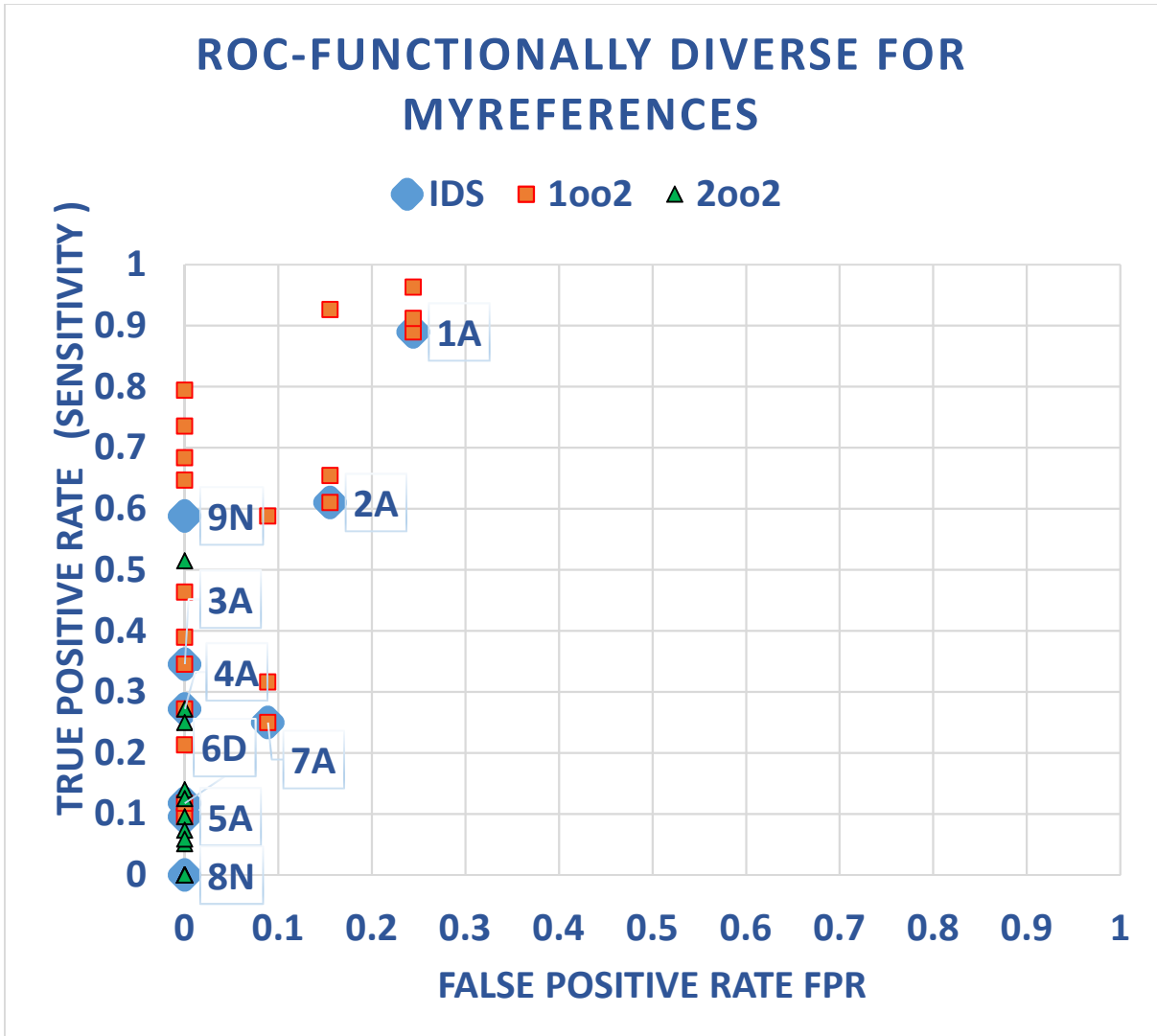


Figure 3 THE ROC PLOT SHOWING THE INDIVIDUAL IDSs, 1002 AND 2002 CONFIGURATIONS . THE ROC FOR MYREFERENCES WHEN THE PAIRS WERE FUNCTIONALLY DIVERSE



2.1.3.1.2 Accuracy

Figure 4 THE ACCURACY FOR A GIVEN SYSTEM A WHEN PAIRED WITH ANOTHER SYSTEM B FOR MYREFERENCES, THE CHART SHOWS THE INDIVIDUAL IDSs, 1002 AND 2002 CONFIGURATIONS

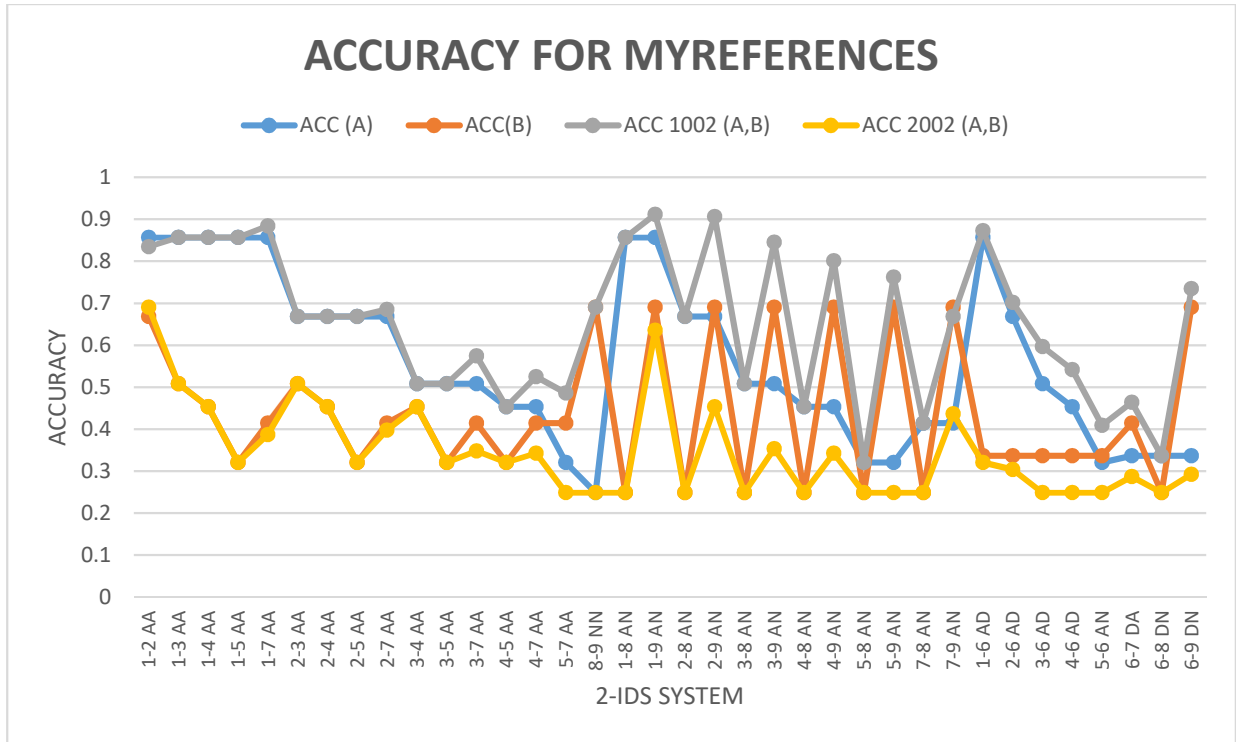
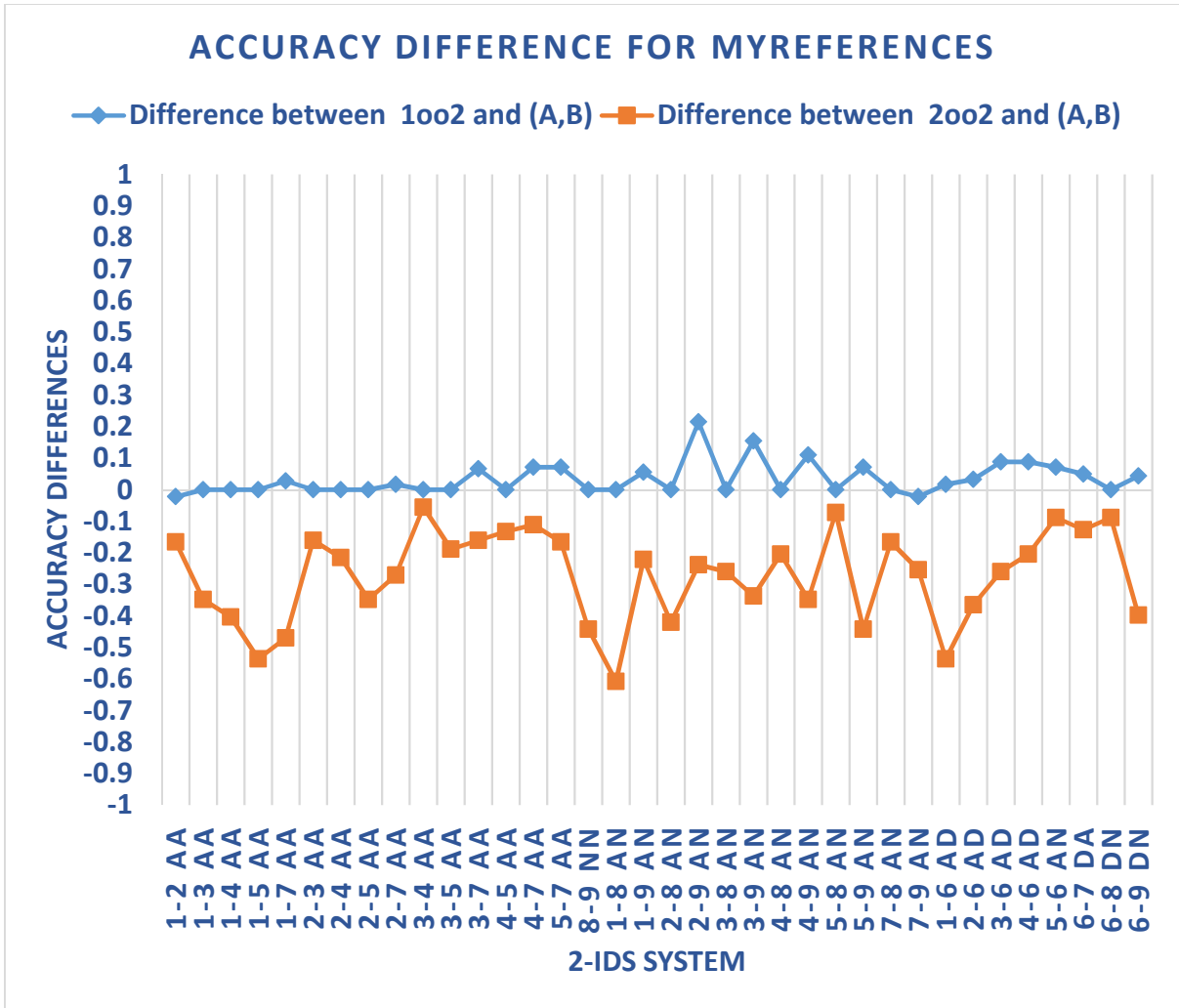


Figure 5 THE ACCURACY DIFFERENCE OF 1002 AND 2002 CONFIGURATIONS, COMAPRED WITH THE BEST SINGLE SYSTEM IN THE RESPECTIVE PAIR FOR MyREFERENCES



2.1.3.1.3 Specificity

Figure 6 THE SPECIFICITY FOR A GIVEN SYSTEM A WHEN PAIRED WITH ANOTHER SYSTEM B FOR MYREFERENCES, THE CHART SHOWS THE INDIVIDUAL IDSs, 1002 AND 2002 CONFIGURATIONS

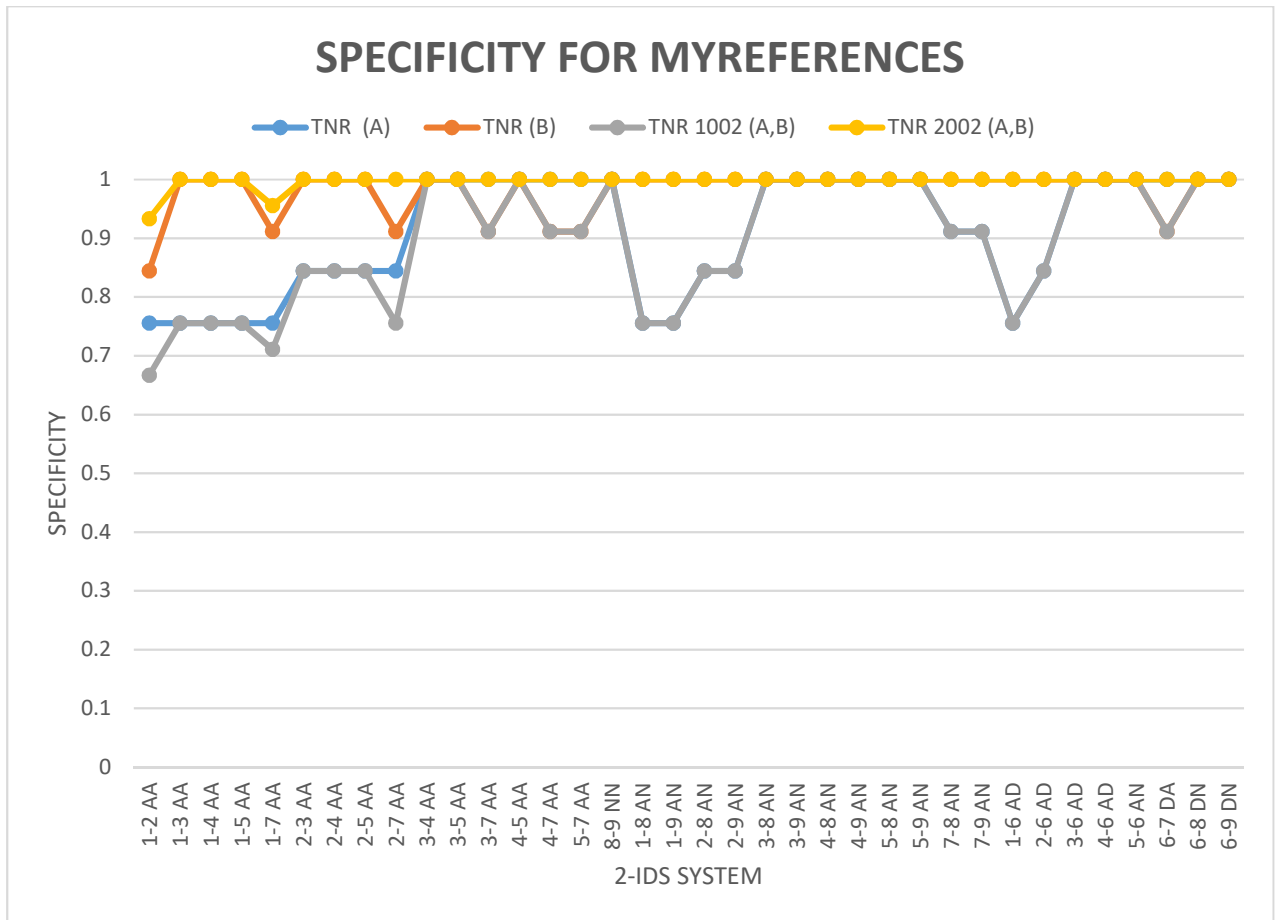
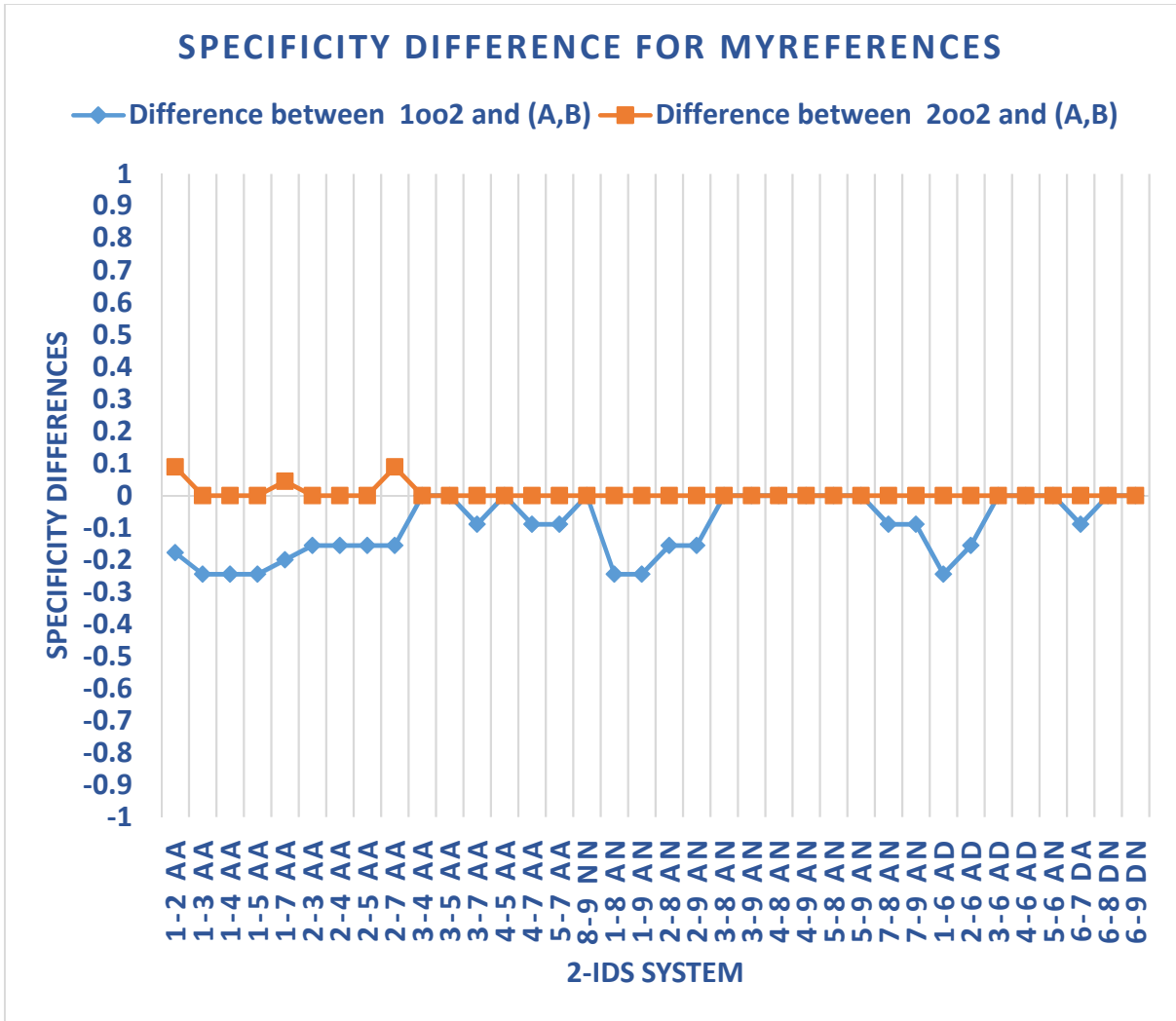


Figure 7 THE SPECIFICITY DIFFERENCE OF 1002 AND 2002 CONFIGURATIONS, COMAPRED WITH THE BEST SINGLE SYSTEM IN THE RESPECTIVE PAIR FOR MYREFERENCES



2.1.3.1.4 Sensitivity

Figure 8 THE SENSITIVITY FOR A GIVEN SYSTEM A WHEN PAIRED WITH ANOTHER SYSTEM B FOR MYREFERENCES, THE CHART SHOWS THE INDIVIDUAL IDSS, 1002 AND 2002 CONFIGURATIONS

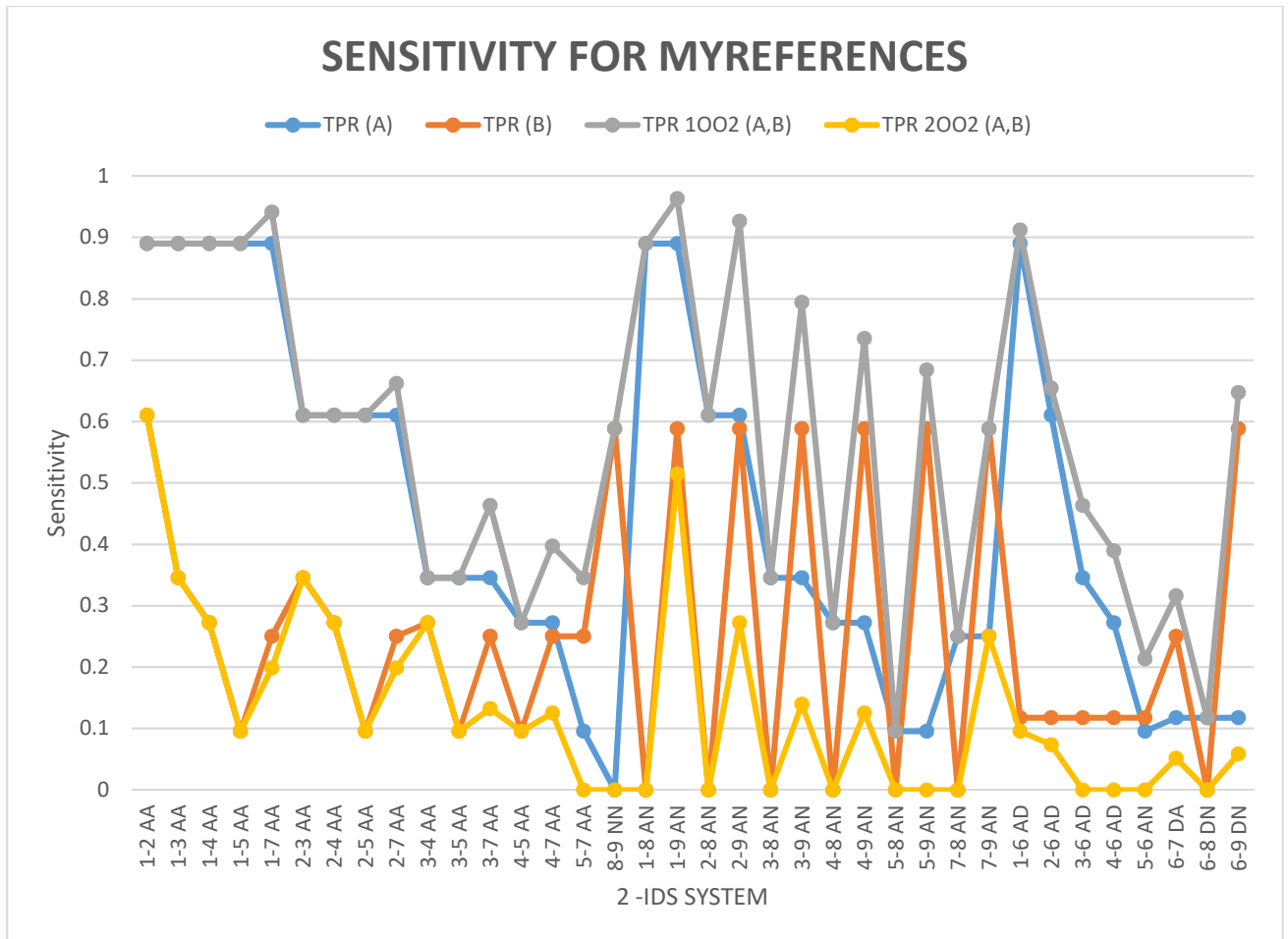
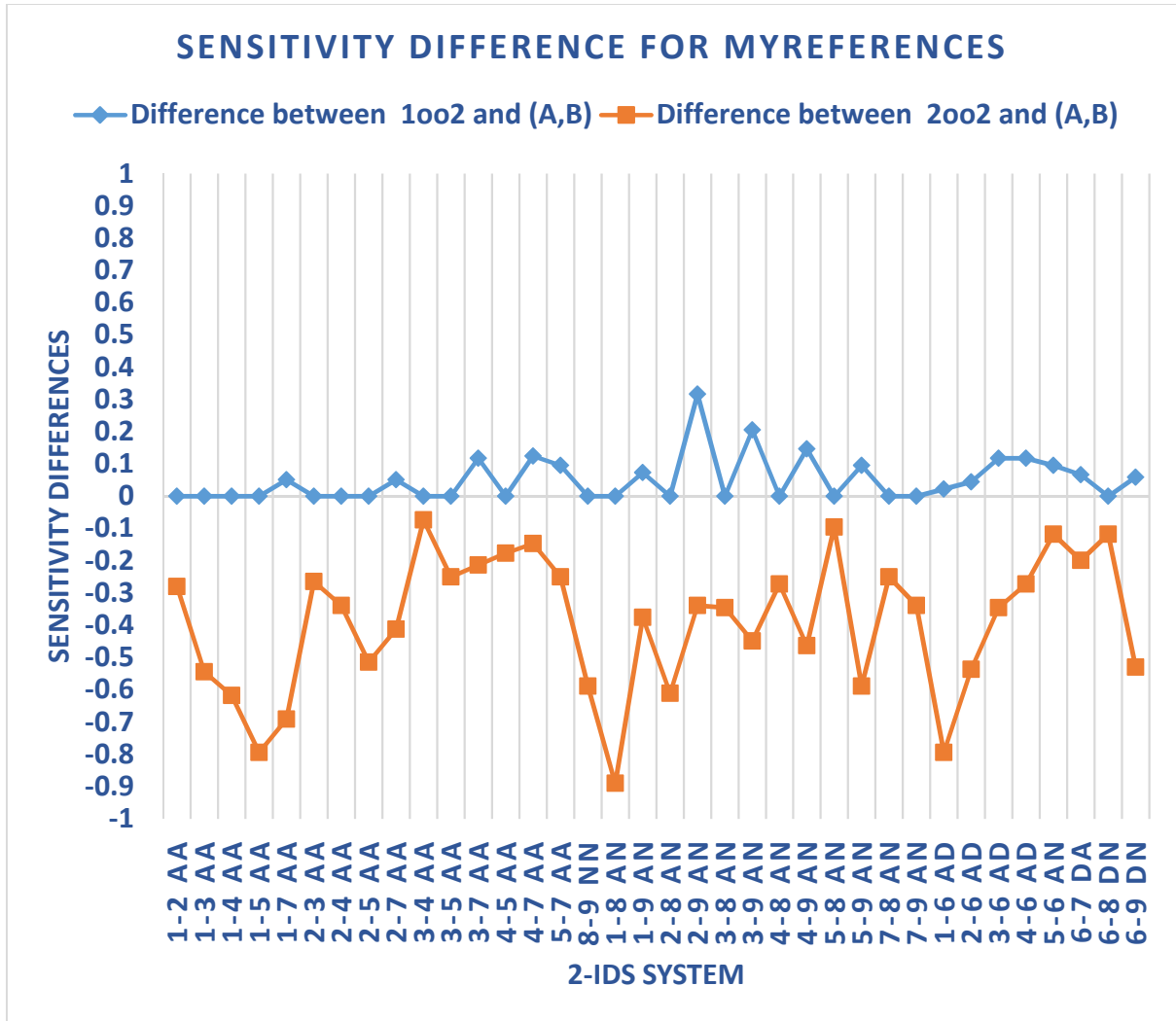


Figure 9 THE SENSITIVITY DIFFERENCE OF 1002 AND 2002 CONFIGURATIONS, COMAPRED WITH THE BEST SINGLE SYSTEM IN THE RESPECTIVE PAIR FOR MyREFERENCES



2.1.3.1.5 Improvement and deterioration in Sensitivity Specificity

Figure 10 DIFFERENCES IN SENSITIVITY AND SPECIFICITY FOR A GIVEN SYSTEM A WHEN PAIRED WITH ANOTHER SYSTEM B FOR MYREFERENCES FOR A 1002 CONFIGURATION

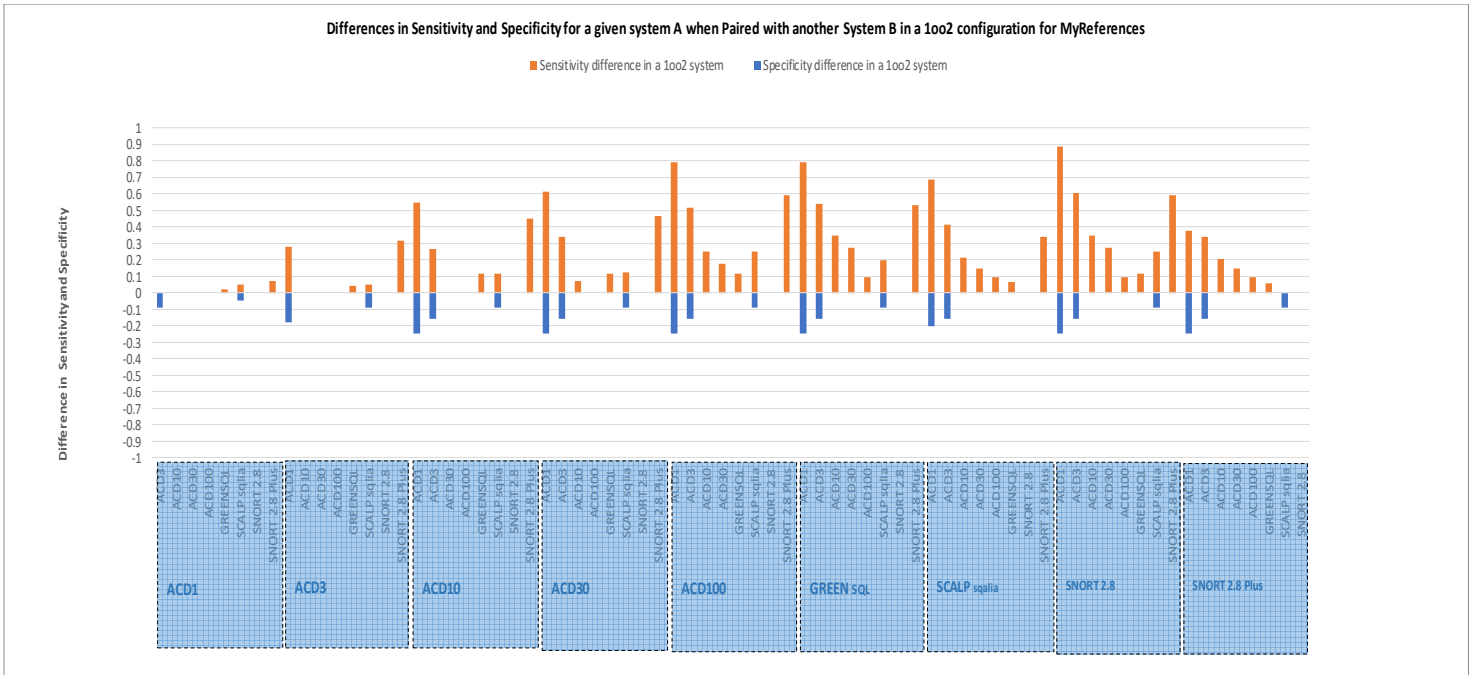
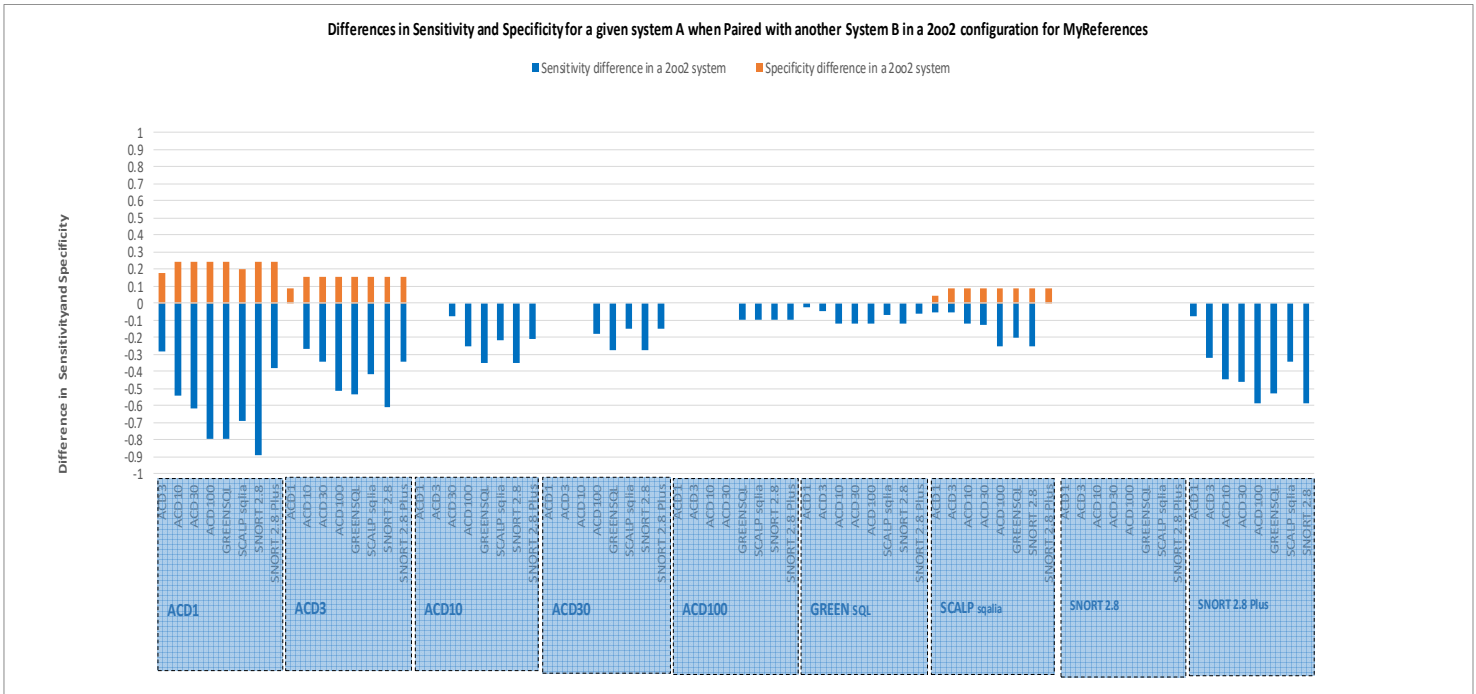


Figure 11 DIFFERENCES IN SENSITIVITY AND SPECIFICITY FOR A GIVEN SYSTEM A WHEN PAIRED WITH ANOTHER SYSTEM B FOR MYREFERENCES FOR A 2002 CONFIGURATION



2.1.3.2 PhpBB

2.1.3.2.1 ROC

Figure 12 ROC PLOT SHOWING THE INDIVIDUAL IDSs, 1002 AND 2002 CONFIGURATIONS FOR PHPBB

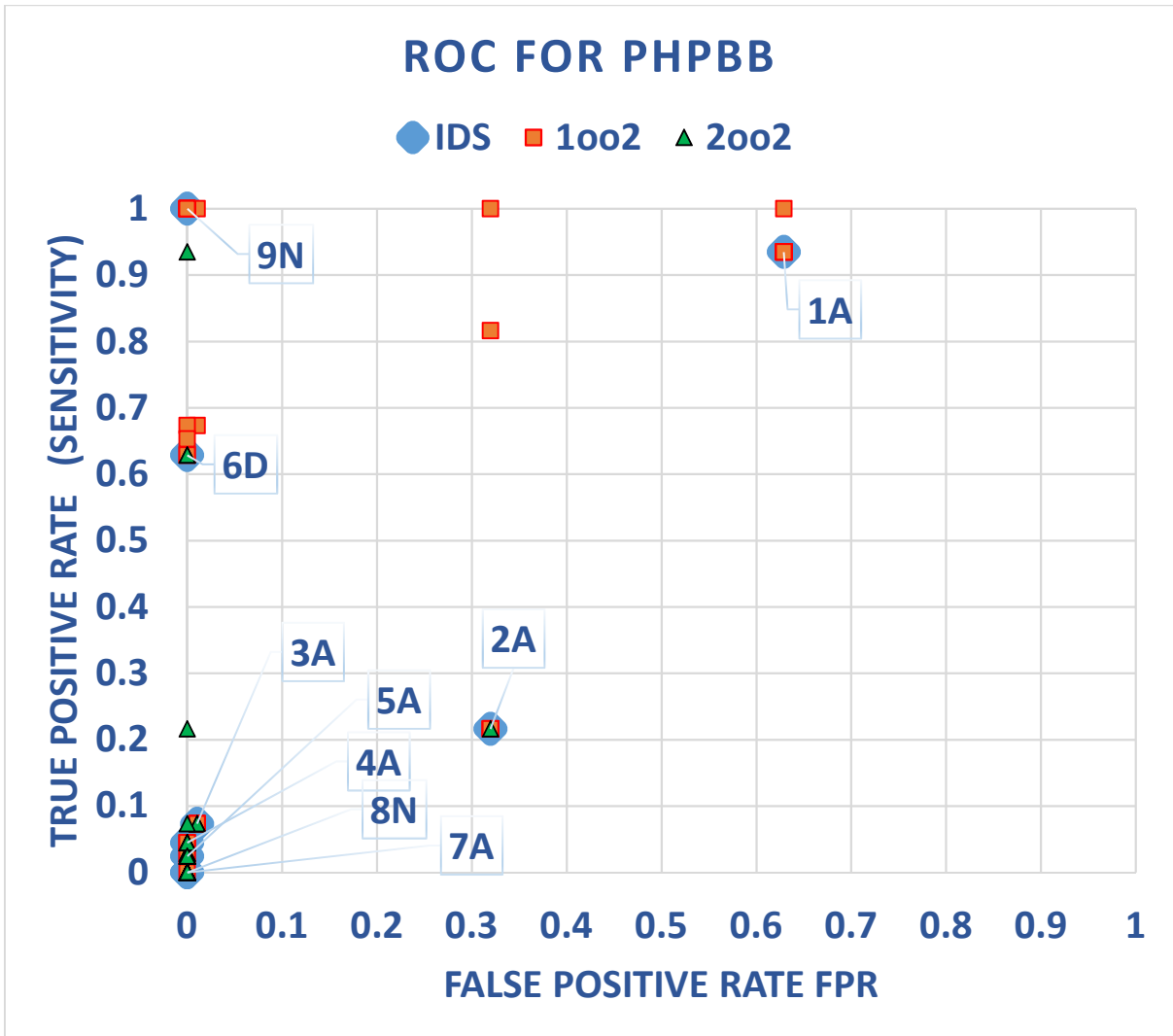


Figure 13 THE ROC PLOT SHOWING THE INDIVIDUAL IDSs, 1002 AND 2002 CONFIGURATIONS . THE ROC FOR PHPBB WHEN THE PAIRS WERE FUNCTIONALLY REDUNDANT

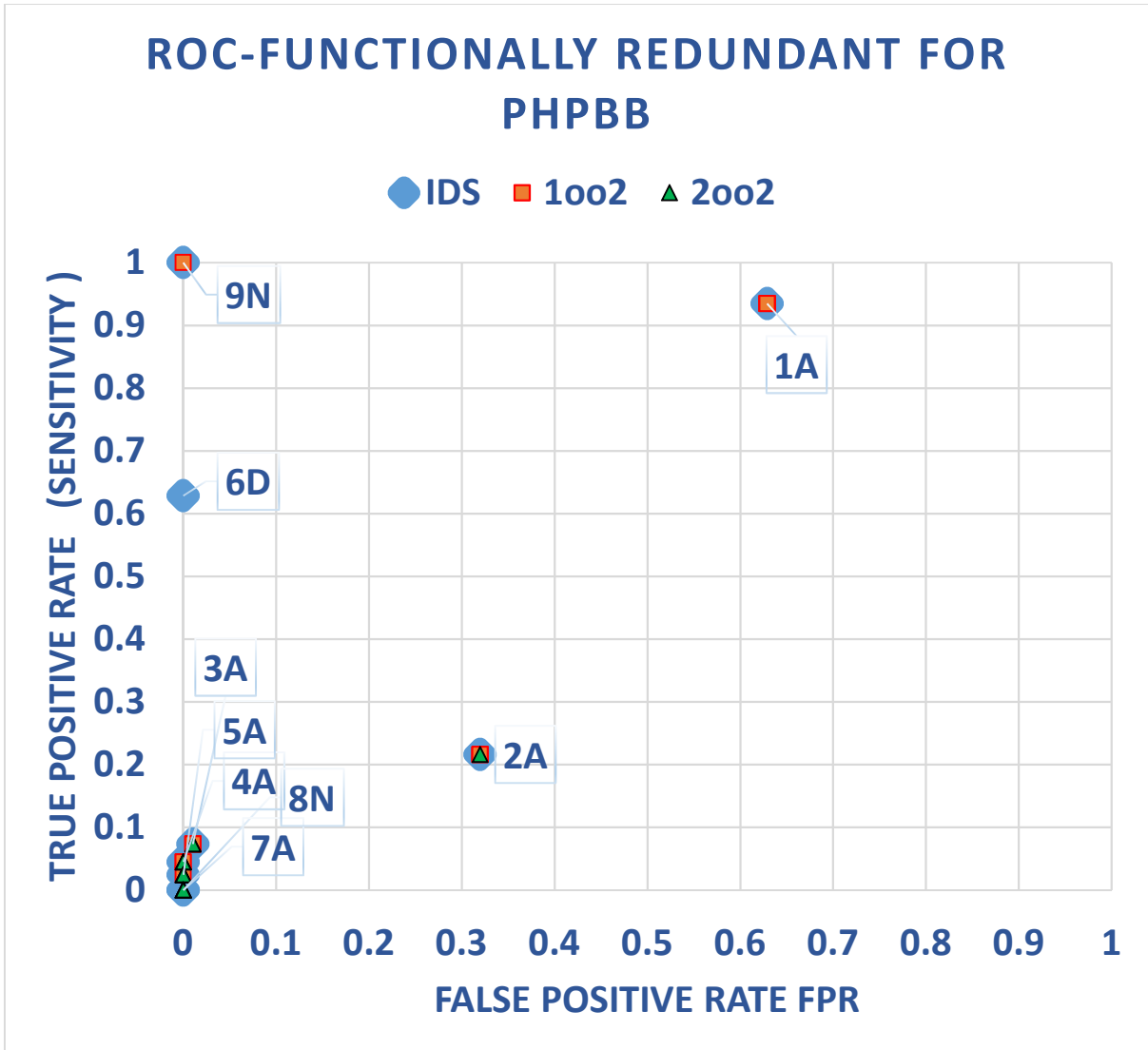
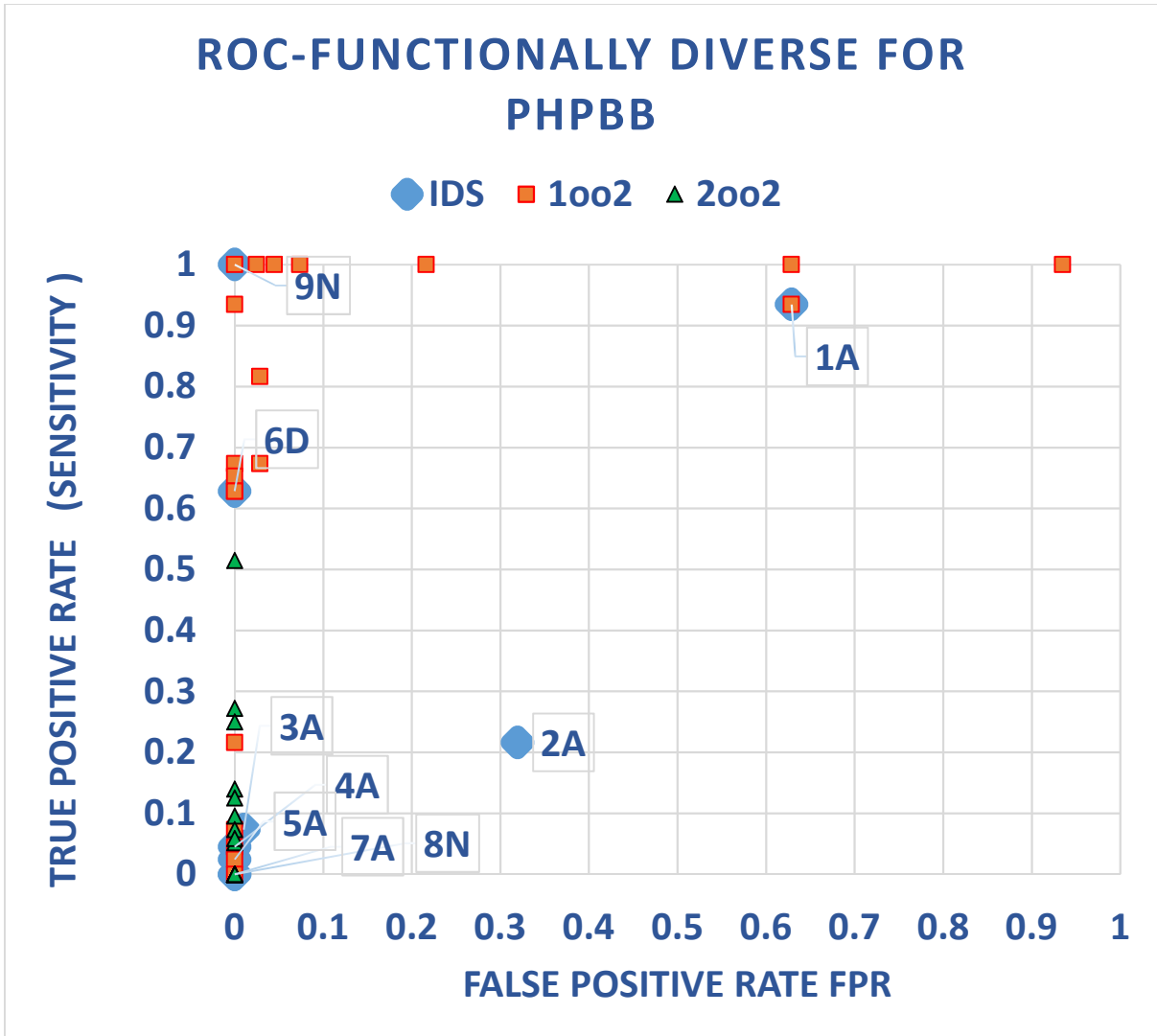


Figure 14 THE ROC PLOT SHOWING THE INDIVIDUAL IDSs, 1002 AND 2002 CONFIGURATIONS . THE ROC FOR MYREFERENCES WHEN THE PAIRS WERE FUNCTIONALLY DIVERSE



2.1.3.2.2 Accuracy

Figure 15 THE ACCURACY FOR A GIVEN SYSTEM A WHEN PAIRED WITH ANOTHER SYSTEM B FOR PHPBB, THE CHART SHOWS THE INDIVIDUAL IDS, 1002 AND 2002 CONFIGURATIONS

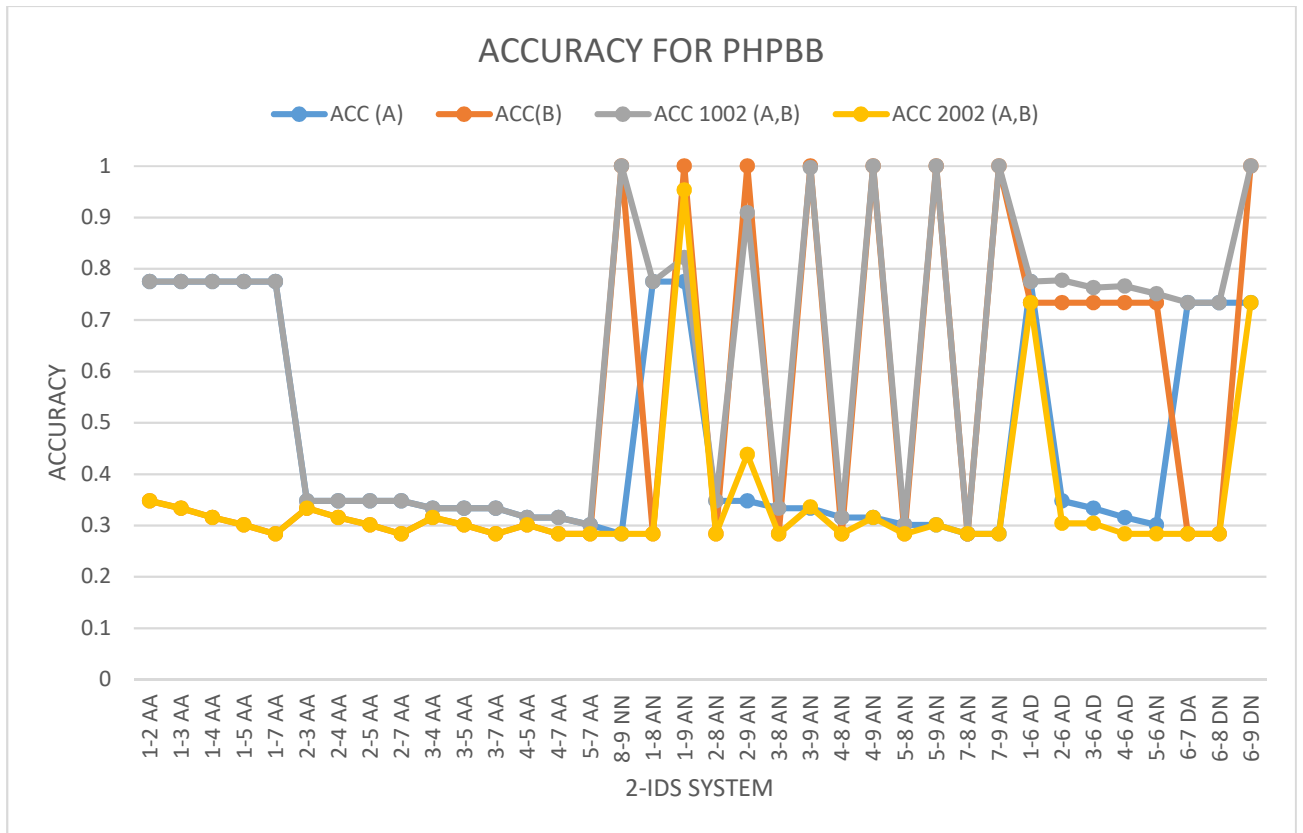
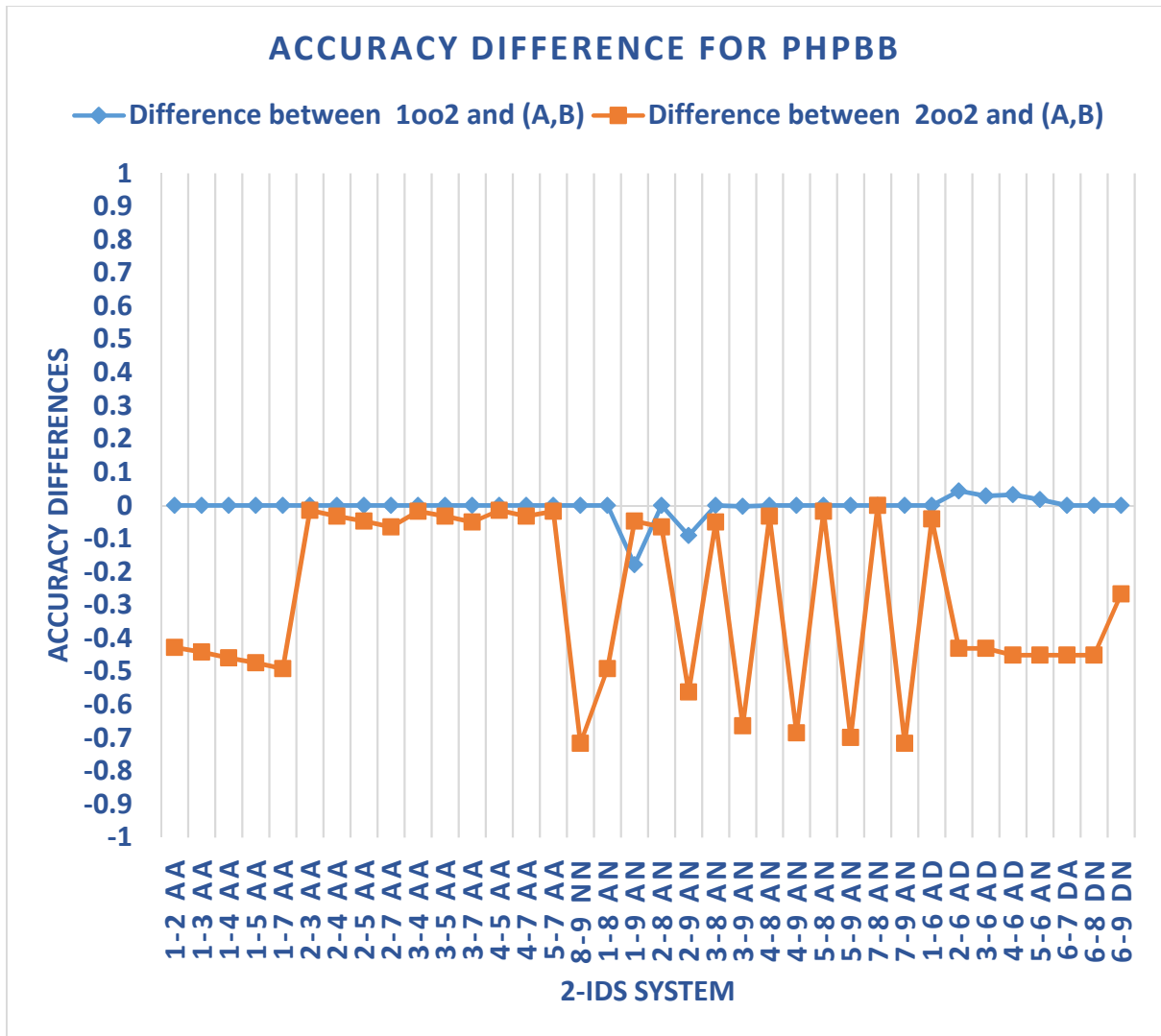


Figure 16 THE ACCURACY DIFFERENCE OF 1002 AND 2002 CONFIGURATIONS, COMPARED WITH THE BEST SINGLE SYSTEM IN THE RESPECTIVE PAIR FOR PHPBB



2.1.3.2.3 Specificity

Figure 17 THE SPECIFICITY FOR A GIVEN SYSTEM A WHEN PAIRED WITH ANOTHER SYSTEM B FOR PHPBB, THE CHART SHOWS THE INDIVIDUAL IDSs, 1002 AND 2002 CONFIGURATIONS

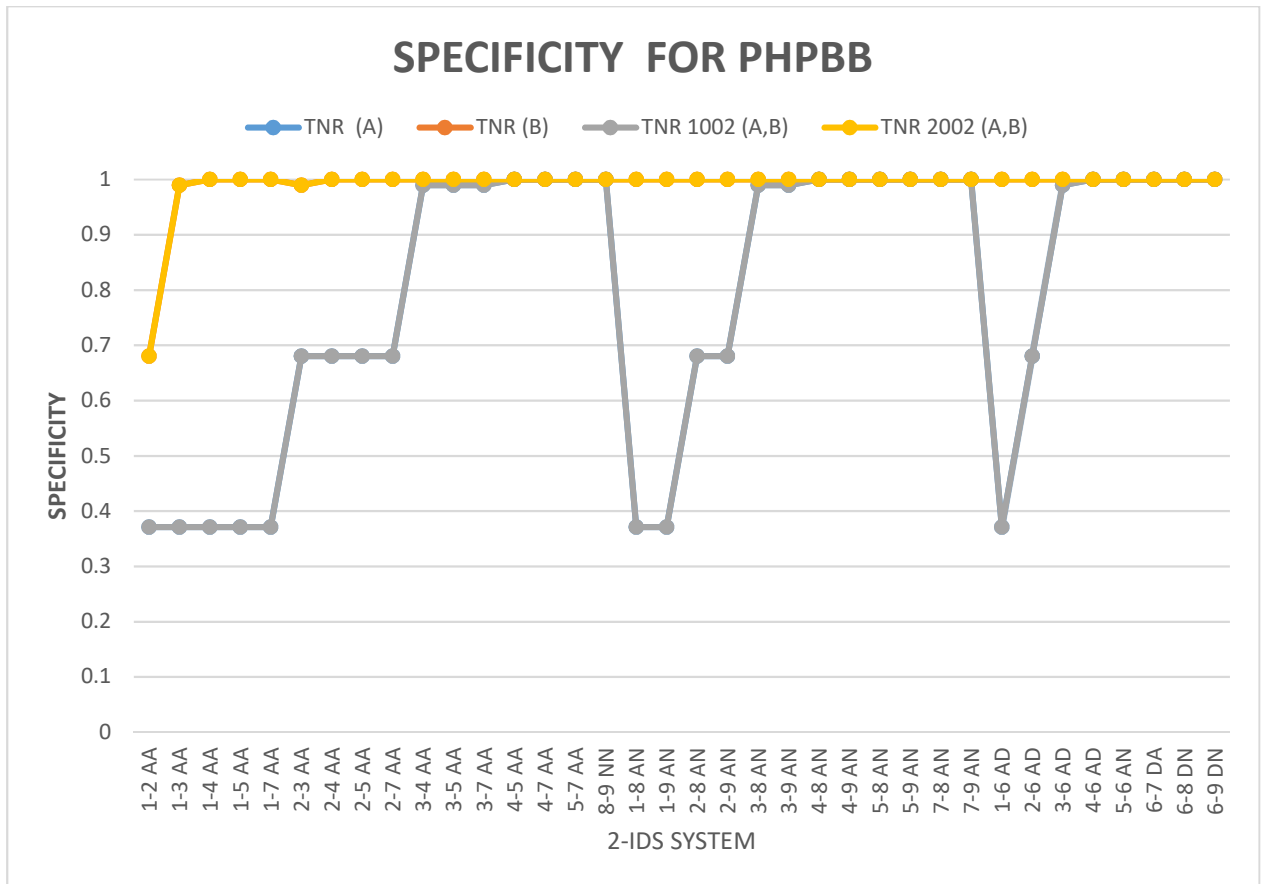
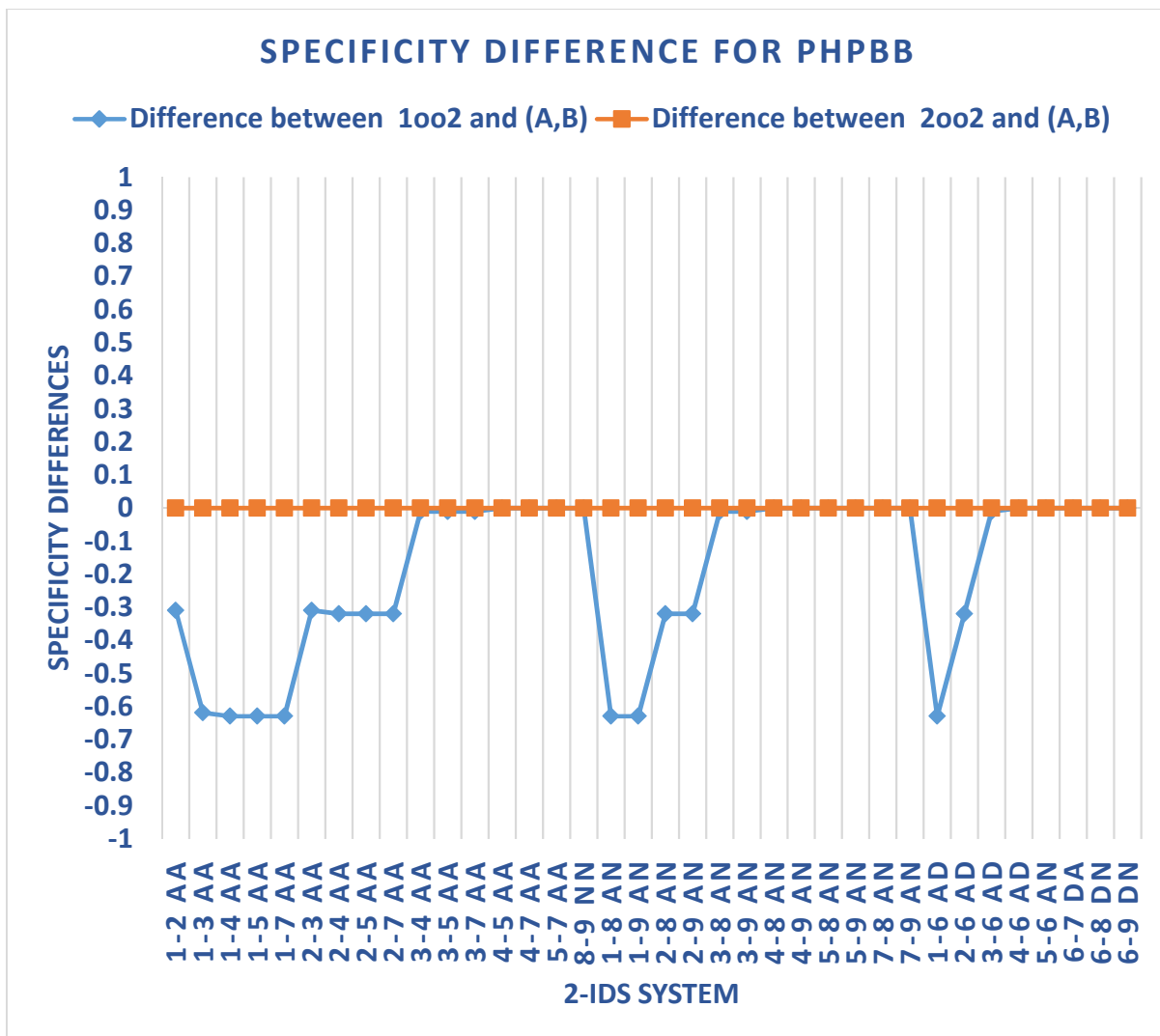


Figure 18 THE SPECIFICITY DIFFERENCE OF 1002 AND 2002 CONFIGURATIONS, COMAPRED WITH THE BEST SINGLE SYSTEM IN THE RESPECTIVE PAIR FOR PHPBB



2.1.3.2.4 Sensitivity

Figure 19 THE SENSITIVITY FOR A GIVEN SYSTEM A WHEN PAIRED WITH ANOTHER SYSTEM B FOR PHPBB, THE CHART SHOWS THE INDIVIDUAL IDSs, 1002 AND 2002 CONFIGURATIONS

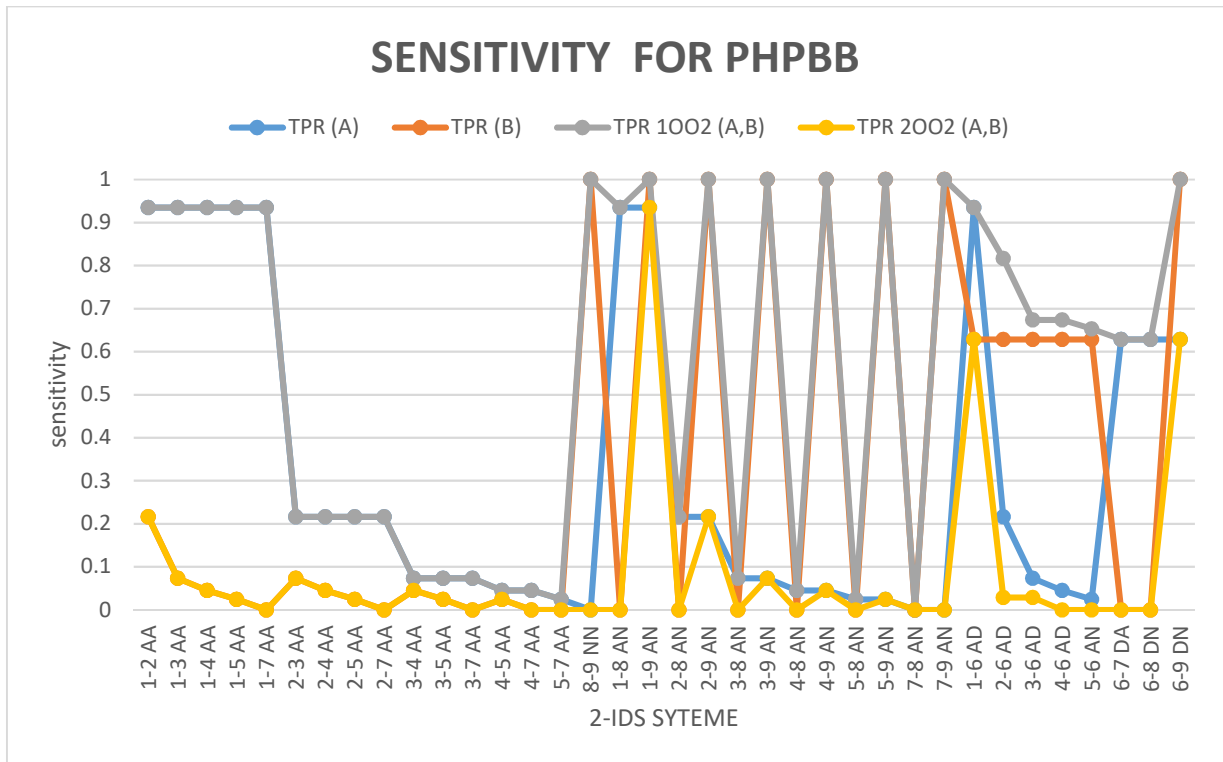
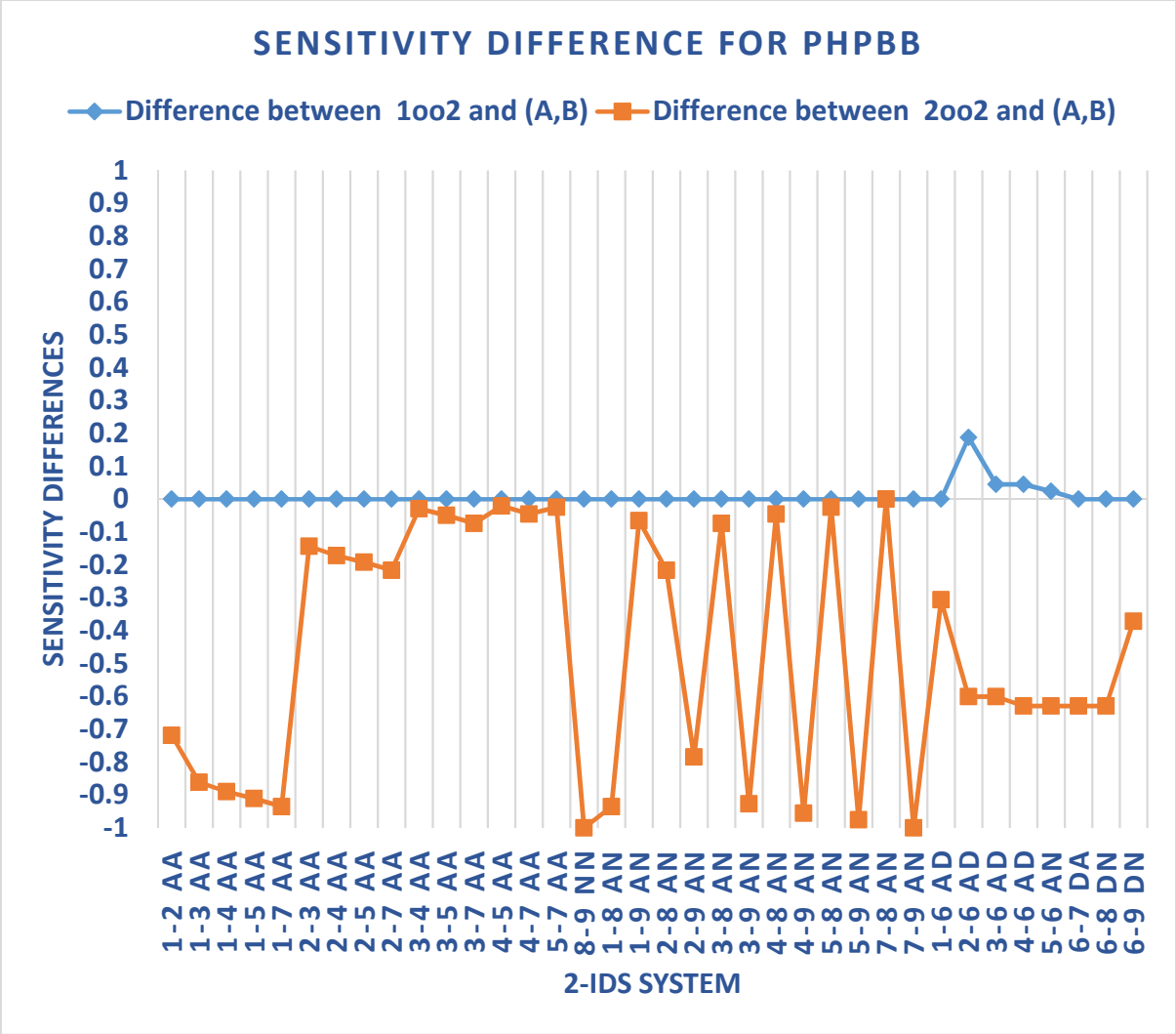


Figure 20 THE SENSITIVITY DIFFERENCE OF 1002 AND 2002 CONFIGURATIONS, COMAPRED WITH THE BEST SINGLE SYSTEM IN THE RESPECTIVE PAIR FOR PHPBB



2.1.3.2.5 Improvement and deterioration in Sensitivity Specificity

Figure 21 DIFFERENCES IN SENSITIVITY AND SPECIFICITY FOR A GIVEN SYSTEM A WHEN PAIRED WITH ANOTHER SYSTEM B FOR PHPBB FOR A 1002 CONFIGURATION

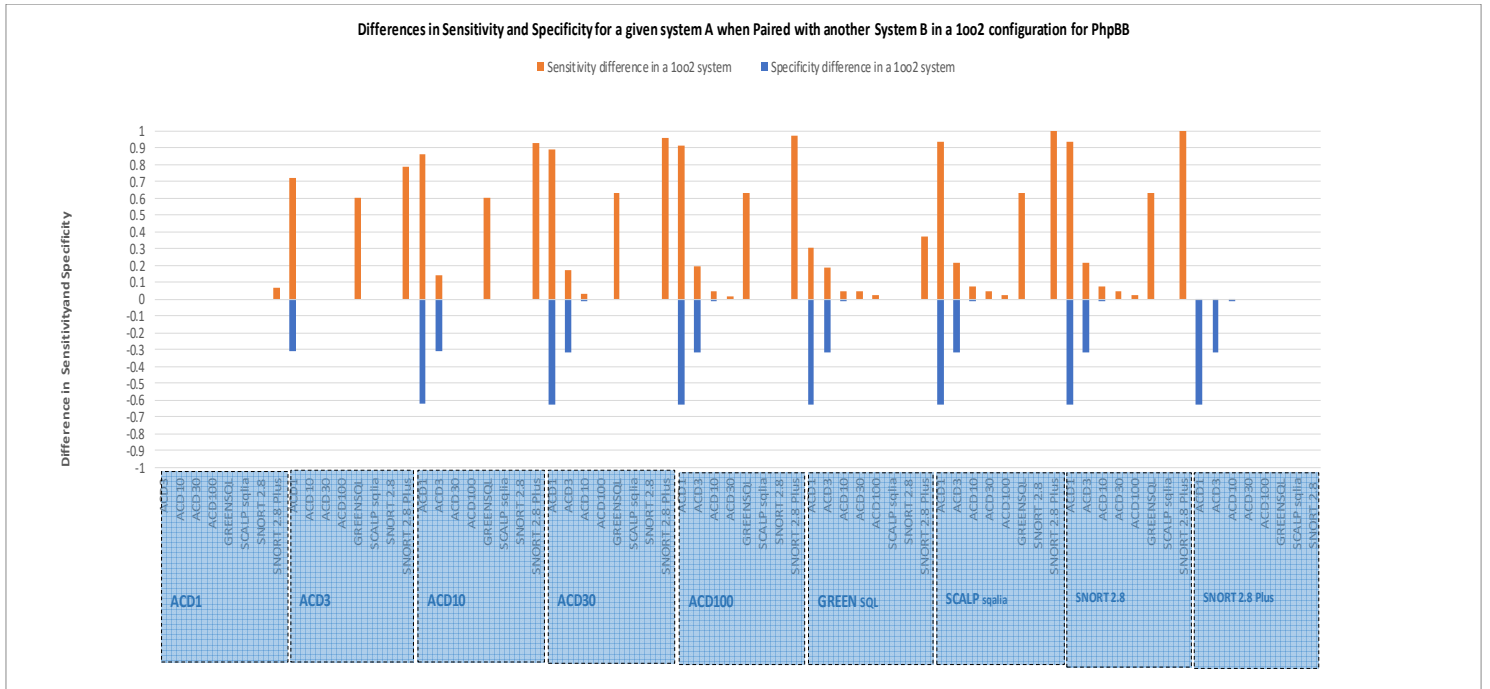
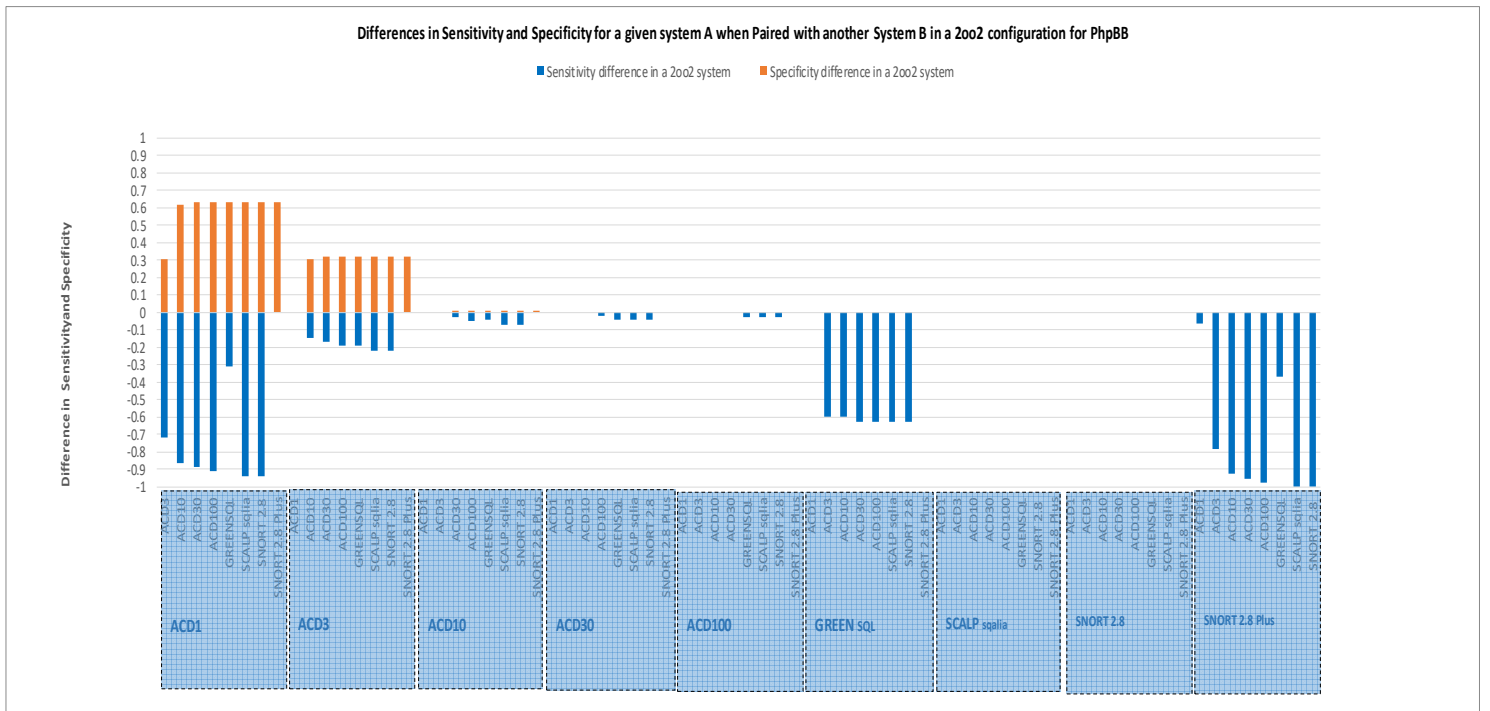


Figure 22 DIFFERENCES IN SENSITIVITY AND SPECIFICITY FOR A GIVEN SYSTEM A WHEN PAIRED WITH ANOTHER SYSTEM B FOR PHPBB FOR A 2002 CONFIGURATION



2.1.3.3 TikiWiki

2.1.3.3.1 ROC

Figure 23 THE ROC PLOT SHOWING THE INDIVIDUAL IDSs, 1002 AND 2002 CONFIGURATIONS FOR TIKIWIKI

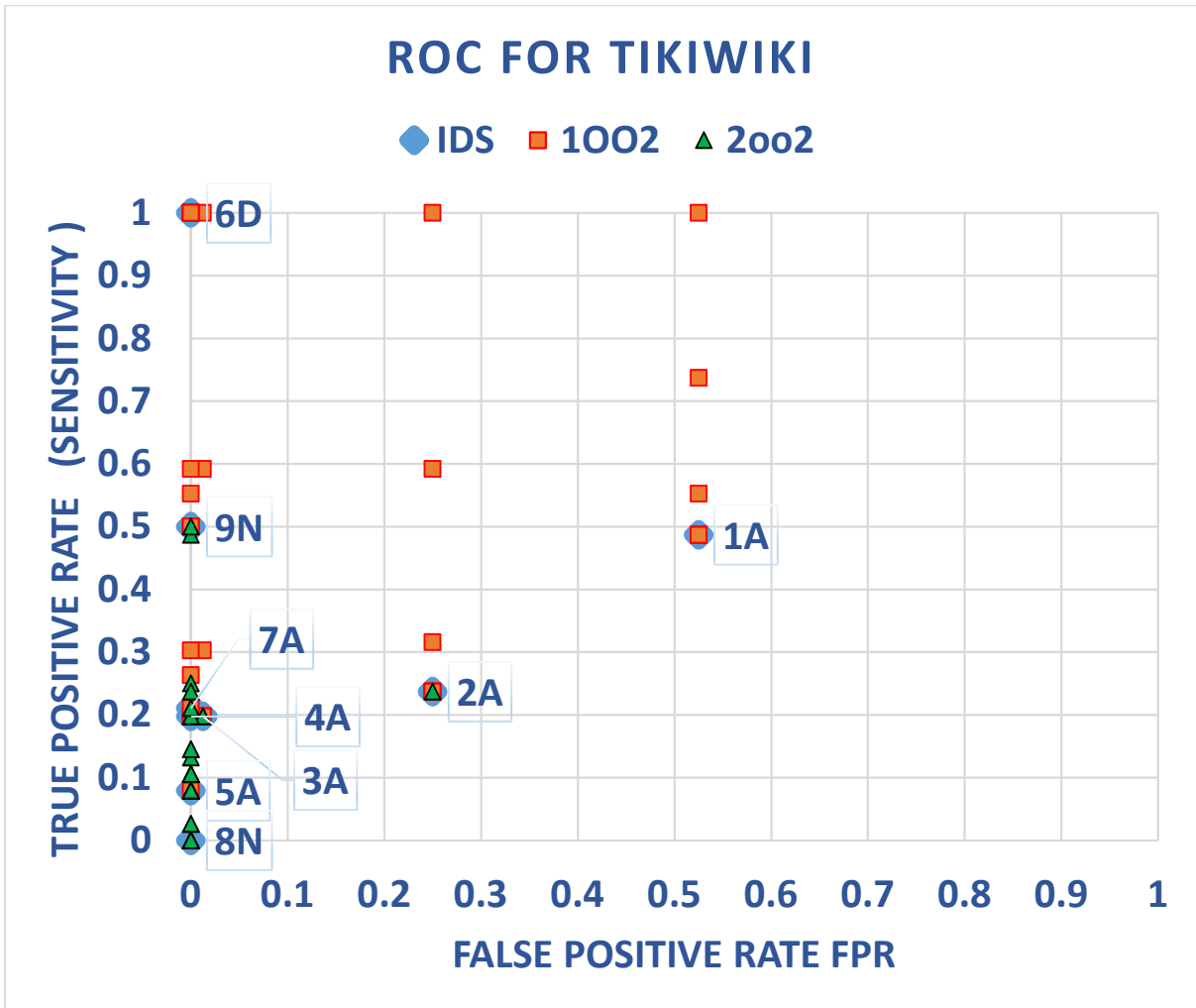


Figure 24 THE ROC PLOT SHOWING THE INDIVIDUAL IDSs, 1002 AND 2002 CONFIGURATIONS . THE ROC FOR TIKIWIKI WHEN THE PAIRS WERE FUNCTIONALLY REDUNDANT

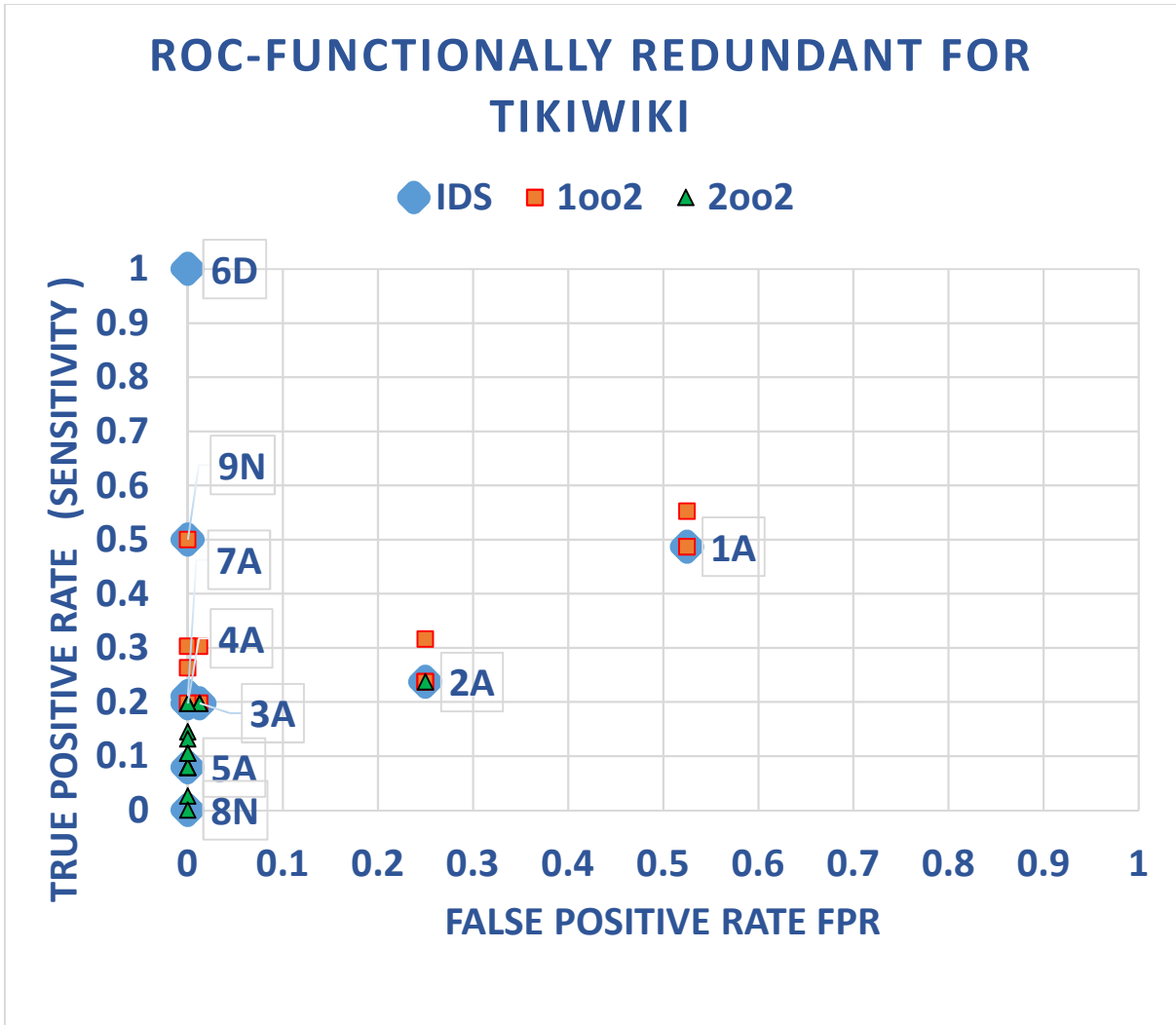
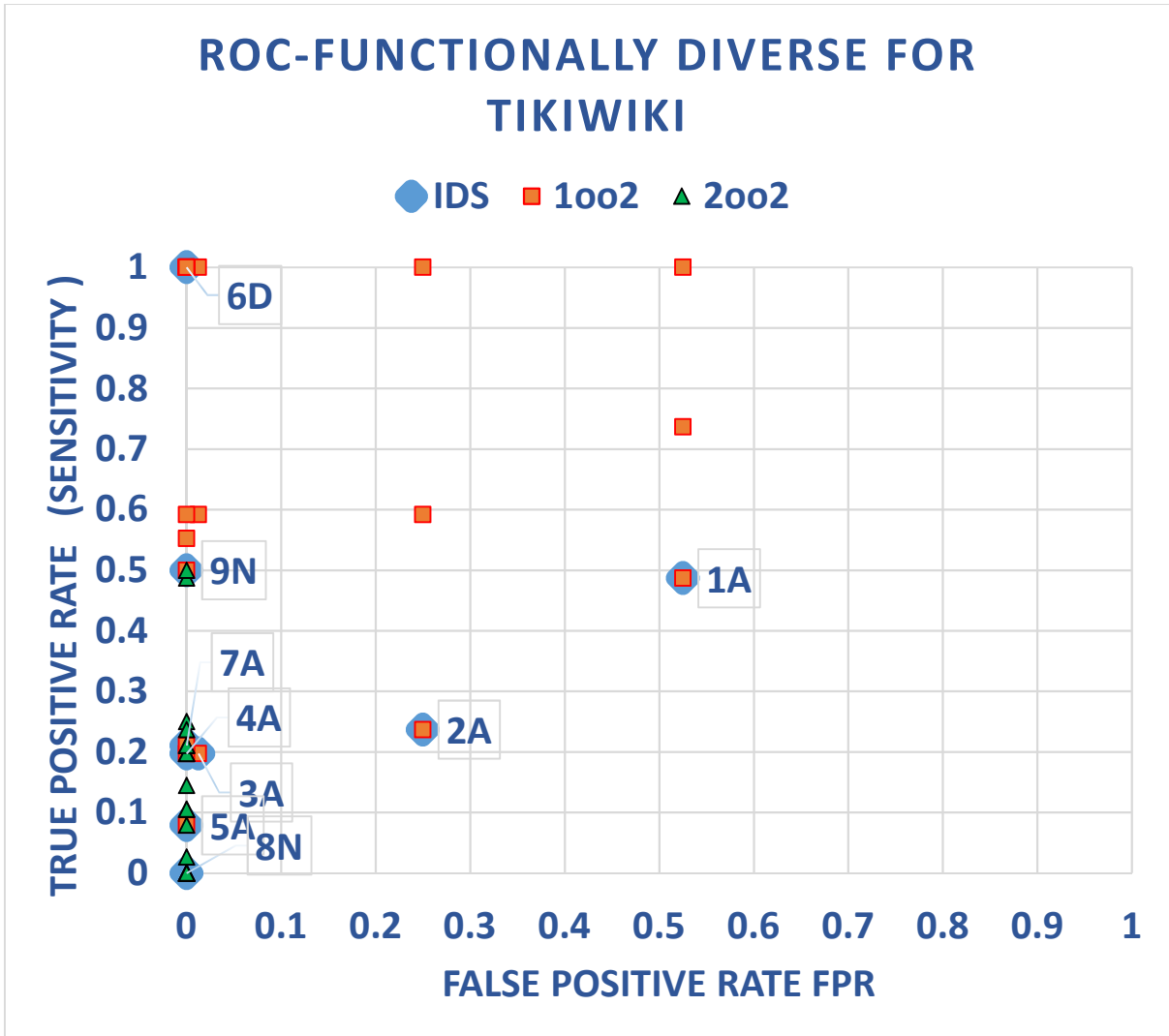


Figure 25 THE ROC PLOT SHOWING THE INDIVIDUAL IDSs, 1002 AND 2002 CONFIGURATIONS . THE ROC FOR TIKIWIKI WHEN THE PAIRS WERE FUNCTIONALLY DIVERSE



2.1.3.3.2 Accuracy

Figure 26 THE ACCURACY FOR A GIVEN SYSTEM A WHEN PAIRED WITH ANOTHER SYSTEM B FOR TIKIWIKI, THE CHART SHOWS THE INDIVIDUAL IDSs, 1002 AND 2002 CONFIGURATIONS

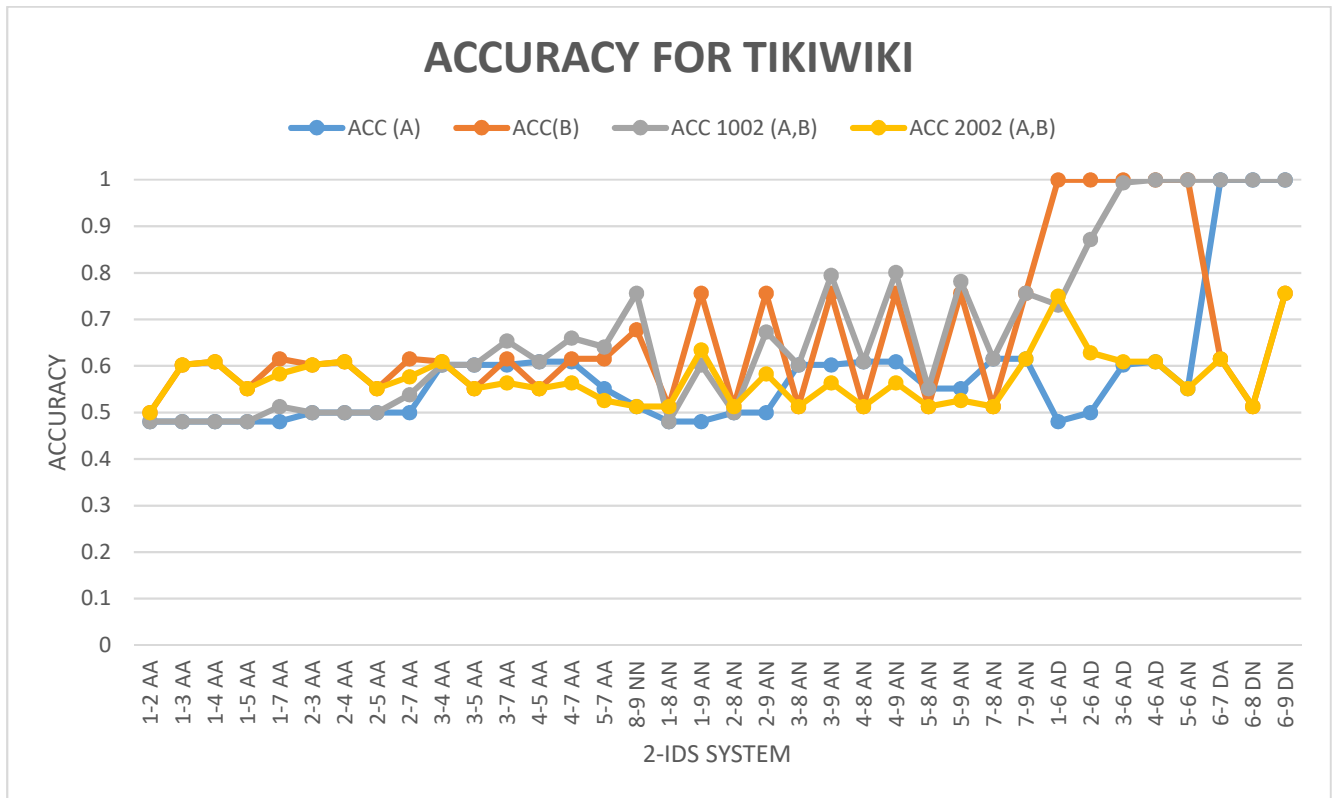
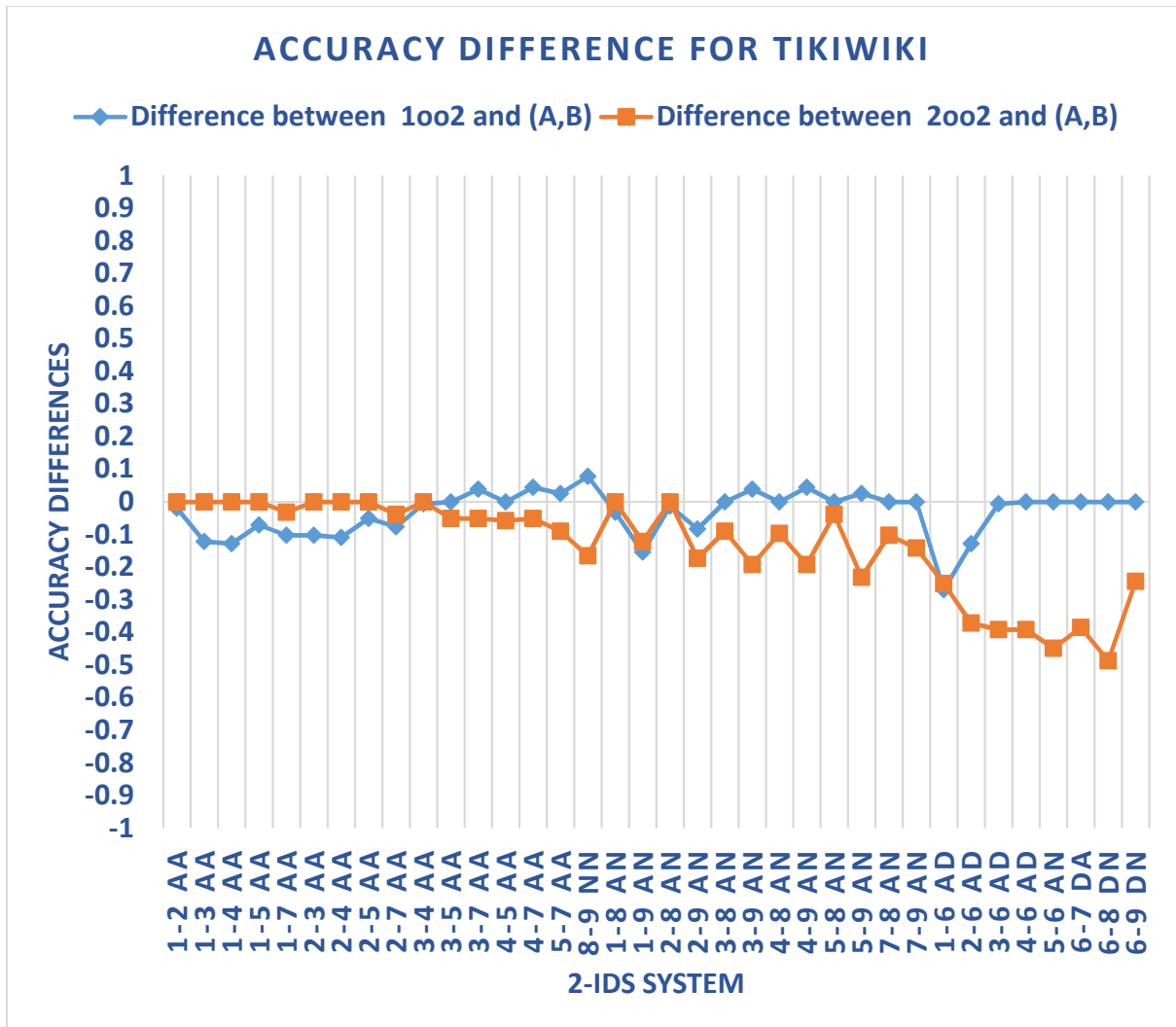


Figure 27 THE ACCURACY DIFFERENCE OF 1002 AND 2002 CONFIGURATIONS, COMAPRED WITH THE BEST SINGLE SYSTEM IN THE RESPECTIVE PAIR FOR TIKIWIKI



2.1.3.3.3 Specificity

Figure 28 THE SPECIFICITY FOR A GIVEN SYSTEM A WHEN PAIRED WITH ANOTHER SYSTEM B FOR TIKIWIKI, THE CHART SHOWS THE INDIVIDUAL IDSs, 1002 AND 2002 CONFIGURATIONS

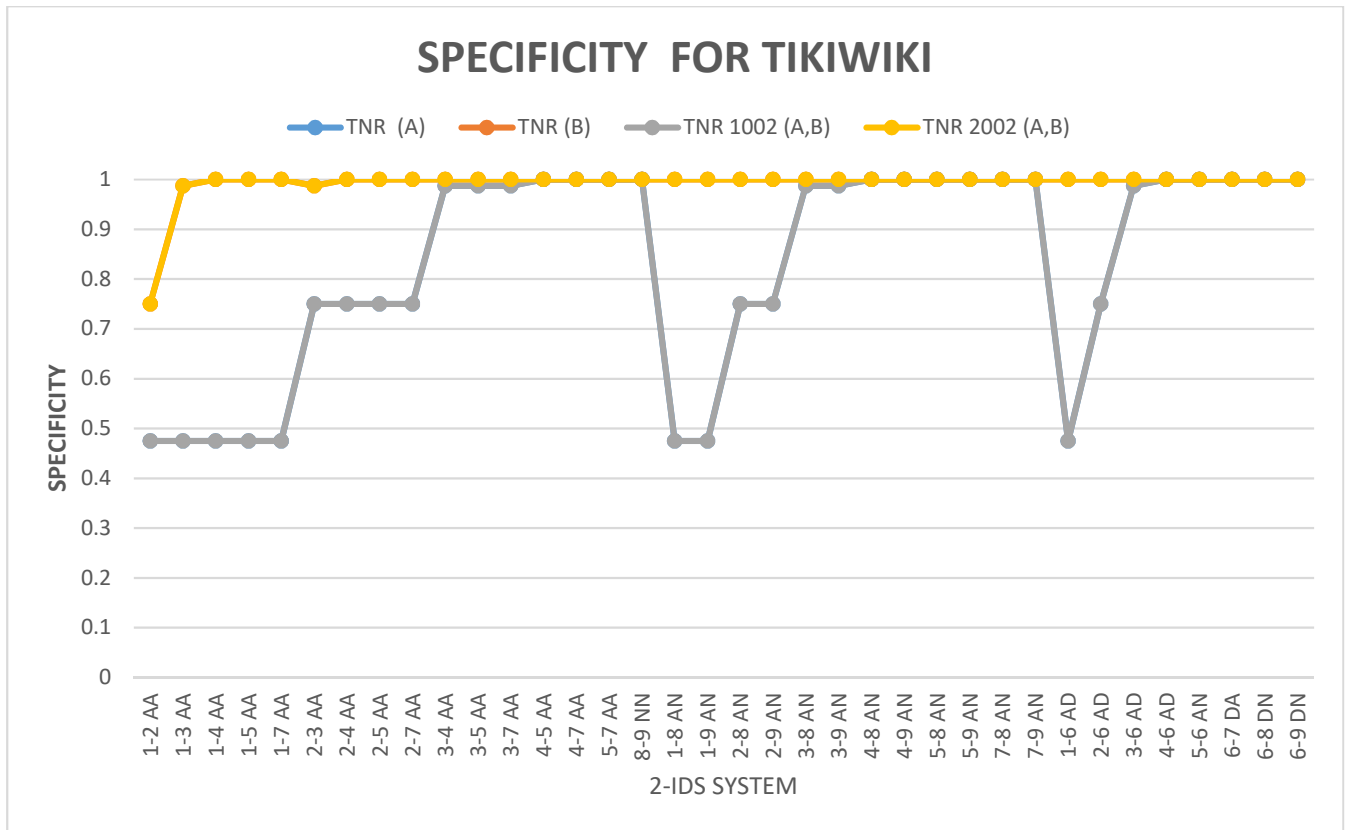
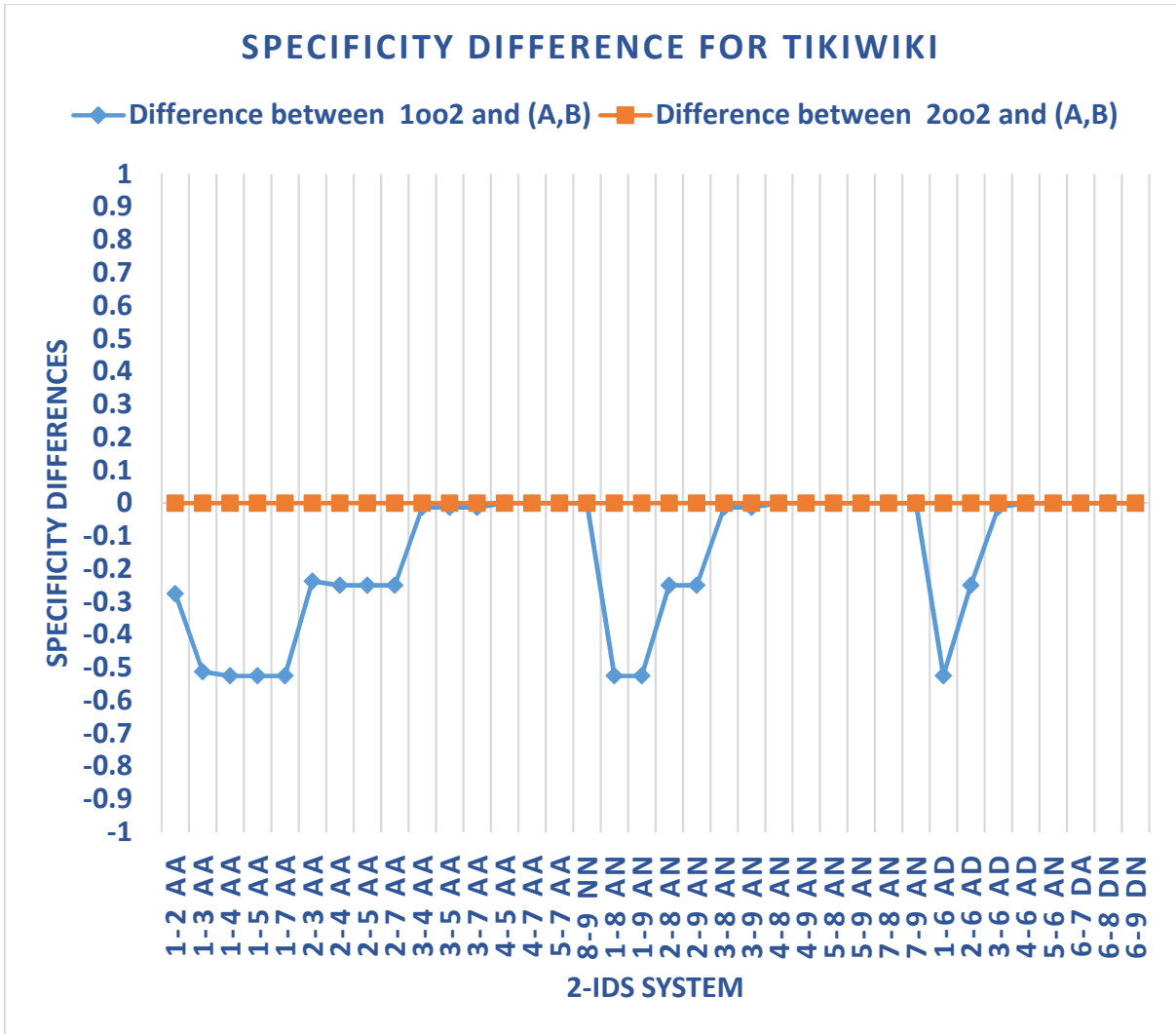


Figure 29 THE SPECIFICITY DIFFERENCE OF 1002 AND 2002 CONFIGURATIONS, COMAPRED WITH THE BEST SINGLE SYSTEM IN THE RESPECTIVE PAIR FOR TIKIWIKI



2.1.3.3.4 Sensitivity

Figure 30 THE SENSITIVITY FOR A GIVEN SYSTEM A WHEN PAIRED WITH ANOTHER SYSTEM B FOR TIKIWIKI, THE CHART SHOWS THE INDIVIDUAL IDSs, 1002 AND 2002 CONFIGURATIONS

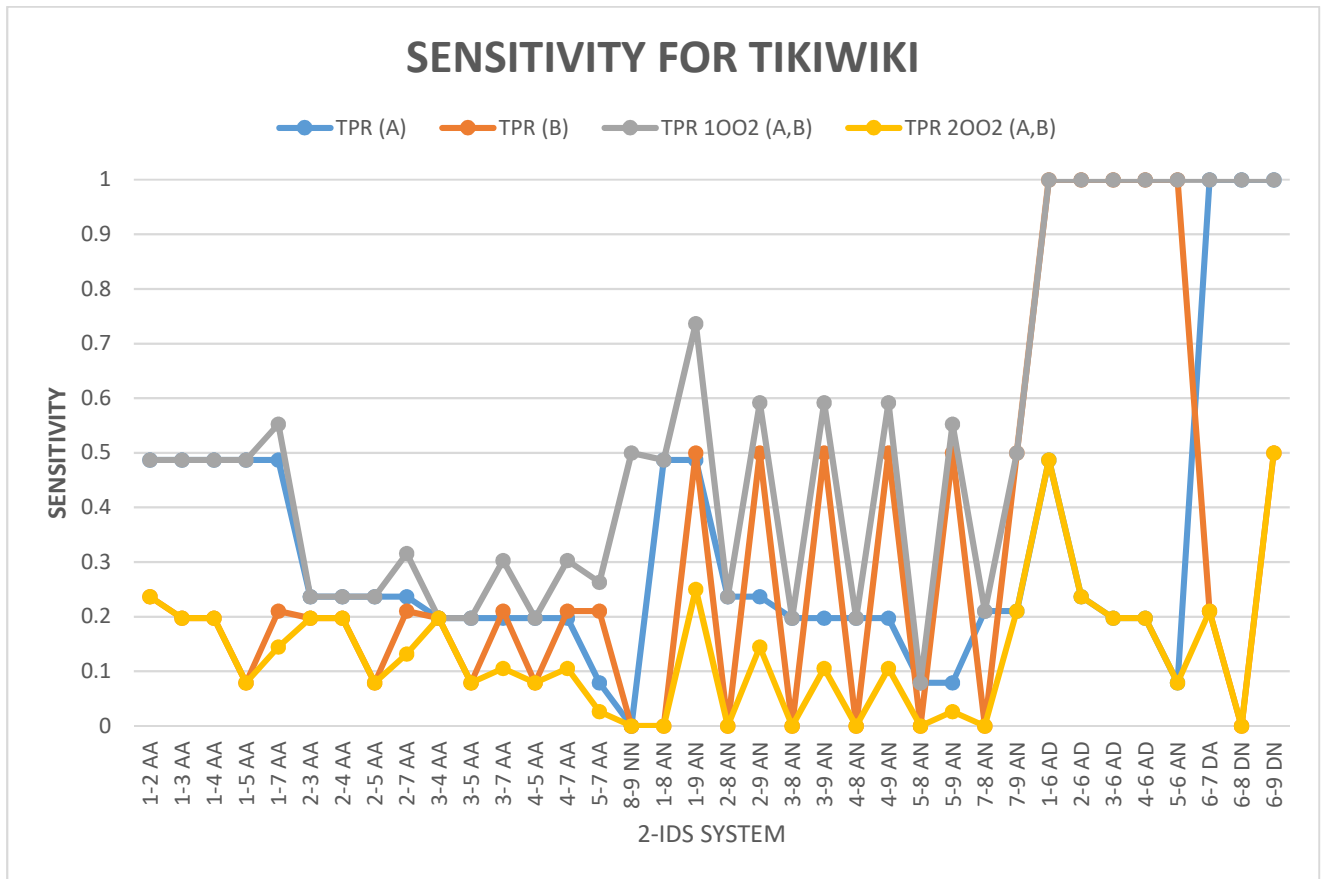
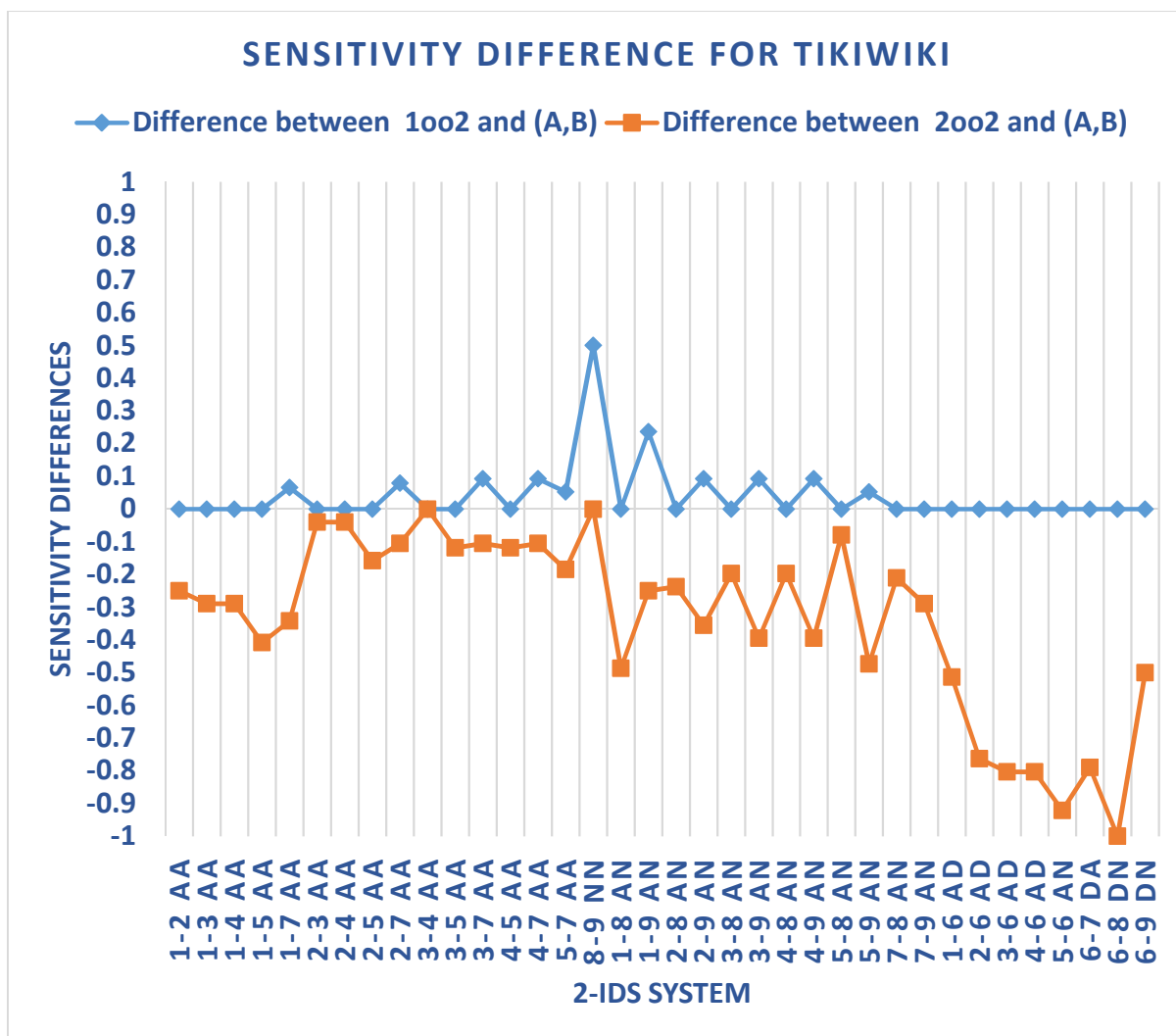


Figure 31 THE SENSITIVITY DIFFERENCE OF 1002 AND 2002 CONFIGURATIONS, COMAPRED WITH THE BEST SINGLE SYSTEM IN THE RESPECTIVE PAIR FOR TIKIWIKI



2.1.3.3.5 Improvement and deterioration in Sensitivity Specificity

Figure 32 DIFFERENCES IN SENSITIVITY AND SPECIFICITY FOR A GIVEN SYSTEM A WHEN PAIRED WITH ANOTHER SYSTEM B FOR TIKIWIKI FOR A 1002 CONFIGURATION

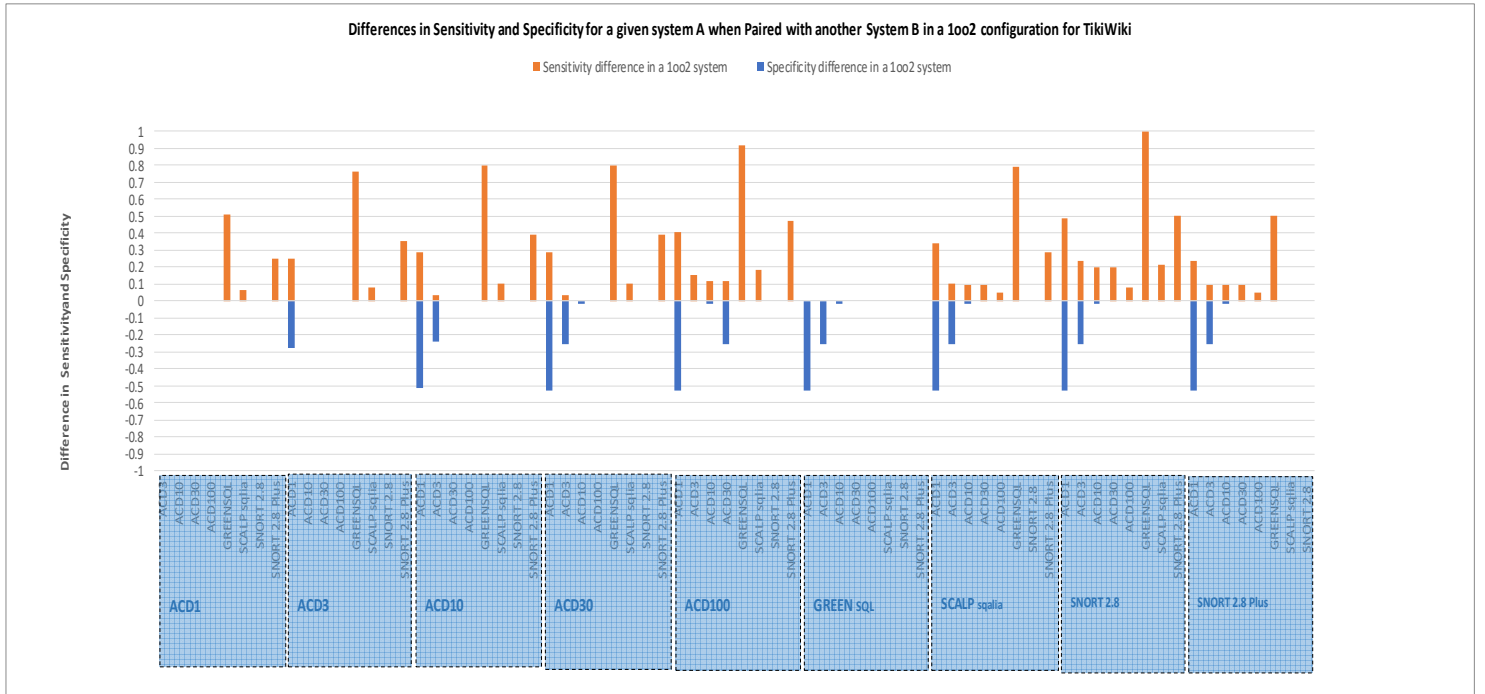
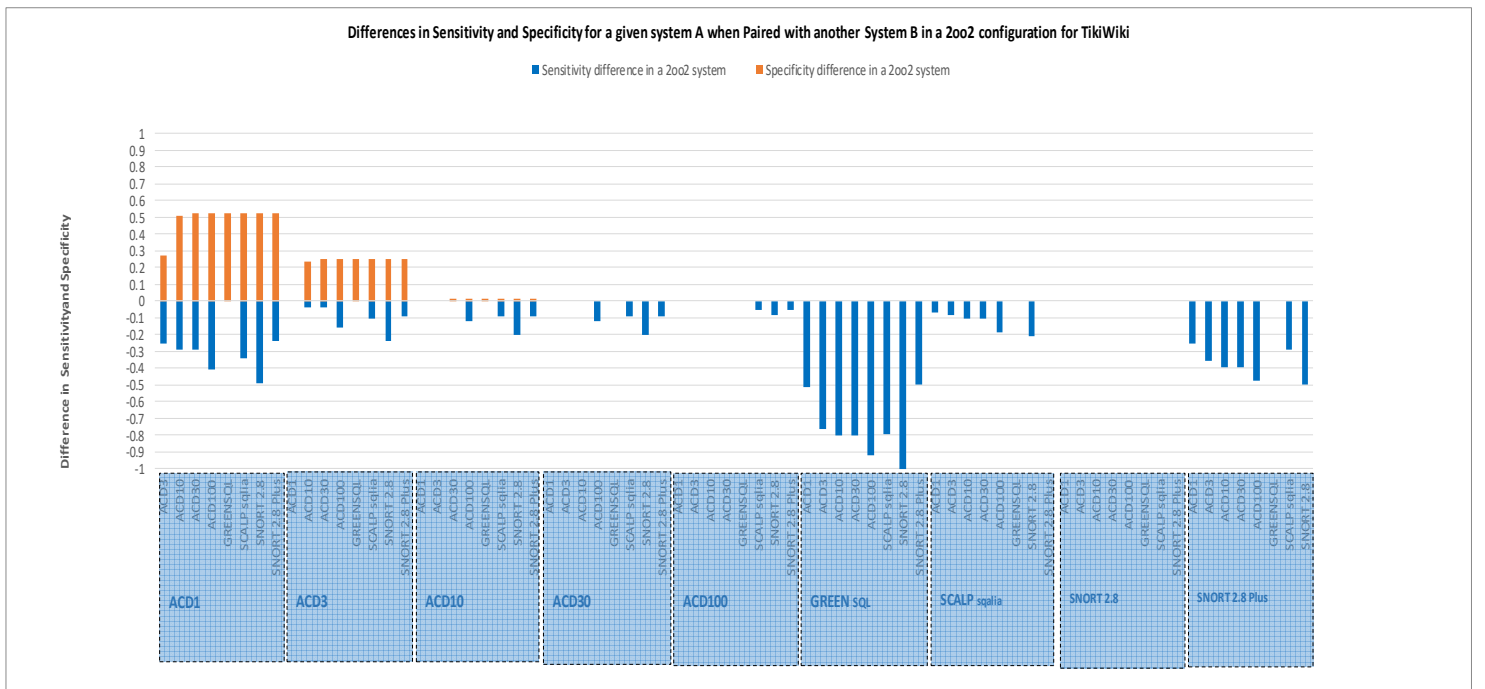


Figure 33 DIFFERENCES IN SENSITIVITY AND SPECIFICITY FOR A GIVEN SYSTEM A WHEN PAIRED WITH ANOTHER SYSTEM B FOR TIKIWIKI FOR A 2002 CONFIGURATION



2.2 Analysis by type of attack:

1-out-of 2 and 2-out-of 2 with considering the SQL injection attack method

Web Application	IDS	Crawling Actions	Successful Attack (GET+POST)	GET METHOD	POST METHOD
MY REFERENCE	9	45	136	99	37
PHP BB	9	97	245	77	168
TIKIWIKI	9	80	76	33	43

Table 10 Classifying by attack method POST and GET

2.2.1 Summary Statistics

Table 11

COUNTS OF DETECTIONS AND FAILURES FOR BENIGN TRAFFIC (FALSE POSITIVE AND TRUE NEGATIVE) AND FOR LEGITIMATE ATTACK (FALSE NEGATIVE AND TRUE POSITIVE) FOR EACH IDS AND FOR THE 36 COMBINATIONS OF 2-VERSION SYSTEMS 1002 AND 2002 FOR MyREFERENCES WHEN ATTACKS WERE READ (GET) AND TAKING INTO ACCOUNT THE TYPE OF IDS.

Combined System Label	A	B	FP				TN				FN				TP				Sensitivity		Specificity	
			FP (A)	FP (B)	FP 1002(A,B)	FP 2002 (A,B)	TN (A)	TN (B)	TN 1002 (A,B)	TN 2002 (A,B)	FN (A)	FN (B)	FN 1002 (A,B)	FN 2002 (A,B)	TP (A)	TP (B)	TP 1002 (A,B)	TP 2002 (A,B)	1002 (A,B)	2002 (A,B)	1002 (A,B)	2002 (A,B)
1-2 AA	1A	2A	11	7	15	3	34	38	30	42	15	16	15	16	84	83	84	83	0.85	0.84	0.67	0.93
1-3 AA	1A	3A	11	0	11	0	34	45	34	45	15	52	15	52	84	47	84	47	0.85	0.47	0.76	1.00
1-4 AA	1A	4A	11	0	11	0	34	45	34	45	15	62	15	62	84	37	84	37	0.85	0.37	0.76	1.00
1-5 AA	1A	5A	11	0	11	0	34	45	34	45	15	86	15	86	84	13	84	13	0.85	0.13	0.76	1.00
1-7 AA	1A	7A	11	4	13	2	34	41	32	43	15	65	8	72	84	34	91	27	0.92	0.27	0.71	0.96
2-3 AA	2A	3A	7	0	7	0	38	45	38	45	16	52	16	52	83	47	83	47	0.84	0.47	0.84	1.00
2-4 AA	2A	4A	7	0	7	0	38	45	38	45	16	62	16	62	83	37	83	37	0.84	0.37	0.84	1.00
2-5 AA	2A	5A	7	0	7	0	38	45	38	45	16	86	16	86	83	13	83	13	0.84	0.13	0.84	1.00
2-7 AA	2A	7A	7	4	11	0	38	41	34	45	16	65	9	72	83	34	90	27	0.91	0.27	0.76	1.00
3-4 AA	3A	4A	0	0	0	0	45	45	45	45	52	62	52	62	47	37	47	37	0.47	0.37	1.00	1.00
3-5 AA	3A	5A	0	0	0	0	45	45	45	45	52	86	52	86	47	13	47	13	0.47	0.13	1.00	1.00
3-7 AA	3A	7A	0	4	4	0	45	41	41	45	52	65	36	81	47	34	63	18	0.64	0.18	0.91	1.00
4-5 AA	4A	5A	0	0	0	0	45	45	45	45	62	86	62	86	37	13	37	13	0.37	0.13	1.00	1.00
4-7 AA	4A	7A	0	4	4	0	45	41	41	45	62	65	45	82	37	34	54	17	0.55	0.17	0.91	1.00
5-7 AA	5A	7A	0	4	4	0	45	41	41	45	86	65	52	99	13	34	47	0	0.47	0.00	0.91	1.00
8-9 NN	8N	9N	0	0	0	0	45	45	45	45	99	52	52	99	0	47	47	0	0.47	0.00	1.00	1.00
1-8 AN	1A	8N	11	0	11	0	34	45	34	45	15	99	15	99	84	0	84	0	0.85	0.00	0.76	1.00
1-9 AN	1A	9N	11	0	11	0	34	45	34	45	15	52	5	62	84	47	94	37	0.95	0.37	0.76	1.00
2-8 AN	2A	8N	7	0	7	0	38	45	38	45	16	99	16	99	83	0	83	0	0.84	0.00	0.84	1.00
2-9 AN	2A	9N	7	0	7	0	38	45	38	45	16	52	6	62	83	47	93	37	0.94	0.37	0.84	1.00
3-8 AN	3A	8N	0	0	0	0	45	45	45	45	52	99	52	99	47	0	47	0	0.47	0.00	1.00	1.00
3-9 AN	3A	9N	0	0	0	0	45	45	45	45	52	52	24	80	47	47	75	19	0.76	0.19	1.00	1.00
4-8 AN	4A	8N	0	0	0	0	45	45	45	45	62	99	62	99	37	0	37	0	0.37	0.00	1.00	1.00
4-9 AN	4A	9N	0	0	0	0	45	45	45	45	62	52	32	82	37	47	67	17	0.68	0.17	1.00	1.00
5-8 AN	5A	8N	0	0	0	0	45	45	45	45	86	99	86	99	13	0	13	0	0.13	0.00	1.00	1.00
5-9 AN	5A	9N	0	0	0	0	45	45	45	45	86	52	39	99	13	47	60	0	0.61	0.00	1.00	1.00
7-8 AN	7A	8N	4	0	4	0	41	45	41	45	65	99	65	99	34	0	34	0	0.34	0.00	0.91	1.00
7-9 AN	7A	9N	4	0	4	0	41	45	41	45	65	52	52	65	34	47	47	34	0.47	0.34	0.91	1.00
1-6 AD	1A	6D	11	0	11	0	34	45	34	45	15	85	12	88	84	14	87	11	0.88	0.11	0.76	1.00
2-6 AD	2A	6D	7	0	7	0	38	45	38	45	16	85	12	89	83	14	87	10	0.88	0.10	0.84	1.00
3-6 AD	3A	6D	0	0	0	0	45	45	45	45	52	85	38	99	47	14	61	0	0.62	0.00	1.00	1.00
4-6 AD	4A	6D	0	0	0	0	45	45	45	45	62	85	48	99	37	14	51	0	0.52	0.00	1.00	1.00
5-6 AD	5A	6D	0	0	0	0	45	45	45	45	86	85	72	99	13	14	27	0	0.27	0.00	1.00	1.00
6-7 DA	6D	7A	0	4	4	0	45	41	41	45	85	65	58	92	14	34	41	7	0.41	0.07	0.91	1.00
6-8 DN	6D	8N	0	0	0	0	45	45	45	45	85	99	85	99	14	0	14	0	0.14	0.00	1.00	1.00
6-9 DN	6D	9N	0	0	0	0	45	45	45	45	85	52	45	92	14	47	54	7	0.55	0.07	1.00	1.00

Table 12

COUNTS OF DETECTIONS AND FAILURES FOR BENIGN TRAFFIC (FALSE POSITIVE AND TRUE NEGATIVE) AND FOR LEGITIMATE ATTACK (FALSE NEGATIVE AND TRUE POSITIVE) FOR EACH IDS AND FOR THE 36 COMBINATIONS OF 2-VERSION SYSTEMS 1002 AND 2002 FOR MYREFERENCES WHEN ATTACKS WHERE WRITE (POST) AND TAKING INTO ACCOUNT THE TYPE OF IDS

Combined System Label	A	B	FP				TN				FN				TP				Sensitivity		Specificity	
			FP (A)	FP (B)	FP 1002(A,B)	FP 2002 (A,B)	TN (A)	TN (B)	TN 1002 (A,B)	TN 2002 (A,B)	FN (A)	FN (B)	FN 1002 (A,B)	FN 2002 (A,B)	TP (A)	TP (B)	TP 1002 (A,B)	TP 2002 (A,B)	1002 (A,B)	2002 (A,B)	1002 (A,B)	2002 (A,B)
			1-2 AA	1A	2A	11	7	15	3	34	38	30	42	0	37	0	37	37	0	37	0	1.00
1-3 AA	1A	3A	11	0	11	0	34	45	34	45	0	37	0	37	37	0	37	0	1.00	0.00	0.76	1.00
1-4 AA	1A	4A	11	0	11	0	34	45	34	45	0	37	0	37	37	0	37	0	1.00	0.00	0.76	1.00
1-5 AA	1A	5A	11	0	11	0	34	45	34	45	0	37	0	37	37	0	37	0	1.00	0.00	0.76	1.00
1-7 AA	1A	7A	11	4	13	2	34	41	32	43	0	37	0	37	37	0	37	0	1.00	0.00	0.71	0.96
2-3 AA	2A	3A	7	0	7	0	38	45	38	45	37	37	37	37	0	0	0	0	0.00	0.00	0.84	1.00
2-4 AA	2A	4A	7	0	7	0	38	45	38	45	37	37	37	37	0	0	0	0	0.00	0.00	0.84	1.00
2-5 AA	2A	5A	7	0	7	0	38	45	38	45	37	37	37	37	0	0	0	0	0.00	0.00	0.84	1.00
2-7 AA	2A	7A	7	4	11	0	38	41	34	45	37	37	37	37	0	0	0	0	0.00	0.00	0.76	1.00
3-4 AA	3A	4A	0	0	0	0	45	45	45	45	37	37	37	37	0	0	0	0	0.00	0.00	1.00	1.00
3-5 AA	3A	5A	0	0	0	0	45	45	45	45	37	37	37	37	0	0	0	0	0.00	0.00	1.00	1.00
3-7 AA	3A	7A	0	4	4	0	45	41	41	45	37	37	37	37	0	0	0	0	0.00	0.00	0.91	1.00
4-5 AA	4A	5A	0	0	0	0	45	45	45	45	37	37	37	37	0	0	0	0	0.00	0.00	1.00	1.00
4-7 AA	4A	7A	0	4	4	0	45	41	41	45	37	37	37	37	0	0	0	0	0.00	0.00	0.91	1.00
5-7 AA	5A	7A	0	4	4	0	45	41	41	45	37	37	37	37	0	0	0	0	0.00	0.00	0.91	1.00
8-9 NN	8N	9N	0	0	0	0	45	45	45	45	37	4	4	37	0	33	33	0	0.89	0.00	1.00	1.00
1-8 AN	1A	8N	11	0	11	0	34	45	34	45	0	37	0	37	37	0	37	0	1.00	0.00	0.76	1.00
1-9 AN	1A	9N	11	0	11	0	34	45	34	45	0	4	0	4	37	33	37	33	1.00	0.89	0.76	1.00
2-8 AN	2A	8N	7	0	7	0	38	45	38	45	37	37	37	37	0	0	0	0	0.00	0.00	0.84	1.00
2-9 AN	2A	9N	7	0	7	0	38	45	38	45	37	4	4	37	0	33	33	0	0.89	0.00	0.84	1.00
3-8 AN	3A	8N	0	0	0	0	45	45	45	45	37	37	37	37	0	0	0	0	0.00	0.00	1.00	1.00
3-9 AN	3A	9N	0	0	0	0	45	45	45	45	37	4	4	37	0	33	33	0	0.89	0.00	1.00	1.00
4-8 AN	4A	8N	0	0	0	0	45	45	45	45	37	37	37	37	0	0	0	0	0.00	0.00	1.00	1.00
4-9 AN	4A	9N	0	0	0	0	45	45	45	45	37	4	4	37	0	33	33	0	0.89	0.00	1.00	1.00
5-8 AN	5A	8N	0	0	0	0	45	45	45	45	37	37	37	37	0	0	0	0	0.00	0.00	1.00	1.00
5-9 AN	5A	9N	0	0	0	0	45	45	45	45	37	4	4	37	0	33	33	0	0.89	0.00	1.00	1.00
7-8 AN	7A	8N	4	0	4	0	41	45	41	45	37	37	37	37	0	0	0	0	0.00	0.00	0.91	1.00
7-9 AN	7A	9N	4	0	4	0	41	45	41	45	37	4	4	37	0	33	33	0	0.89	0.00	0.91	1.00
1-6 AD	1A	6D	11	0	11	0	34	45	34	45	0	35	0	35	37	2	37	2	1.00	0.05	0.76	1.00
2-6 AD	2A	6D	7	0	7	0	38	45	38	45	37	35	35	37	0	2	2	0	0.05	0.00	0.84	1.00
3-6 AD	3A	6D	0	0	0	0	45	45	45	45	37	35	35	37	0	2	2	0	0.05	0.00	1.00	1.00
4-6 AD	4A	6D	0	0	0	0	45	45	45	45	37	35	35	37	0	2	2	0	0.05	0.00	1.00	1.00
5-6 AD	5A	6D	0	0	0	0	45	45	45	45	37	35	35	37	0	2	2	0	0.05	0.00	1.00	1.00
6-7 DA	6D	7A	0	4	4	0	45	41	41	45	35	37	35	37	2	0	2	0	0.05	0.00	0.91	1.00
6-8 DN	6D	8N	0	0	0	0	45	45	45	45	35	37	35	37	2	0	2	0	0.05	0.00	1.00	1.00
6-9 DN	6D	9N	0	0	0	0	45	45	45	45	35	4	3	36	2	33	34	1	0.92	0.03	1.00	1.00

Table 13

COUNTS OF DETECTIONS AND FAILURES FOR BENIGN TRAFFIC (FALSE POSITIVE AND TRUE NEGATIVE) AND FOR LEGITIMATE ATTACK (FALSE NEGATIVE AND TRUE POSITIVE) FOR EACH IDS AND FOR THE 36 COMBINATIONS OF 2-VERSION SYSTEMS 1002 AND 2002 FOR PHPBB WHEN ATTACKS WHERE READ (GET) AND TAKING INTO ACCOUNT THE TYPE OF IDS.

Combined System Label	A	B	FP				TN				FN				TP				Sensitivity		Specificity	
			FP (A)	FP (B)	FP 1002(A,B)	FP 2002 (A,B)	TN (A)	TN (B)	TN 1002 (A,B)	TN 2002 (A,B)	FN (A)	FN (B)	FN 1002 (A,B)	FN 2002 (A,B)	TP (A)	TP (B)	TP 1002 (A,B)	TP 2002 (A,B)	1002 (A,B)	2002 (A,B)	1002 (A,B)	2002 (A,B)
1-2 AA	1A	2A	61	31	61	31	36	66	36	66	16	31	16	31	61	46	61	46	0.79	0.60	0.37	0.68
1-3 AA	1A	3A	61	1	61	1	36	96	36	96	16	66	16	66	61	11	61	11	0.79	0.14	0.37	0.99
1-4 AA	1A	4A	61	0	61	0	36	97	36	97	16	66	16	66	61	11	61	11	0.79	0.14	0.37	1.00
1-5 AA	1A	5A	61	0	61	0	36	97	36	97	16	71	16	71	61	6	61	6	0.79	0.08	0.37	1.00
1-7 AA	1A	7A	61	0	61	0	36	97	36	97	16	77	16	77	61	0	61	0	0.79	0.00	0.37	1.00
2-3 AA	2A	3A	31	1	31	1	66	96	66	96	31	66	31	66	46	11	46	11	0.60	0.14	0.68	0.99
2-4 AA	2A	4A	31	0	31	0	66	97	66	97	31	66	31	66	46	11	46	11	0.60	0.14	0.68	1.00
2-5 AA	2A	5A	31	0	31	0	66	97	66	97	31	71	31	71	46	6	46	6	0.60	0.08	0.68	1.00
2-7 AA	2A	7A	31	0	31	0	66	97	66	97	31	77	31	77	46	0	46	0	0.60	0.00	0.68	1.00
3-4 AA	3A	4A	1	0	1	0	96	97	96	97	66	66	66	66	11	11	11	11	0.14	0.14	0.99	1.00
3-5 AA	3A	5A	1	0	1	0	96	97	96	97	66	71	66	71	11	6	11	6	0.14	0.08	0.99	1.00
3-7 AA	3A	7A	1	0	1	0	96	97	96	97	66	77	66	77	11	0	11	0	0.14	0.00	0.99	1.00
4-5 AA	4A	5A	0	0	0	0	97	97	97	97	66	71	66	71	11	6	11	6	0.14	0.08	1.00	1.00
4-7 AA	4A	7A	0	0	0	0	97	97	97	97	66	77	66	77	11	0	11	0	0.14	0.00	1.00	1.00
5-7 AA	5A	7A	0	0	0	0	97	97	97	97	71	77	71	77	6	0	6	0	0.08	0.00	1.00	1.00
8-9 NN	8N	9N	0	0	0	0	97	97	97	97	77	0	0	0	0	77	77	77	1.00	1.00	1.00	1.00
1-8 AN	1A	8N	61	0	61	0	36	97	36	97	16	77	16	77	61	0	61	0	0.79	0.00	0.37	1.00
1-9 AN	1A	9N	61	0	61	0	36	97	36	97	16	0	0	16	61	77	77	61	1.00	0.79	0.37	1.00
2-8 AN	2A	8N	31	0	31	0	66	97	66	97	31	77	31	77	46	0	46	0	0.60	0.00	0.68	1.00
2-9 AN	2A	9N	31	0	31	0	66	97	66	97	31	0	0	31	46	77	77	46	1.00	0.60	0.68	1.00
3-8 AN	3A	8N	1	0	1	0	96	97	96	97	66	77	66	77	11	0	11	0	0.14	0.00	0.99	1.00
3-9 AN	3A	9N	1	0	1	0	96	97	96	97	66	0	0	66	11	77	77	11	1.00	0.14	0.99	1.00
4-8 AN	4A	8N	0	0	0	0	97	97	97	97	66	77	66	77	11	0	11	0	0.14	0.00	1.00	1.00
4-9 AN	4A	9N	0	0	0	0	97	97	97	97	66	0	0	66	11	77	77	11	1.00	0.14	1.00	1.00
5-8 AN	5A	8N	0	0	0	0	97	97	97	97	71	77	71	77	6	0	6	0	0.08	0.00	1.00	1.00
5-9 AN	5A	9N	0	0	0	0	97	97	97	97	71	0	0	71	6	77	77	6	1.00	0.08	1.00	1.00
7-8 AN	7A	8N	0	0	0	0	97	97	97	97	77	77	77	77	0	0	0	0	0.00	0.00	1.00	1.00
7-9 AN	7A	9N	0	0	0	0	97	97	97	97	77	0	0	0	0	77	77	77	1.00	1.00	1.00	1.00
1-6 AD	1A	6D	61	0	61	0	36	97	36	97	16	77	16	77	61	0	61	0	0.79	0.00	0.37	1.00
2-6 AD	2A	6D	31	0	31	0	66	97	66	97	31	77	31	77	46	0	46	0	0.60	0.00	0.68	1.00
3-6 AD	3A	6D	1	0	1	0	96	97	96	97	66	77	66	77	11	0	11	0	0.14	0.00	0.99	1.00
4-6 AD	4A	6D	0	0	0	0	97	97	97	97	66	77	66	77	11	0	11	0	0.14	0.00	1.00	1.00
5-6 AD	5A	6D	0	0	0	0	97	97	97	97	71	77	71	77	6	0	6	0	0.08	0.00	1.00	1.00
6-7 DA	6D	7A	0	0	0	0	97	97	97	97	77	77	77	77	0	0	0	0	0.00	0.00	1.00	1.00
6-8 DN	6D	8N	0	0	0	0	97	97	97	97	77	77	77	77	0	0	0	0	0.00	0.00	1.00	1.00
6-9 DN	6D	9N	0	0	0	0	97	97	97	97	77	0	0	77	0	77	77	0	1.00	0.00	1.00	1.00

Table 14

COUNTS OF DETECTIONS AND FAILURES FOR BENIGN TRAFFIC (FALSE POSITIVE AND TRUE NEGATIVE) AND FOR LEGITIMATE ATTACK (FALSE NEGATIVE AND TRUE POSITIVE) FOR EACH IDS AND FOR THE 36 COMBINATIONS OF 2-VERSION SYSTEMS 1002 AND 2002 FOR PHPBB WHEN ATTACKS WERE WRITE (POST) AND TAKING INTO ACCOUNT THE TYPE OF IDS

Combined System Label	A	B	FP				TN				FN				TP				Sensitivity		Specificity	
			FP (A)	FP (B)	FP 1002(A,B)	FP 2002 (A,B)	TN (A)	TN (B)	TN 1002 (A,B)	TN 2002 (A,B)	FN (A)	FN (B)	FN 1002 (A,B)	FN 2002 (A,B)	TP (A)	TP (B)	TP 1002 (A,B)	TP 2002 (A,B)	1002 (A,B)	2002 (A,B)	1002 (A,B)	2002 (A,B)
1-2 AA	1A	2A	61	31	61	31	36	66	36	66	0	161	0	161	168	7	168	7	1.00	0.04	0.37	0.68
1-3 AA	1A	3A	61	1	61	1	36	96	36	96	0	161	0	161	168	7	168	7	1.00	0.04	0.37	0.99
1-4 AA	1A	4A	61	0	61	0	36	97	36	97	0	168	0	168	168	0	168	0	1.00	0.00	0.37	1.00
1-5 AA	1A	5A	61	0	61	0	36	97	36	97	0	168	0	168	168	0	168	0	1.00	0.00	0.37	1.00
1-7 AA	1A	7A	61	0	61	0	36	97	36	97	0	168	0	168	168	0	168	0	1.00	0.00	0.37	1.00
2-3 AA	2A	3A	31	1	31	1	66	96	66	96	161	161	161	161	7	7	7	7	0.04	0.04	0.68	0.99
2-4 AA	2A	4A	31	0	31	0	66	97	66	97	161	168	161	168	7	0	7	0	0.04	0.00	0.68	1.00
2-5 AA	2A	5A	31	0	31	0	66	97	66	97	161	168	161	168	7	0	7	0	0.04	0.00	0.68	1.00
2-7 AA	2A	7A	31	0	31	0	66	97	66	97	161	168	161	168	7	0	7	0	0.04	0.00	0.68	1.00
3-4 AA	3A	4A	1	0	1	0	96	97	96	97	161	168	161	168	7	0	7	0	0.04	0.00	0.99	1.00
3-5 AA	3A	5A	1	0	1	0	96	97	96	97	161	168	161	168	7	0	7	0	0.04	0.00	0.99	1.00
3-7 AA	3A	7A	1	0	1	0	96	97	96	97	161	168	161	168	7	0	7	0	0.04	0.00	0.99	1.00
4-5 AA	4A	5A	0	0	0	0	97	97	97	97	168	168	168	168	0	0	0	0	0.00	0.00	1.00	1.00
4-7 AA	4A	7A	0	0	0	0	97	97	97	97	168	168	168	168	0	0	0	0	0.00	0.00	1.00	1.00
5-7 AA	5A	7A	0	0	0	0	97	97	97	97	168	168	168	168	0	0	0	0	0.00	0.00	1.00	1.00
8-9 NN	8N	9N	0	0	0	0	97	97	97	97	168	0	0	168	0	168	168	0	1.00	0.00	1.00	1.00
1-8 AN	1A	8N	61	0	61	0	36	97	36	97	0	168	0	168	168	0	168	0	1.00	0.00	0.37	1.00
1-9 AN	1A	9N	61	0	61	0	36	97	36	97	0	0	0	0	168	168	168	168	1.00	1.00	0.37	1.00
2-8 AN	2A	8N	31	0	31	0	66	97	66	97	161	168	161	168	7	0	7	0	0.04	0.00	0.68	1.00
2-9 AN	2A	9N	31	0	31	0	66	97	66	97	161	0	0	161	7	168	168	7	1.00	0.04	0.68	1.00
3-8 AN	3A	8N	1	0	1	0	96	97	96	97	161	168	161	168	7	0	7	0	0.04	0.00	0.99	1.00
3-9 AN	3A	9N	1	0	1	0	96	97	96	97	161	0	0	161	7	168	168	7	1.00	0.04	0.99	1.00
4-8 AN	4A	8N	0	0	0	0	97	97	97	97	168	168	168	168	0	0	0	0	0.00	0.00	1.00	1.00
4-9 AN	4A	9N	0	0	0	0	97	97	97	97	168	0	0	168	0	168	168	0	1.00	0.00	1.00	1.00
5-8 AN	5A	8N	0	0	0	0	97	97	97	97	168	168	168	168	0	0	0	0	0.00	0.00	1.00	1.00
5-9 AN	5A	9N	0	0	0	0	97	97	97	97	168	0	0	168	0	168	168	0	1.00	0.00	1.00	1.00
7-8 AN	7A	8N	0	0	0	0	97	97	97	97	168	168	168	168	0	0	0	0	0.00	0.00	1.00	1.00
7-9 AN	7A	9N	0	0	0	0	97	97	97	97	168	0	0	168	0	168	168	0	1.00	0.00	1.00	1.00
1-6 AD	1A	6D	61	0	61	0	36	97	36	97	0	14	0	14	168	154	168	154	1.00	0.92	0.37	1.00
2-6 AD	2A	6D	31	0	31	0	66	97	66	97	161	14	14	161	7	154	154	7	0.92	0.04	0.68	1.00
3-6 AD	3A	6D	1	0	1	0	96	97	96	97	161	14	14	161	7	154	154	7	0.92	0.04	0.99	1.00
4-6 AD	4A	6D	0	0	0	0	97	97	97	97	168	14	14	168	0	154	154	0	0.92	0.00	1.00	1.00
5-6 AD	5A	6D	0	0	0	0	97	97	97	97	168	14	14	168	0	154	154	0	0.92	0.00	1.00	1.00
6-7 DA	6D	7A	0	0	0	0	97	97	97	97	14	168	14	168	154	0	154	0	0.92	0.00	1.00	1.00
6-8 DN	6D	8N	0	0	0	0	97	97	97	97	14	168	14	168	154	0	154	0	0.92	0.00	1.00	1.00
6-9 DN	6D	9N	0	0	0	0	97	97	97	97	14	0	0	14	154	168	168	154	1.00	0.92	1.00	1.00

Table 15

COUNTS OF DETECTIONS AND FAILURES FOR BENIGN TRAFFIC (FALSE POSITIVE AND TRUE NEGATIVE) AND FOR LEGITIMATE ATTACK (FALSE NEGATIVE AND TRUE POSITIVE) FOR EACH IDS AND FOR THE 36 COMBINATIONS OF 2-VERSION SYSTEMS 1002 AND 2002 FOR TIKIWIKI WHEN ATTACKS WERE READ (GET) AND TAKING INTO ACCOUNT THE TYPE OF IDS.

Combined System Label	A	B	FP				TN				FN				TP				Sensitivity		Specificity	
			FP (A)	FP (B)	FP 1002(A,B)	FP 2002 (A,B)	TN (A)	TN (B)	TN 1002 (A,B)	TN 2002 (A,B)	FN (A)	FN (B)	FN 1002 (A,B)	FN 2002 (A,B)	TP (A)	TP (B)	TP 1002 (A,B)	TP 2002 (A,B)	1002 (A,B)	2002 (A,B)	1002 (A,B)	2002 (A,B)
1-2 AA	1A	2A	42	20	42	20	38	60	38	60	9	15	9	15	24	18	24	18	0.73	0.55	0.48	0.75
1-3 AA	1A	3A	42	1	42	1	38	79	38	79	9	18	9	18	24	15	24	15	0.73	0.45	0.48	0.99
1-4 AA	1A	4A	42	0	42	0	38	80	38	80	9	18	9	18	24	15	24	15	0.73	0.45	0.48	1.00
1-5 AA	1A	5A	42	0	42	0	38	80	38	80	9	27	9	27	24	6	24	6	0.73	0.18	0.48	1.00
1-7 AA	1A	7A	42	0	42	0	38	80	38	80	9	17	4	22	24	16	29	11	0.88	0.33	0.48	1.00
2-3 AA	2A	3A	20	1	20	1	60	79	60	79	15	18	15	18	18	15	18	15	0.55	0.45	0.75	0.99
2-4 AA	2A	4A	20	0	20	0	60	80	60	80	15	18	15	18	18	15	18	15	0.55	0.45	0.75	1.00
2-5 AA	2A	5A	20	0	20	0	60	80	60	80	15	27	15	27	18	6	18	6	0.55	0.18	0.75	1.00
2-7 AA	2A	7A	20	0	20	0	60	80	60	80	15	17	9	23	18	16	24	10	0.73	0.30	0.75	1.00
3-4 AA	3A	4A	1	0	1	0	79	80	79	80	18	18	18	18	15	15	15	15	0.45	0.45	0.99	1.00
3-5 AA	3A	5A	1	0	1	0	79	80	79	80	18	27	18	27	15	6	15	6	0.45	0.18	0.99	1.00
3-7 AA	3A	7A	1	0	1	0	79	80	79	80	18	17	10	25	15	16	23	8	0.70	0.24	0.99	1.00
4-5 AA	4A	5A	0	0	0	0	80	80	80	80	18	27	18	27	15	6	15	6	0.45	0.18	1.00	1.00
4-7 AA	4A	7A	0	0	0	0	80	80	80	80	18	17	10	25	15	16	23	8	0.70	0.24	1.00	1.00
5-7 AA	5A	7A	0	0	0	0	80	80	80	80	27	17	13	31	6	16	20	2	0.61	0.06	1.00	1.00
8-9 NN	8N	9N	0	0	0	0	80	80	80	80	33	13	13	33	0	20	20	0	0.61	0.00	1.00	1.00
1-8 AN	1A	8N	42	0	42	0	38	80	38	80	9	33	9	33	24	0	24	0	0.73	0.00	0.48	1.00
1-9 AN	1A	9N	42	0	42	0	38	80	38	80	9	13	2	20	24	20	31	13	0.94	0.39	0.48	1.00
2-8 AN	2A	8N	20	0	20	0	60	80	60	80	15	33	15	33	18	0	18	0	0.55	0.00	0.75	1.00
2-9 AN	2A	9N	20	0	20	0	60	80	60	80	15	13	6	22	18	20	27	11	0.82	0.33	0.75	1.00
3-8 AN	3A	8N	1	0	1	0	79	80	79	80	18	33	18	33	15	0	15	0	0.45	0.00	0.99	1.00
3-9 AN	3A	9N	1	0	1	0	79	80	79	80	18	13	6	25	15	20	27	8	0.82	0.24	0.99	1.00
4-8 AN	4A	8N	0	0	0	0	80	80	80	80	18	33	18	33	15	0	15	0	0.45	0.00	1.00	1.00
4-9 AN	4A	9N	0	0	0	0	80	80	80	80	18	13	6	25	15	20	27	8	0.82	0.24	1.00	1.00
5-8 AN	5A	8N	0	0	0	0	80	80	80	80	27	33	27	33	6	0	6	0	0.18	0.00	1.00	1.00
5-9 AN	5A	9N	0	0	0	0	80	80	80	80	27	13	9	31	6	20	24	2	0.73	0.06	1.00	1.00
7-8 AN	7A	8N	0	0	0	0	80	80	80	80	17	33	17	33	16	0	16	0	0.48	0.00	1.00	1.00
7-9 AN	7A	9N	0	0	0	0	80	80	80	80	17	13	13	17	16	20	20	16	0.61	0.48	1.00	1.00
1-6 AD	1A	6D	42	0	42	0	38	80	38	80	9	0	0	9	24	33	33	24	1.00	0.73	0.48	1.00
2-6 AD	2A	6D	20	0	20	0	60	80	60	80	15	0	0	15	18	33	33	18	1.00	0.55	0.75	1.00
3-6 AD	3A	6D	1	0	1	0	79	80	79	80	18	0	0	18	15	33	33	15	1.00	0.45	0.99	1.00
4-6 AD	4A	6D	0	0	0	0	80	80	80	80	18	0	0	18	15	33	33	15	1.00	0.45	1.00	1.00
5-6 AD	5A	6D	0	0	0	0	80	80	80	80	27	0	0	27	6	33	33	6	1.00	0.18	1.00	1.00
6-7 DA	6D	7A	0	0	0	0	80	80	80	80	0	17	0	17	33	16	33	16	1.00	0.48	1.00	1.00
6-8 DN	6D	8N	0	0	0	0	80	80	80	80	0	33	0	33	33	0	33	0	1.00	0.00	1.00	1.00
6-9 DN	6D	9N	0	0	0	0	80	80	80	80	0	13	0	13	33	20	33	20	1.00	0.61	1.00	1.00

Table 16

COUNTS OF DETECTIONS AND FAILURES FOR BENIGN TRAFFIC (FALSE POSITIVE AND TRUE NEGATIVE) AND FOR LEGITIMATE ATTACK (FALSE NEGATIVE AND TRUE POSITIVE) FOR EACH IDS AND FOR THE 36 COMBINATIONS OF 2-VERSION SYSTEMS 1002 AND 2002 FOR TIKIWiki WHEN ATTACKS WHERE WRITE (POST) AND TAKING INTO ACCOUNT THE TYPE OF IDS

Combined System Label	A	B	FP				TN				FN				TP				Sensitivity		Specificity	
			FP (A)	FP (B)	FP 1002(A,B)	FP 2002 (A,B)	TN (A)	TN (B)	TN 1002 (A,B)	TN 2002 (A,B)	FN (A)	FN (B)	FN 1002 (A,B)	FN 2002 (A,B)	TP (A)	TP (B)	TP 1002 (A,B)	TP 2002 (A,B)	1002 (A,B)	2002 (A,B)	1002 (A,B)	2002 (A,B)
			1-2 AA	1A	2A	42	20	42	20	38	60	38	60	30	43	30	43	13	0	13	0	0.30
1-3 AA	1A	3A	42	1	42	1	38	79	38	79	30	43	30	43	13	0	13	0	0.30	0.00	0.48	0.99
1-4 AA	1A	4A	42	0	42	0	38	80	38	80	30	43	30	43	13	0	13	0	0.30	0.00	0.48	1.00
1-5 AA	1A	5A	42	0	42	0	38	80	38	80	30	43	30	43	13	0	13	0	0.30	0.00	0.48	1.00
1-7 AA	1A	7A	42	0	42	0	38	80	38	80	30	43	30	43	13	0	13	0	0.30	0.00	0.48	1.00
2-3 AA	2A	3A	20	1	20	1	60	79	60	79	43	43	43	43	0	0	0	0	0.00	0.00	0.75	0.99
2-4 AA	2A	4A	20	0	20	0	60	80	60	80	43	43	43	43	0	0	0	0	0.00	0.00	0.75	1.00
2-5 AA	2A	5A	20	0	20	0	60	80	60	80	43	43	43	43	0	0	0	0	0.00	0.00	0.75	1.00
2-7 AA	2A	7A	20	0	20	0	60	80	60	80	43	43	43	43	0	0	0	0	0.00	0.00	0.75	1.00
3-4 AA	3A	4A	1	0	1	0	79	80	79	80	43	43	43	43	0	0	0	0	0.00	0.00	0.99	1.00
3-5 AA	3A	5A	1	0	1	0	79	80	79	80	43	43	43	43	0	0	0	0	0.00	0.00	0.99	1.00
3-7 AA	3A	7A	1	0	1	0	79	80	79	80	43	43	43	43	0	0	0	0	0.00	0.00	0.99	1.00
4-5 AA	4A	5A	0	0	0	0	80	80	80	80	43	43	43	43	0	0	0	0	0.00	0.00	1.00	1.00
4-7 AA	4A	7A	0	0	0	0	80	80	80	80	43	43	43	43	0	0	0	0	0.00	0.00	1.00	1.00
5-7 AA	5A	7A	0	0	0	0	80	80	80	80	43	43	43	43	0	0	0	0	0.00	0.00	1.00	1.00
8-9 NN	8N	9N	0	0	0	0	80	80	80	80	43	25	25	43	0	18	18	0	0.42	0.00	1.00	1.00
1-8 AN	1A	8N	42	0	42	0	38	80	38	80	30	43	30	43	13	0	13	0	0.30	0.00	0.48	1.00
1-9 AN	1A	9N	42	0	42	0	38	80	38	80	30	25	18	37	13	18	25	6	0.58	0.14	0.48	1.00
2-8 AN	2A	8N	20	0	20	0	60	80	60	80	43	43	43	43	0	0	0	0	0.00	0.00	0.75	1.00
2-9 AN	2A	9N	20	0	20	0	60	80	60	80	43	25	25	43	0	18	18	0	0.42	0.00	0.75	1.00
3-8 AN	3A	8N	1	0	1	0	79	80	79	80	43	43	43	43	0	0	0	0	0.00	0.00	0.99	1.00
3-9 AN	3A	9N	1	0	1	0	79	80	79	80	43	25	25	43	0	18	18	0	0.42	0.00	0.99	1.00
4-8 AN	4A	8N	0	0	0	0	80	80	80	80	43	43	43	43	0	0	0	0	0.00	0.00	1.00	1.00
4-9 AN	4A	9N	0	0	0	0	80	80	80	80	43	25	25	43	0	18	18	0	0.42	0.00	1.00	1.00
5-8 AN	5A	8N	0	0	0	0	80	80	80	80	43	43	43	43	0	0	0	0	0.00	0.00	1.00	1.00
5-9 AN	5A	9N	0	0	0	0	80	80	80	80	43	25	25	43	0	18	18	0	0.42	0.00	1.00	1.00
7-8 AN	7A	8N	0	0	0	0	80	80	80	80	43	43	43	43	0	0	0	0	0.00	0.00	1.00	1.00
7-9 AN	7A	9N	0	0	0	0	80	80	80	80	43	25	25	43	0	18	18	0	0.42	0.00	1.00	1.00
1-6 AD	1A	6D	42	0	42	0	38	80	38	80	30	0	0	30	13	43	43	13	1.00	0.30	0.48	1.00
2-6 AD	2A	6D	20	0	20	0	60	80	60	80	43	0	0	43	0	43	43	0	1.00	0.00	0.75	1.00
3-6 AD	3A	6D	1	0	1	0	79	80	79	80	43	0	0	43	0	43	43	0	1.00	0.00	0.99	1.00
4-6 AD	4A	6D	0	0	0	0	80	80	80	80	43	0	0	43	0	43	43	0	1.00	0.00	1.00	1.00
5-6 AD	5A	6D	0	0	0	0	80	80	80	80	43	0	0	43	0	43	43	0	1.00	0.00	1.00	1.00
6-7 DA	6D	7A	0	0	0	0	80	80	80	80	0	43	0	43	43	0	43	0	1.00	0.00	1.00	1.00
6-8 DN	6D	8N	0	0	0	0	80	80	80	80	0	43	0	43	43	0	43	0	1.00	0.00	1.00	1.00
6-9 DN	6D	9N	0	0	0	0	80	80	80	80	0	25	0	25	43	18	43	18	1.00	0.42	1.00	1.00

2.2.2 Diversity Analysis.

2.2.2.1 MyReferences

2.2.2.1.1 ROC

Figure 34 THE ROC PLOT SHOWING THE INDIVIDUAL IDSs, 1002 AND 2002 CONFIGURATIONS FOR MYREFERENCES WHEN ATTACKS WERE READ (GET)

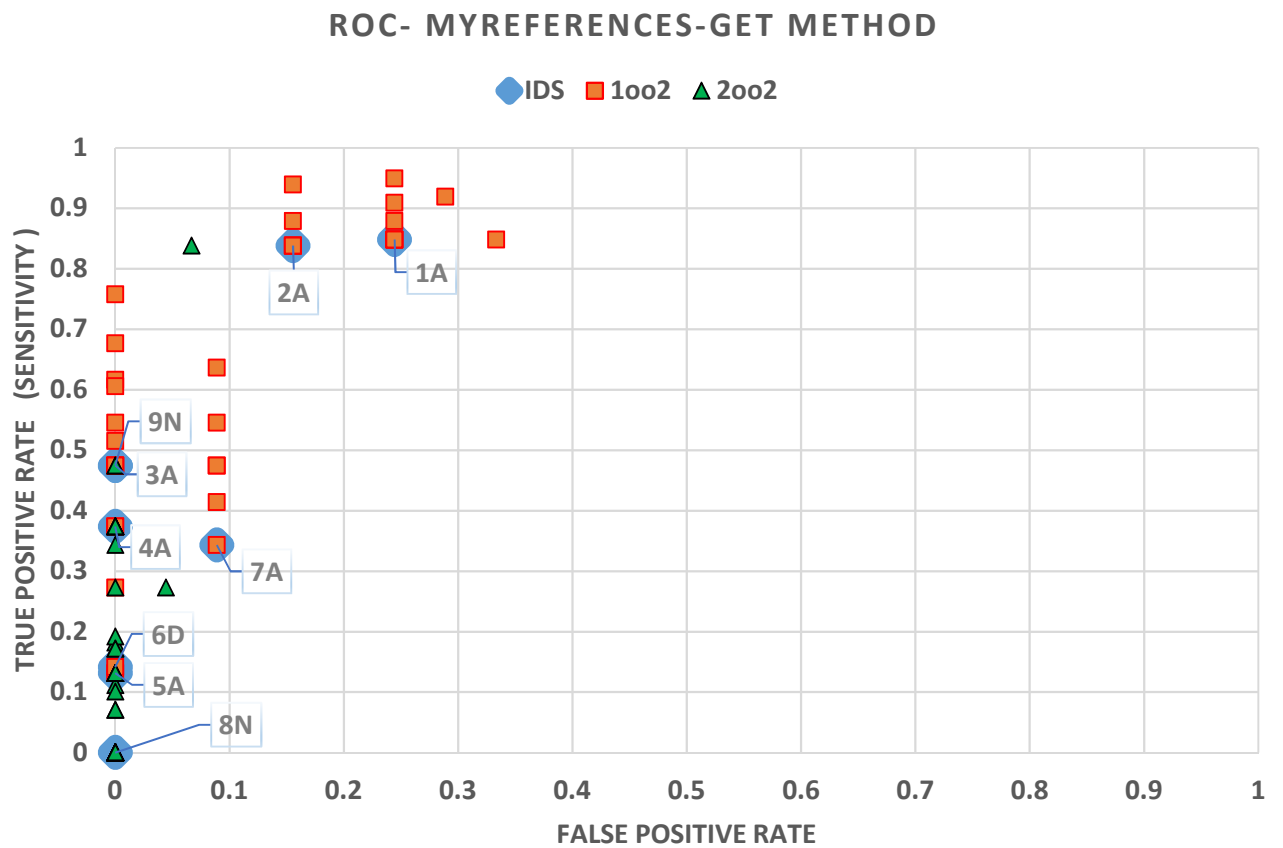
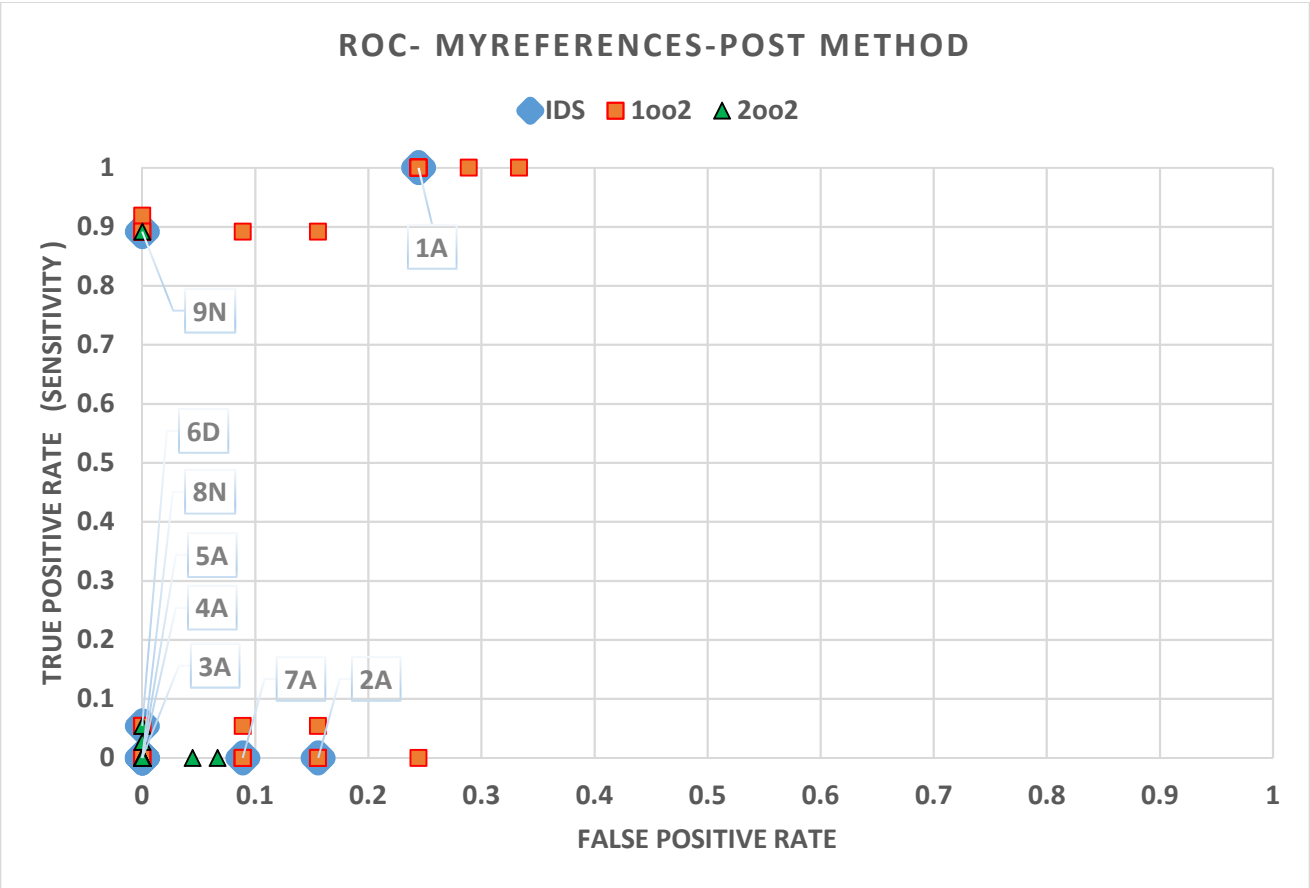


Figure 35 THE ROC PLOT SHOWING THE INDIVIDUAL IDSS, 1002 AND 2002 CONFIGURATIONS FOR MYREFERENCES WHEN ATTACKS WHERE WRITE (POST)



2.2.2.1.2 Accuracy

Figure 36 THE ACCURACY FOR A GIVEN SYSTEM A WHEN PAIRED WITH ANOTHER SYSTEM B FOR MYREFERENCES, THE CHART SHOWS THE INDIVIDUAL IDSs, 1002 AND 2002 CONFIGURATIONS WHEN ATTACKS WHERE READ (GET)

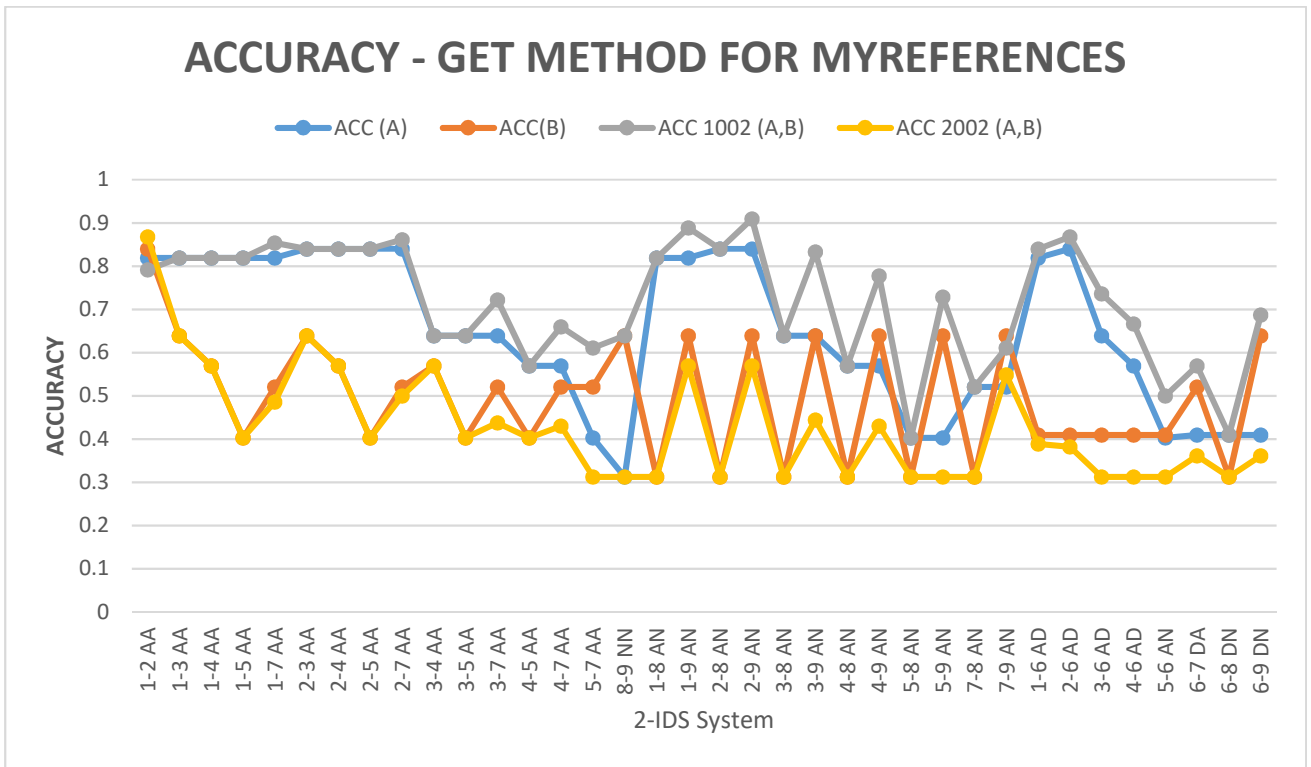


Figure 37 THE ACCURACY DIFFERENCE OF 1002 AND 2002 CONFIGURATIONS, COMPARED WITH THE BEST SINGLE SYSTEM IN THE RESPECTIVE PAIR FOR MYREFERENCES WHEN ATTACKS WHERE READ (GET)

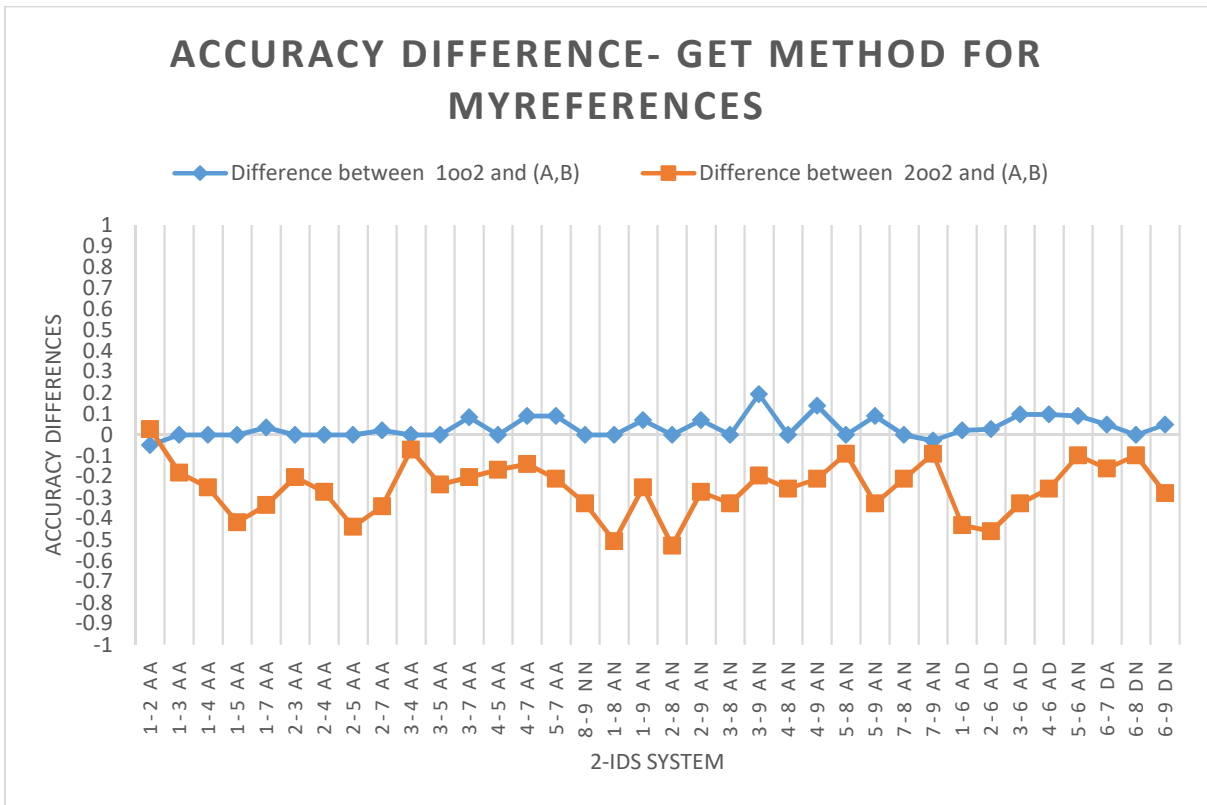


Figure 38 THE ACCURACY DIFFERENCE OF 1002 AND 2002 CONFIGURATIONS, COMAPRED WITH THE BEST SINGLE SYSTEM IN THE RESPECTIVE PAIR FOR MyREFERENCES WHEN ATTACKS WHERE WRITE (POST)

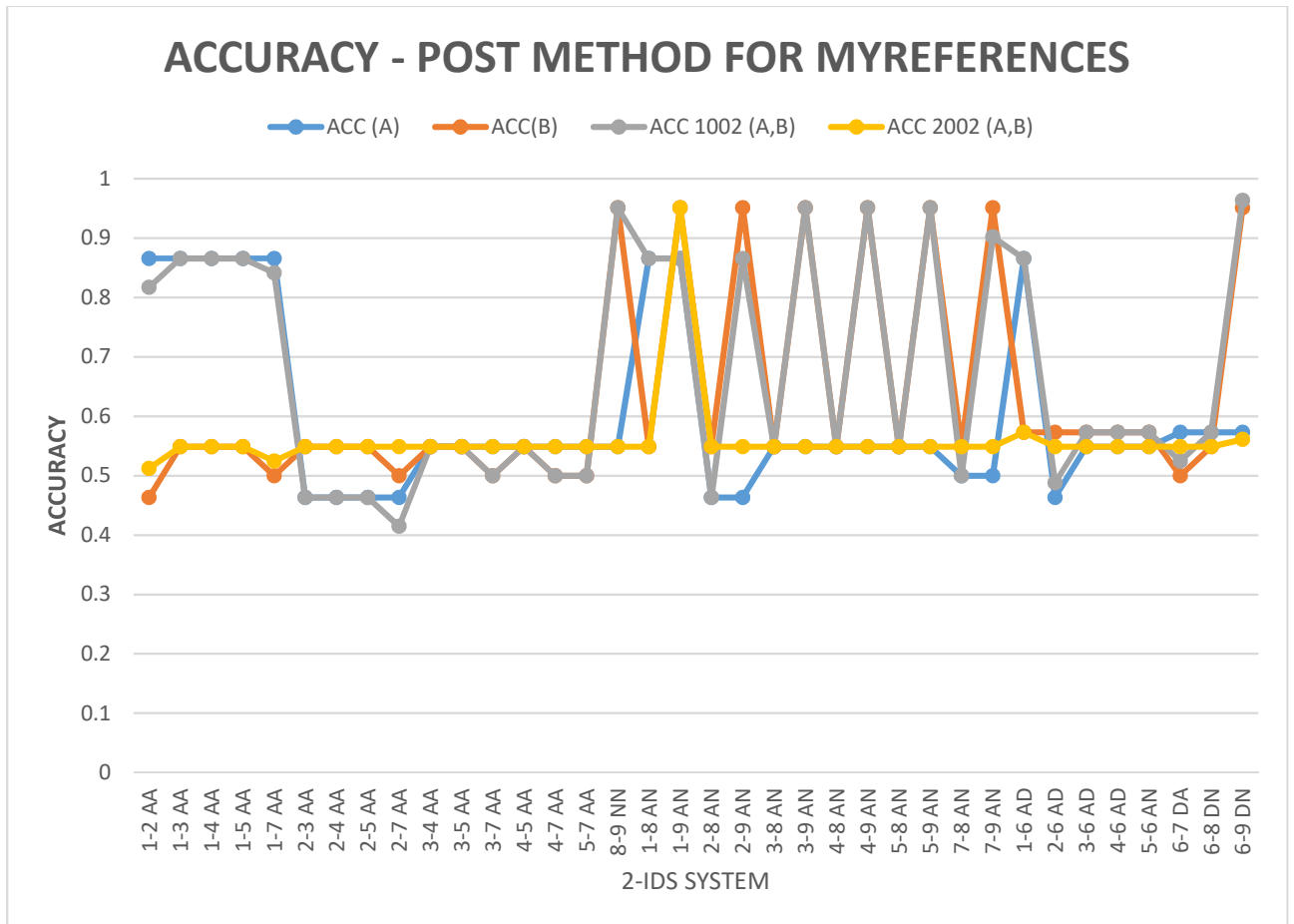
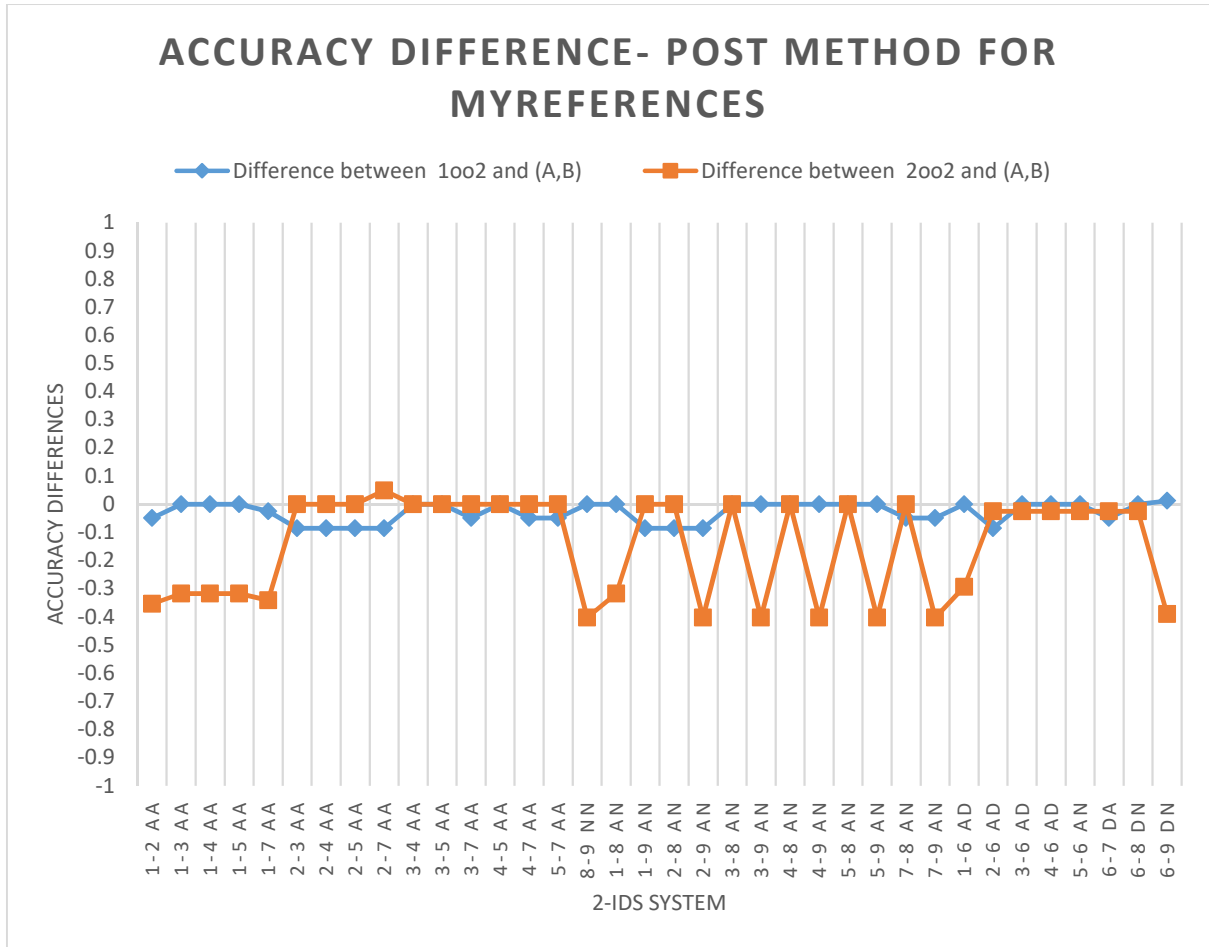


Figure 39 THE ACCURACY DIFFERENCE OF 1002 AND 2002 CONFIGURATIONS, COMAPRED WITH THE BEST SINGLE SYSTEM IN THE RESPECTIVE PAIR FOR MYREFERENCES WHEN ATTACKS WHERE WRITE (POST)



2.2.2.1.3 Specificity

Figure 40 THE SPECIFICITY FOR A GIVEN SYSTEM A WHEN PAIRED WITH ANOTHER SYSTEM B FOR MYREFERENCES, THE CHART SHOWS THE INDIVIDUAL IDSs, 1002 AND 2002 CONFIGURATIONS WHEN ATTACKS WHERE READ (GET)

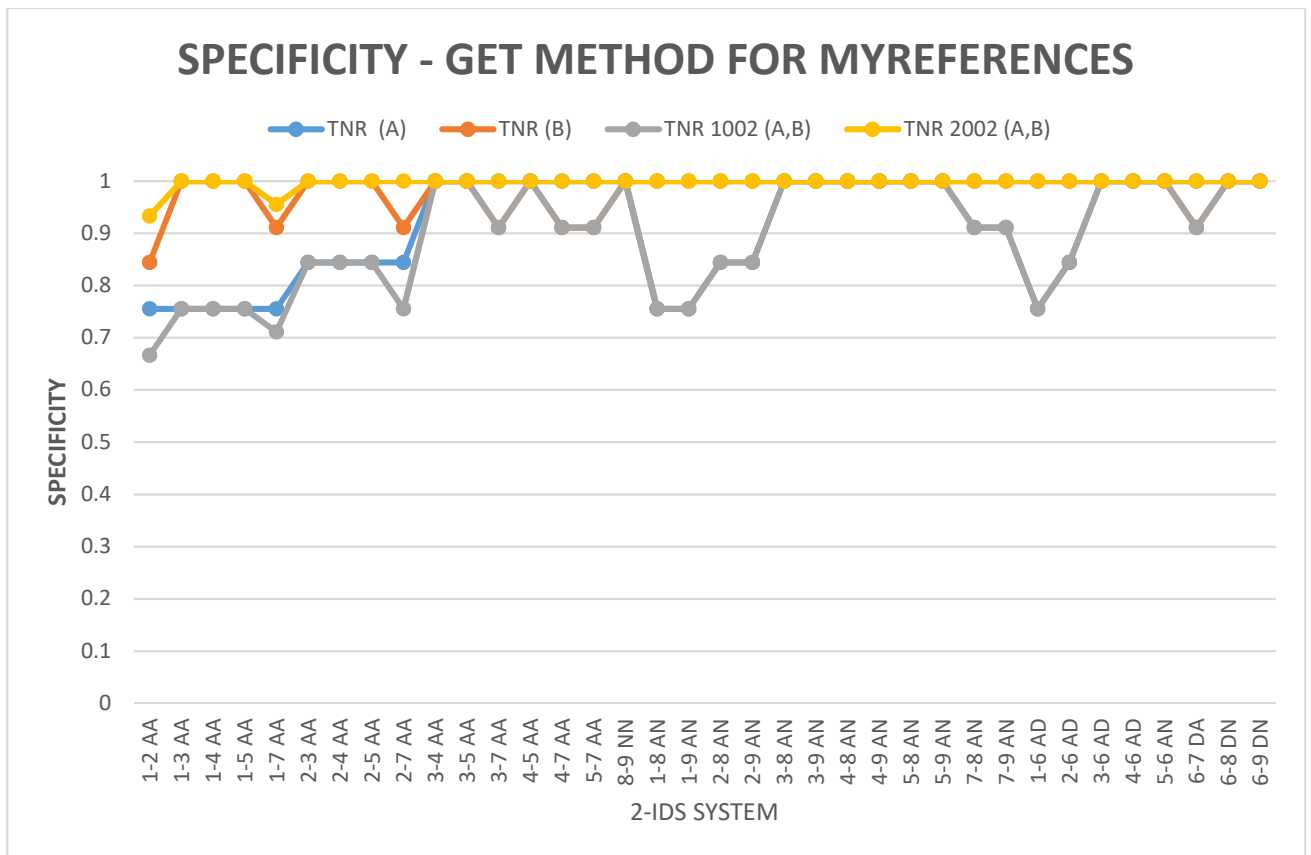


Figure 41 THE SPECIFICITY DIFFERENCE OF 1002 AND 2002 CONFIGURATIONS, COMPARED WITH THE BEST SINGLE SYSTEM IN THE RESPECTIVE PAIR FOR MYREFERENCES WHEN ATTACKS WHERE READ (GET)

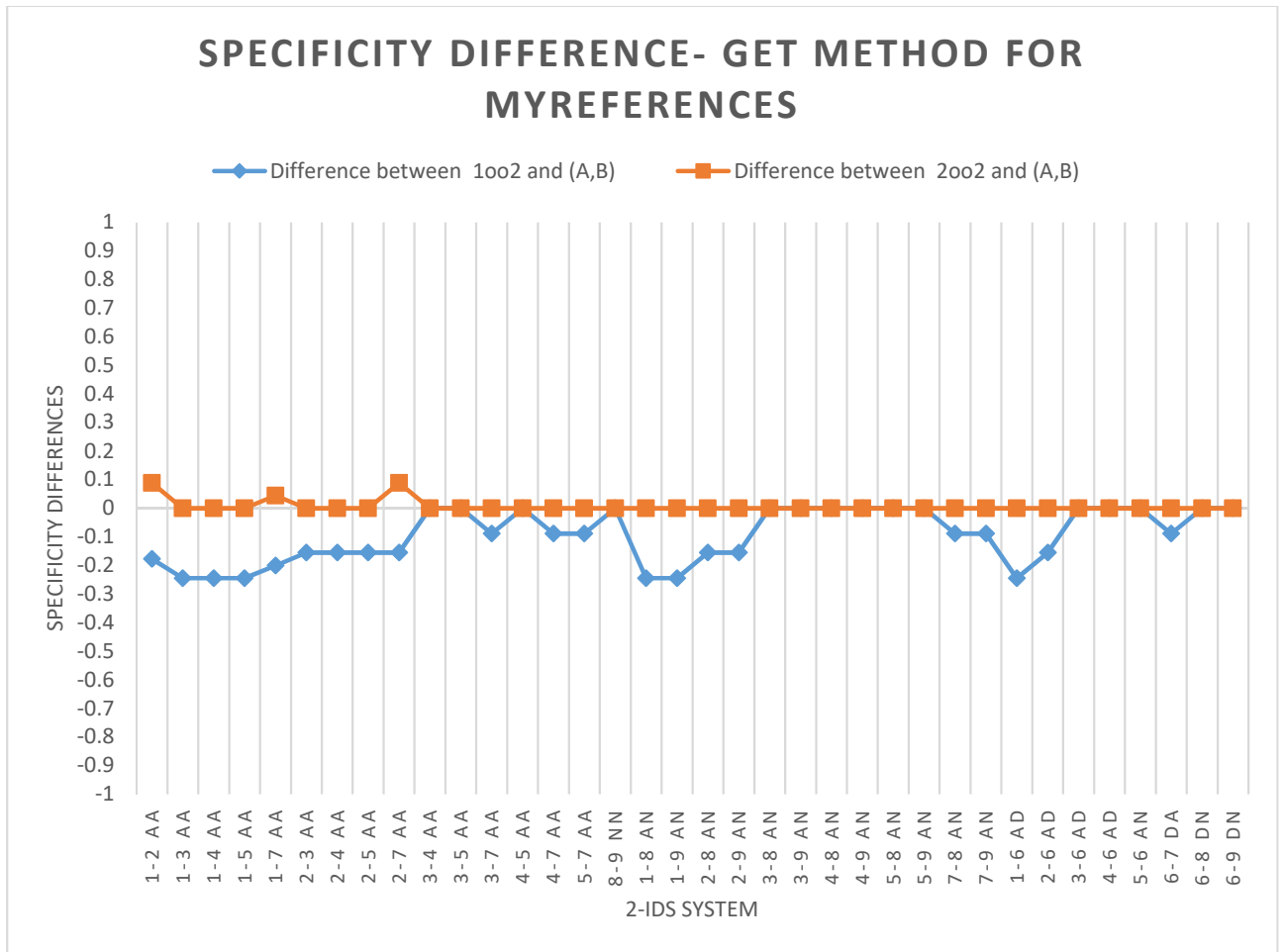


Figure 42 THE SPECIFICITY FOR A GIVEN SYSTEM A WHEN PAIRED WITH ANOTHER SYSTEM B FOR MYREFERENCES, THE CHART SHOWS THE INDIVIDUAL IDSs, 1002 AND 2002 CONFIGURATIONS WHEN ATTACKS WHERE WRITE (POST)

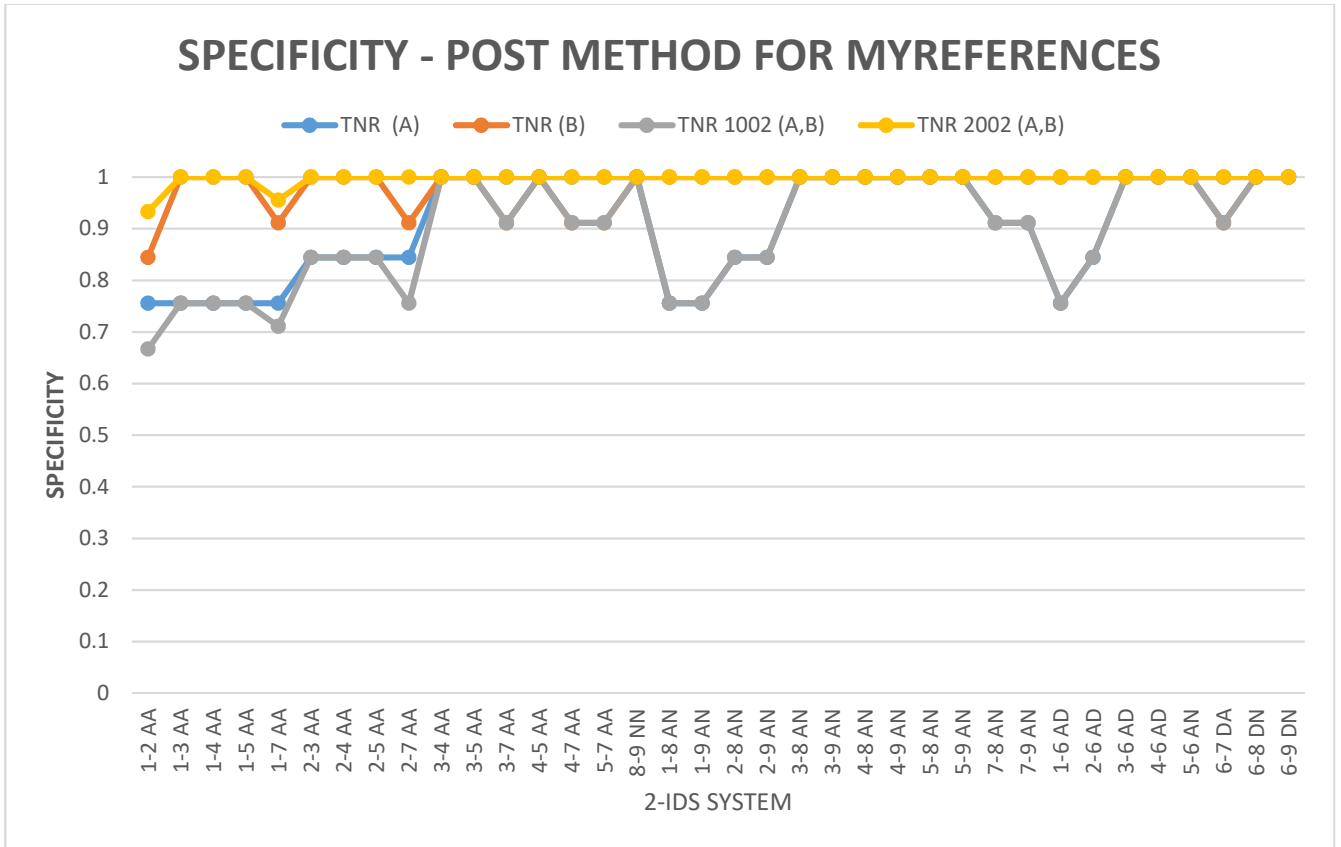
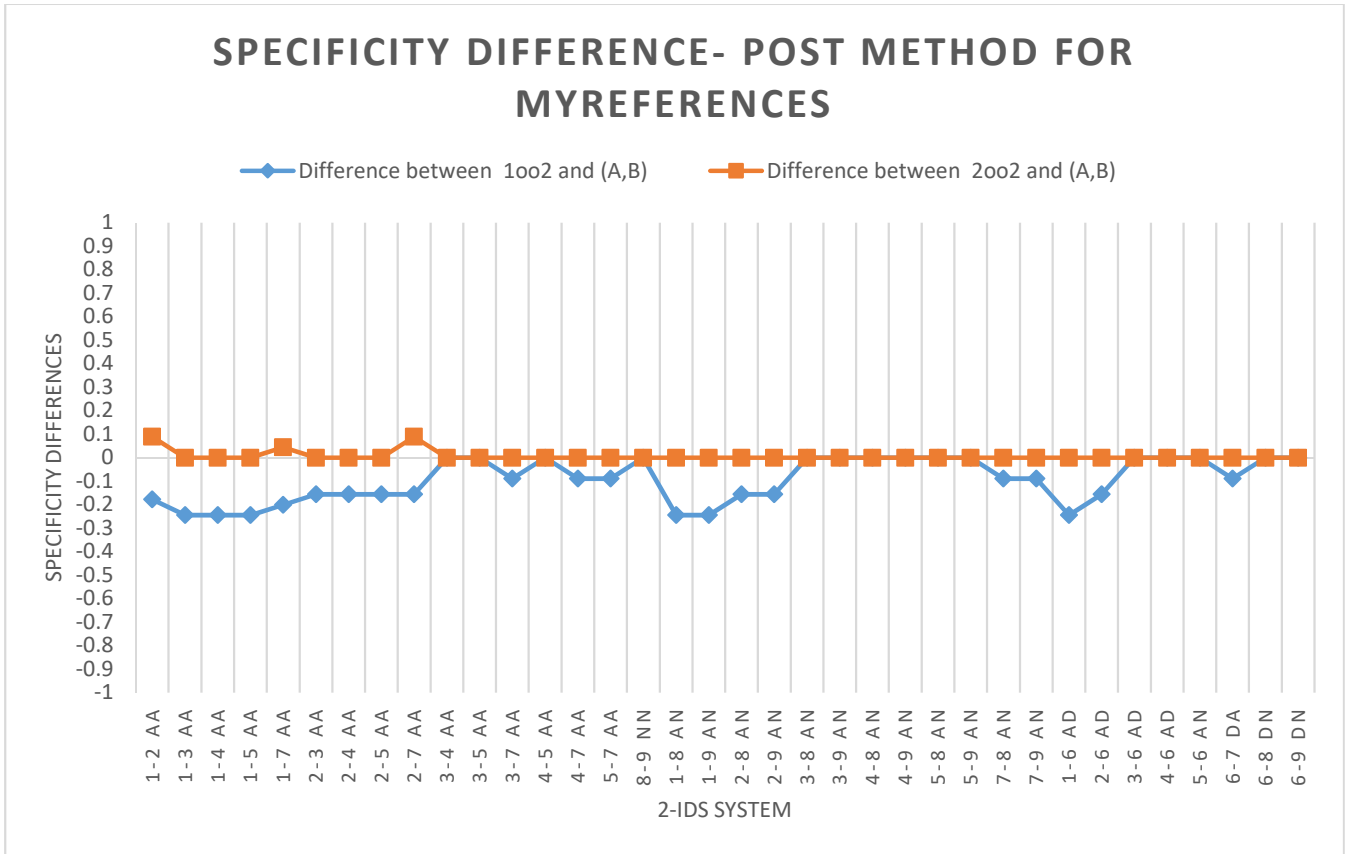


Figure 43 THE SPECIFICITY DIFFERENCE OF 1002 AND 2002 CONFIGURATIONS, COMPARED WITH THE BEST SINGLE SYSTEM IN THE RESPECTIVE PAIR FOR MYREFERENCES WHEN ATTACKS WHERE WRITE (POST)



2.2.2.1.4 Sensitivity

Figure 44 THE SENSITIVITY FOR A GIVEN SYSTEM A WHEN PAIRED WITH ANOTHER SYSTEM B FOR MYREFERENCES, THE CHART SHOWS THE INDIVIDUAL IDSs, 1002 AND 2002 CONFIGURATIONS WHEN ATTACKS WHERE READ (GET)

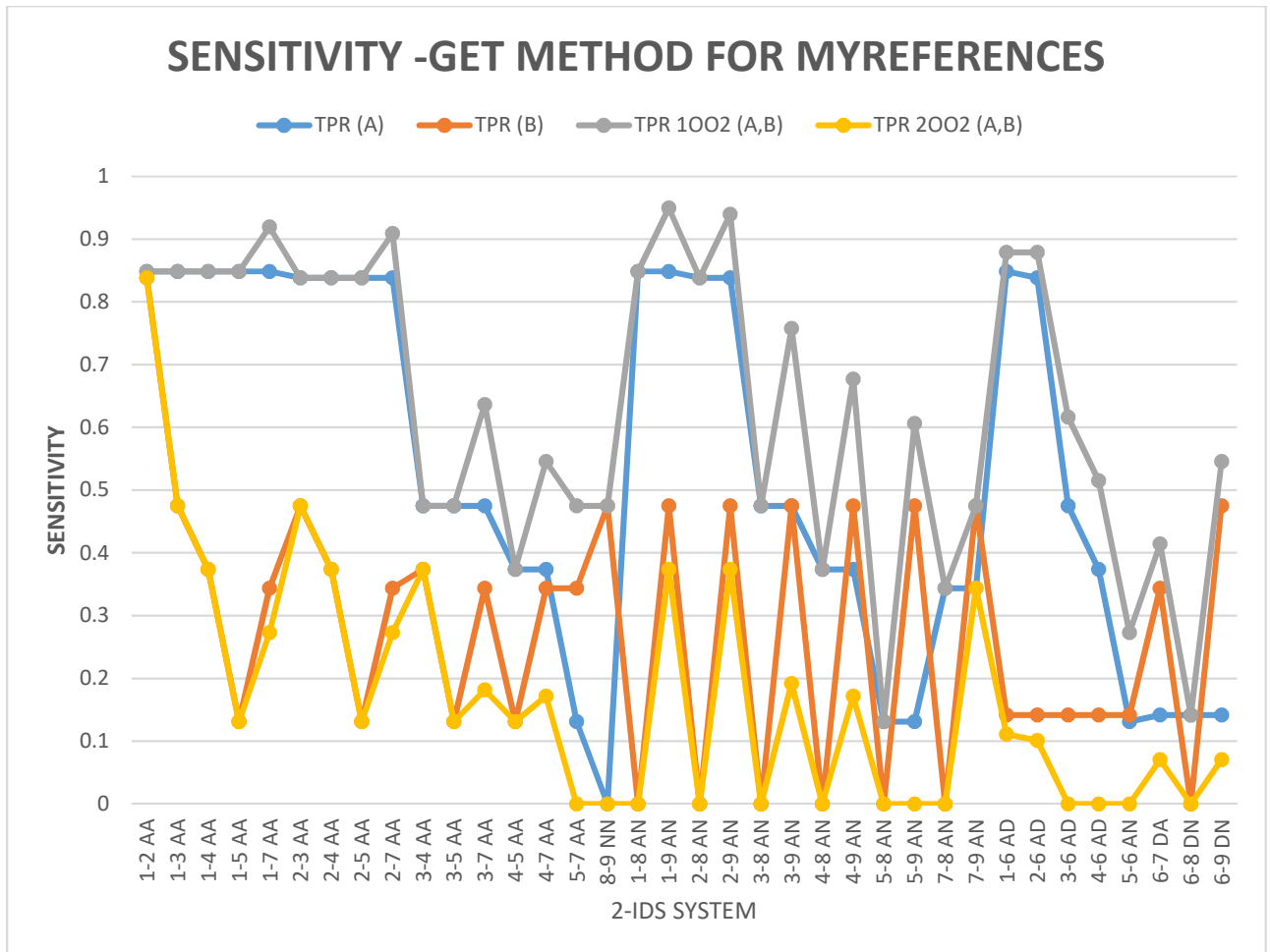


Figure 45 THE SENSITIVITY DIFFERENCE OF 1002 AND 2002 CONFIGURATIONS, COMAPRED WITH THE BEST SINGLE SYSTEM IN THE RESPECTIVE PAIR FOR MyREFERENCES WHEN ATTACKS WHERE READ (GET)

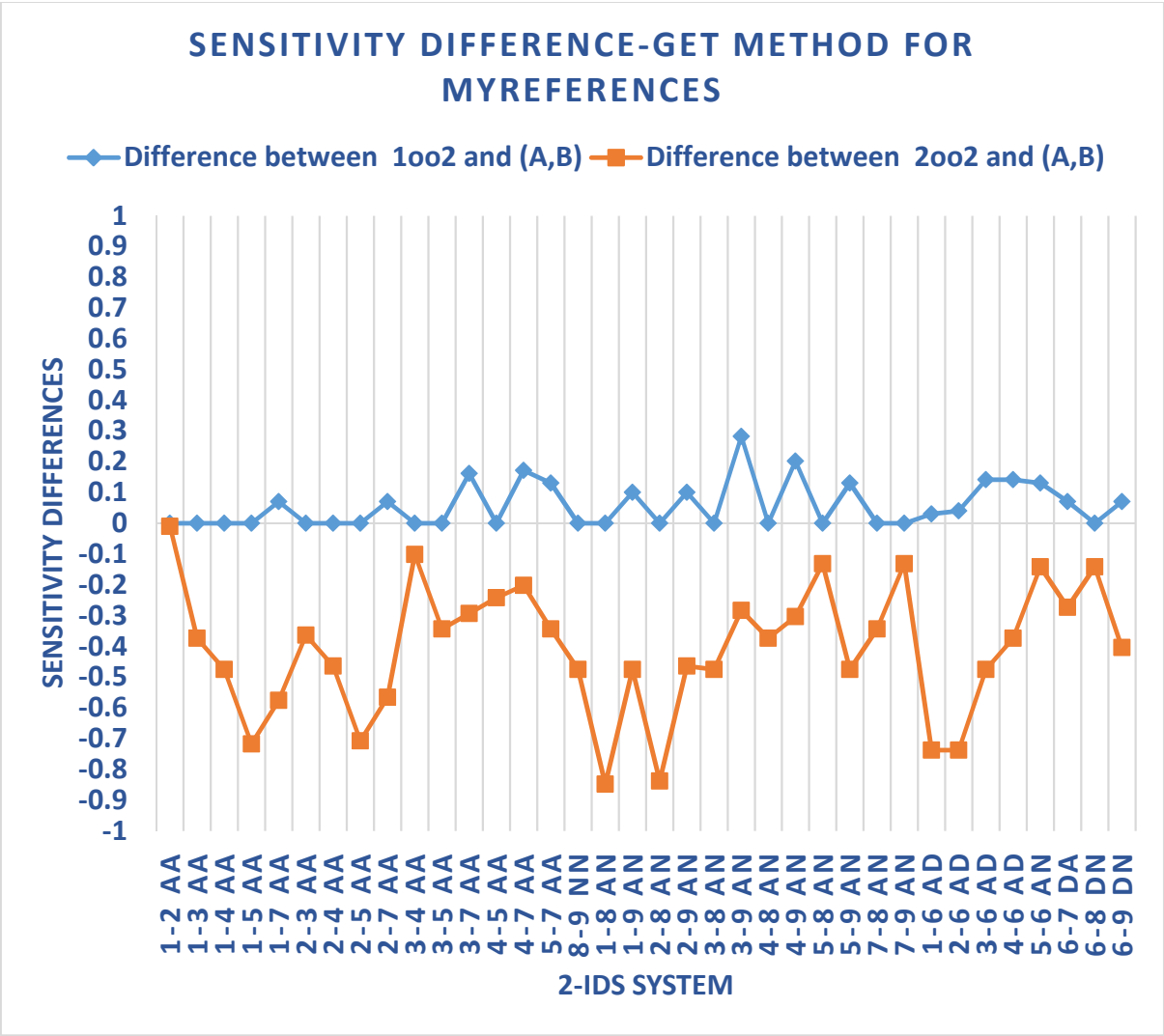


Figure 46 THE SENSITIVITY FOR A GIVEN SYSTEM A WHEN PAIRED WITH ANOTHER SYSTEM B FOR MYREFERENCES, THE CHART SHOWS THE INDIVIDUAL IDSs, 1002 AND 2002 CONFIGURATIONS WHEN ATTACKS WHERE WRITE (POST)

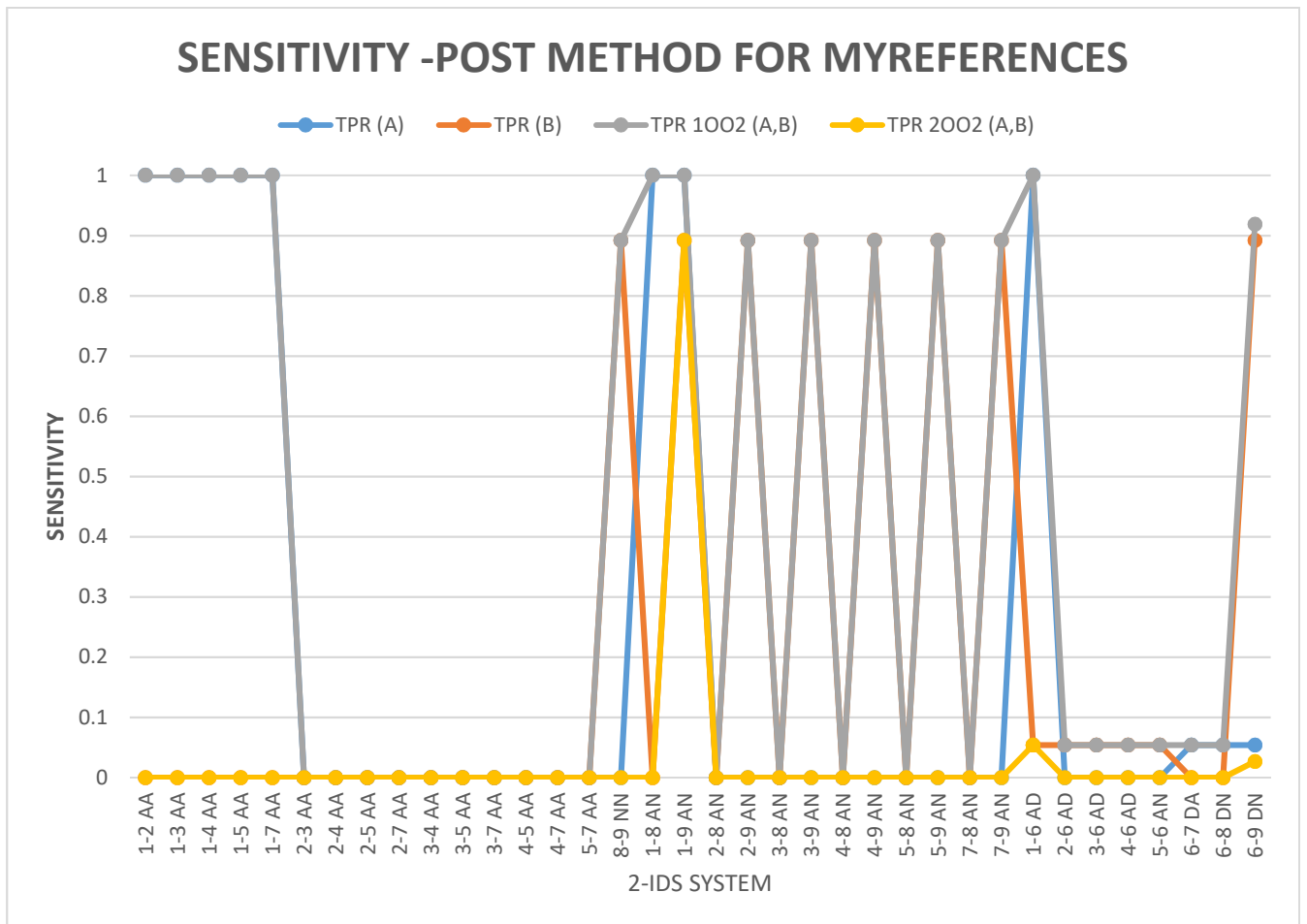
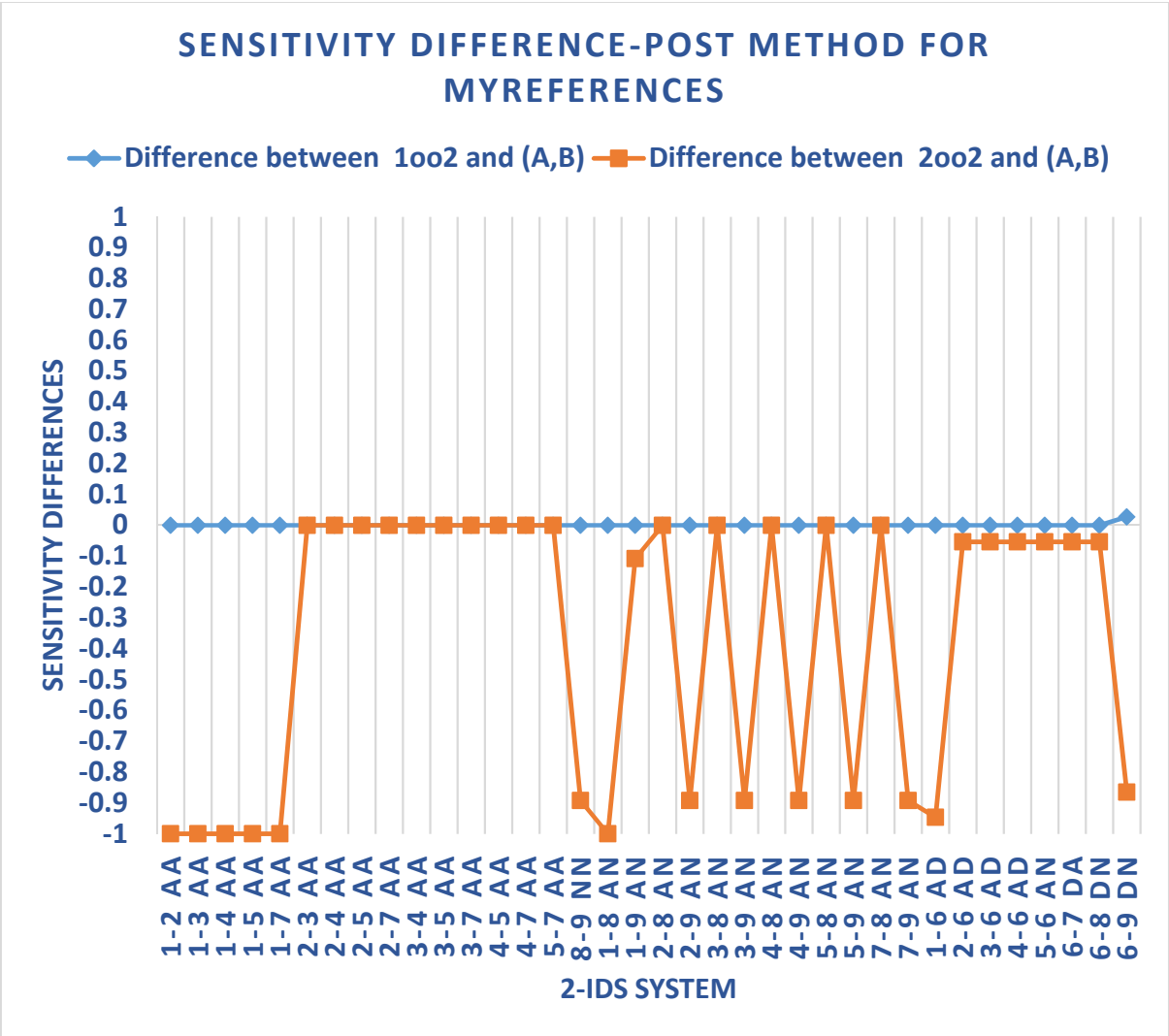


Figure 47 THE SENSITIVITY DIFFERENCE OF 1002 AND 2002 CONFIGURATIONS, COMAPRED WITH THE BEST SINGLE SYSTEM IN THE RESPECTIVE PAIR FOR MyREFERENCES WHEN ATTACKS WHERE WRITE (POST)



2.2.2.2 PhpBB

2.2.2.2.1 ROC

Figure 48 THE ROC PLOT SHOWING THE INDIVIDUAL IDSs, 1002 AND 2002 CONFIGURATIONS FOR PHPBB WHEN ATTACKS WHERE READ (GET)

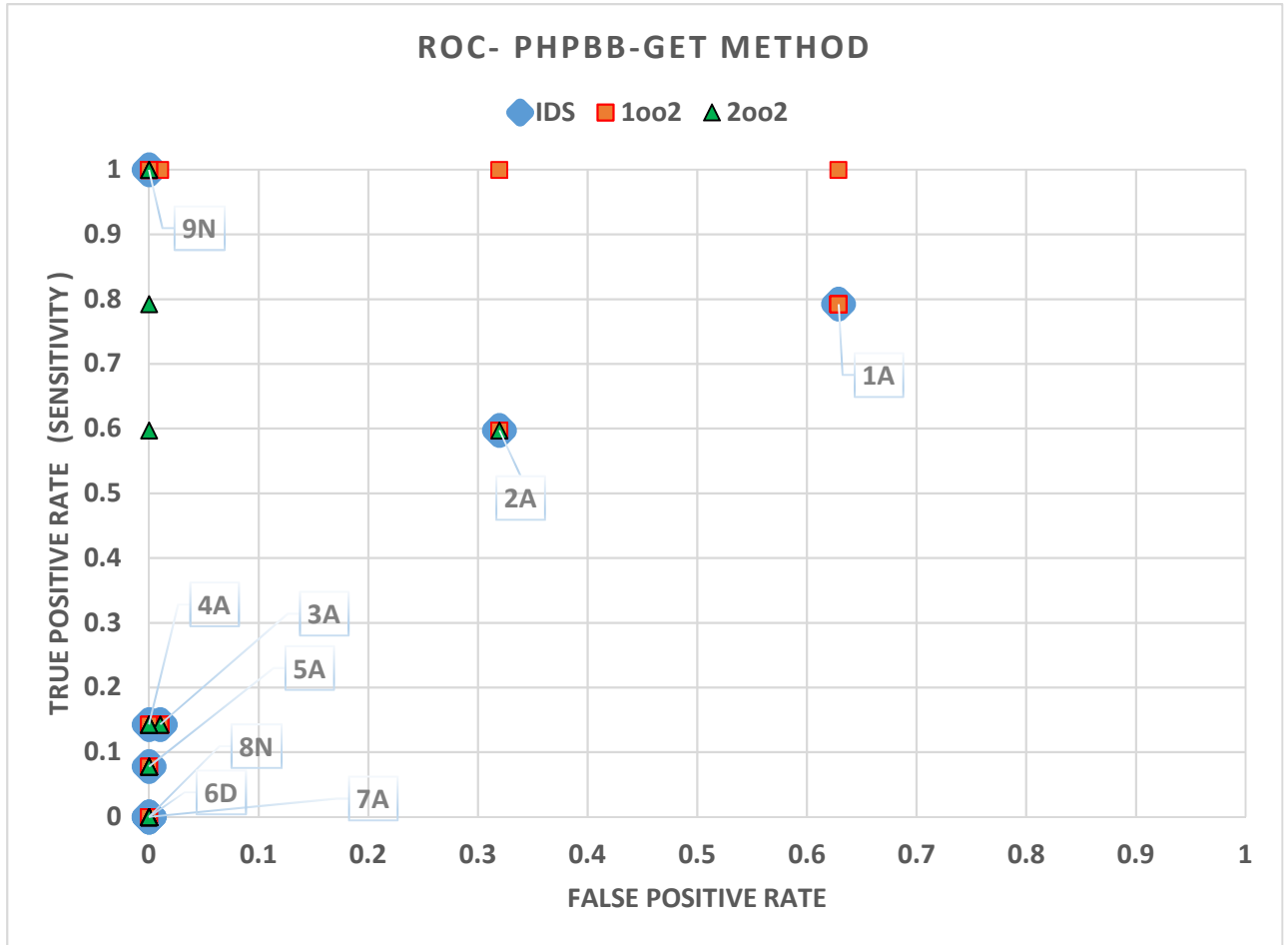
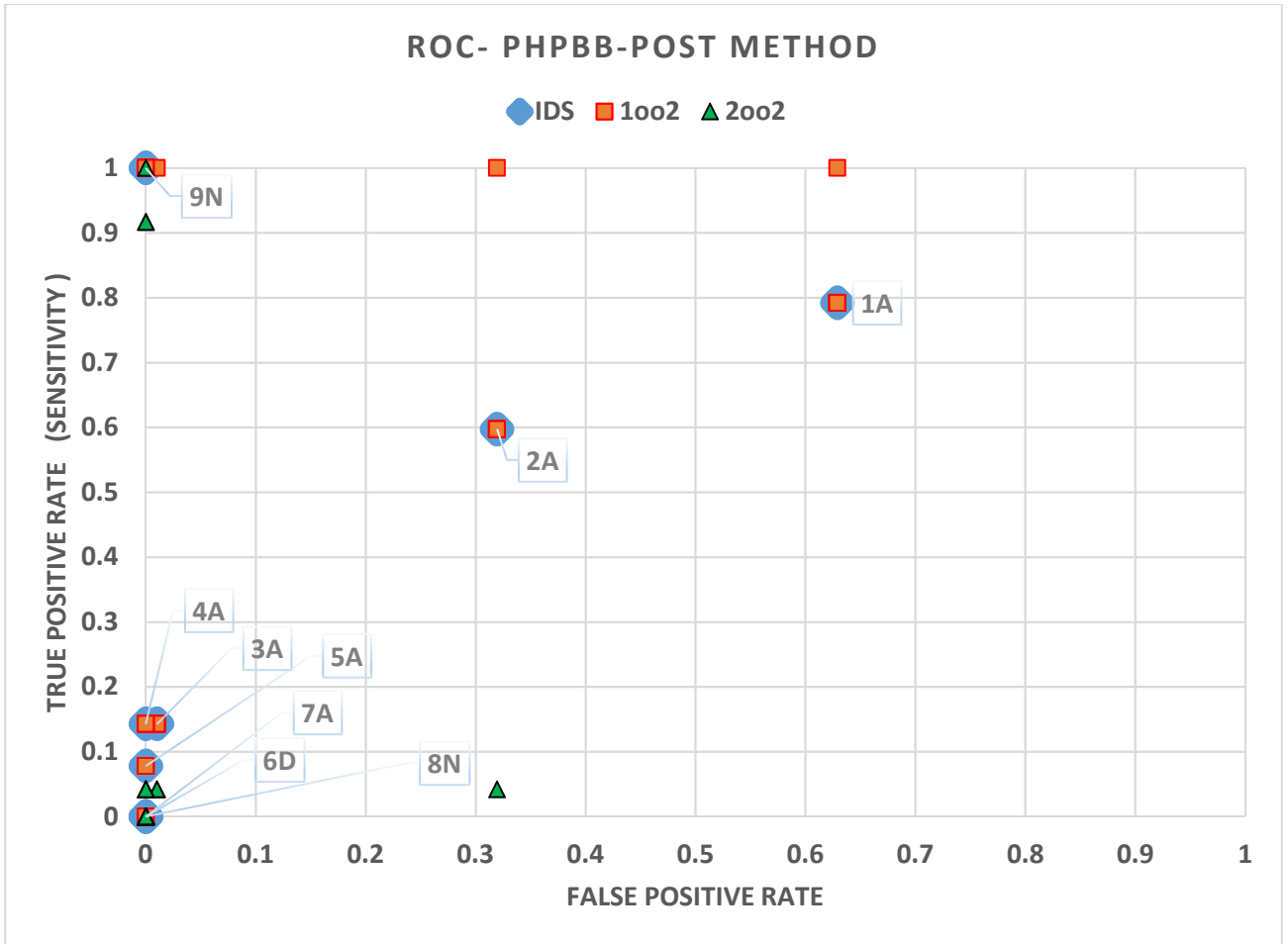


Figure 49 THE ROC PLOT SHOWING THE INDIVIDUAL IDSS, 1002 AND 2002 CONFIGURATIONS FOR PHPBB WHEN ATTACKS WHERE WRITE (POST)



2.2.2.2.2 Accuracy

Figure 50 THE ACCURACY FOR A GIVEN SYSTEM A WHEN PAIRED WITH ANOTHER SYSTEM B FOR PHPBB, THE CHART SHOWS THE INDIVIDUAL IDSs, 1002 AND 2002 CONFIGURATIONS WHEN ATTACKS WHERE READ (GET)

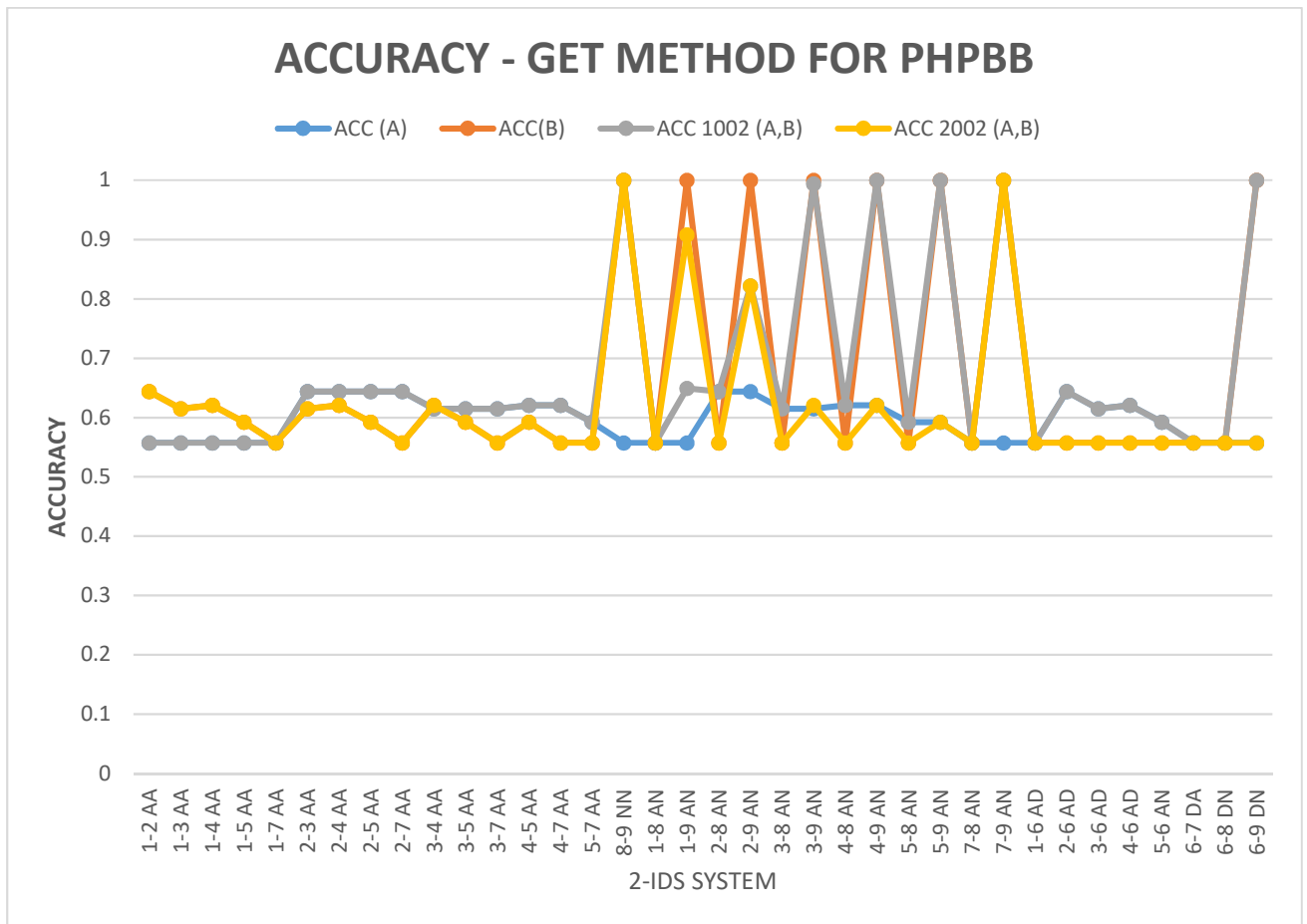


Figure 51 THE ACCURACY DIFFERENCE OF 1002 AND 2002 CONFIGURATIONS, COMPARED WITH THE BEST SINGLE SYSTEM IN THE RESPECTIVE PAIR FOR PHPBB WHEN ATTACKS WHERE READ (GET)

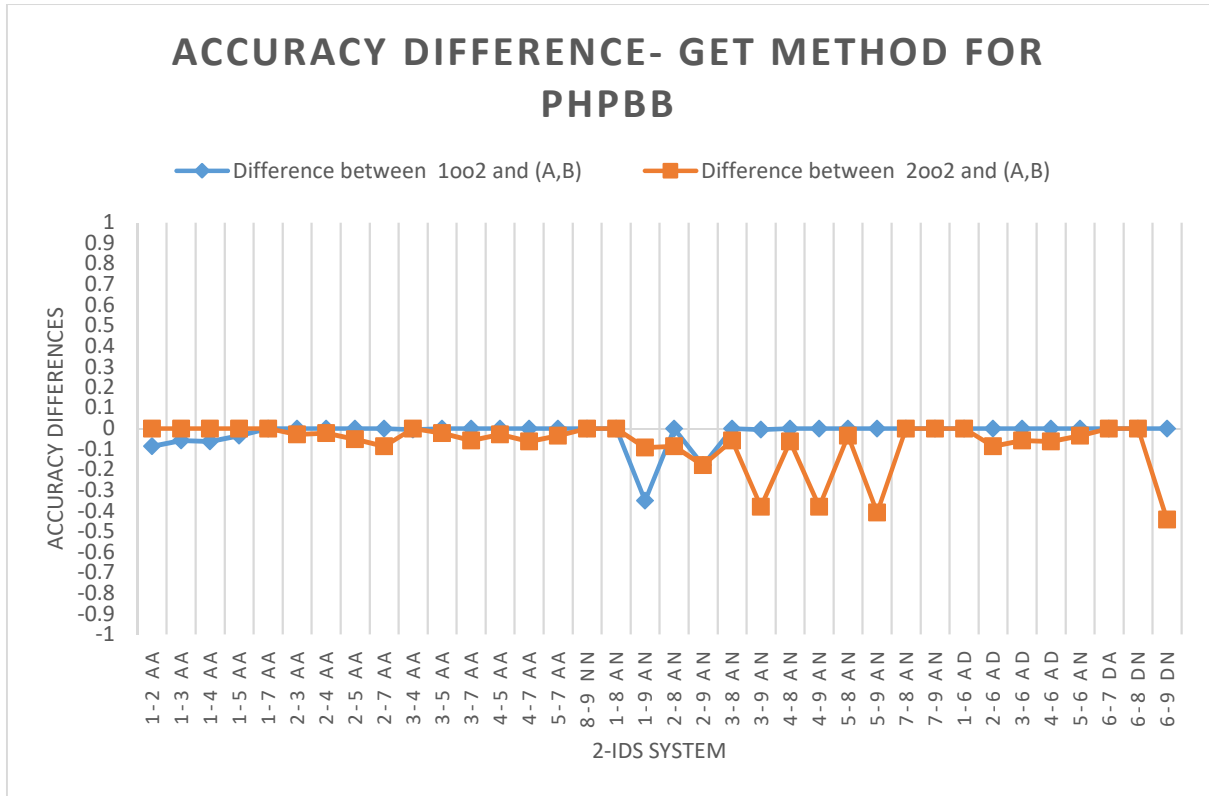


Figure 52 THE ACCURACY FOR A GIVEN SYSTEM A WHEN PAIRED WITH ANOTHER SYSTEM B FOR PHPBB, THE CHART SHOWS THE INDIVIDUAL IDSs, 1002 AND 2002 CONFIGURATIONS WHEN ATTACKS WHERE WRITE (POST)

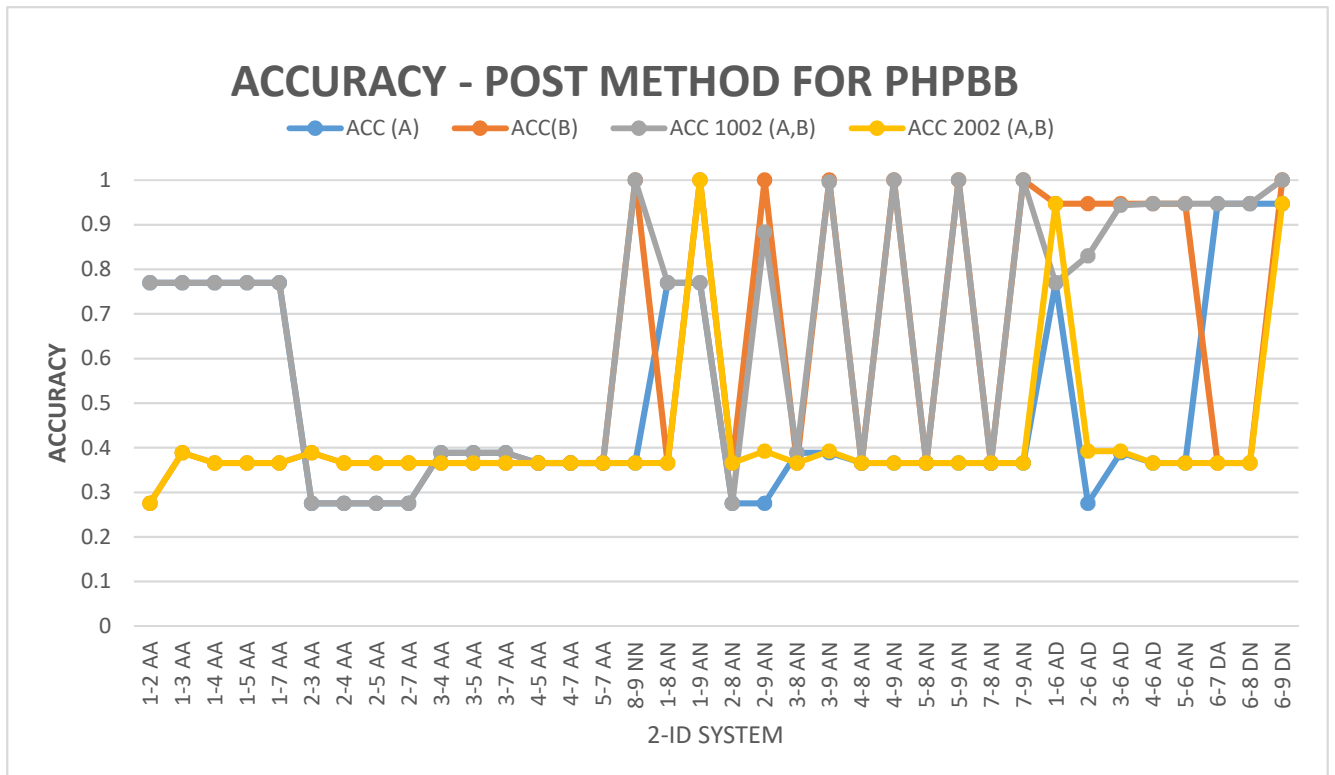
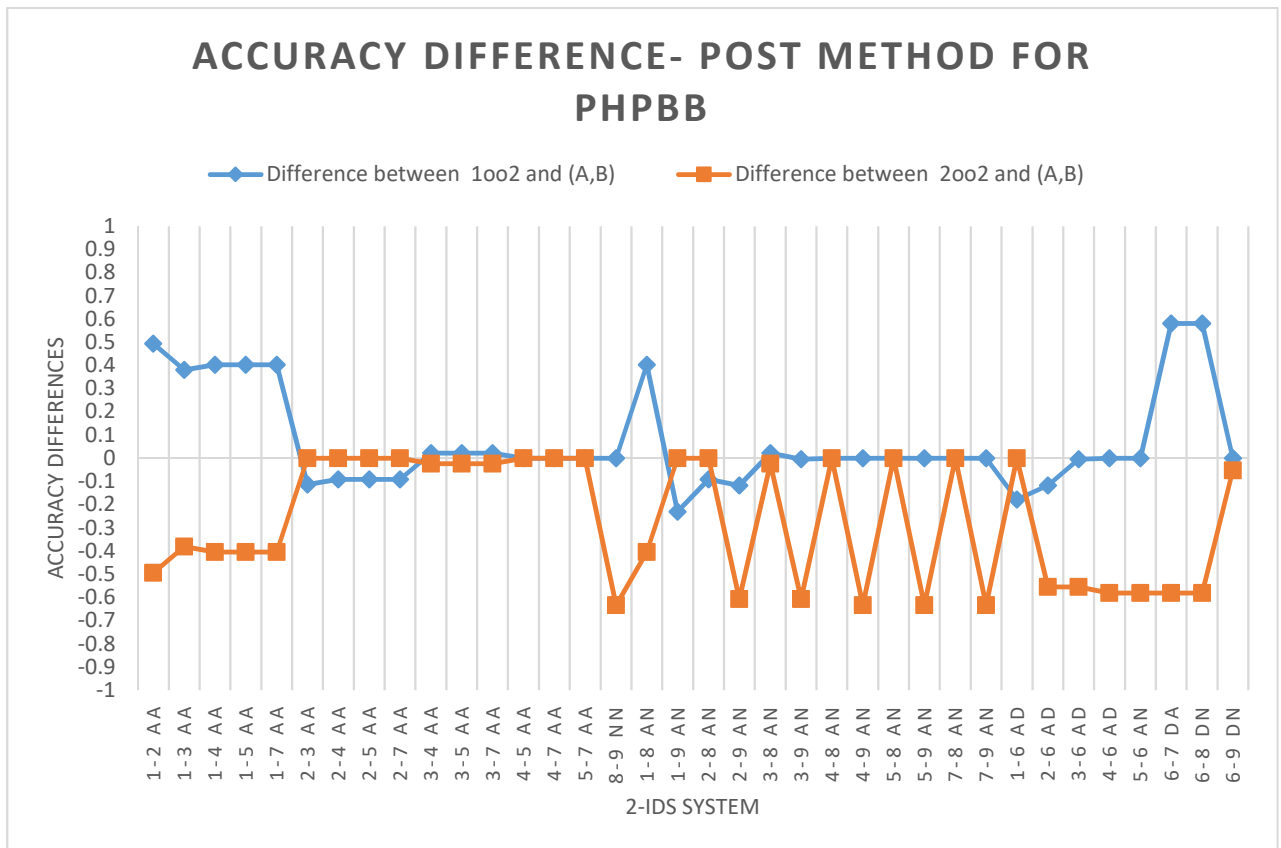


Figure 53 THE ACCURACY DIFFERENCE OF 1002 AND 2002 CONFIGURATIONS, COMPARED WITH THE BEST SINGLE SYSTEM IN THE RESPECTIVE PAIR FOR PHPBB WHEN ATTACKS WHERE WRITE (POST)



2.2.2.2.3 Specificity

Figure 54 THE SPECIFICITY FOR A GIVEN SYSTEM A WHEN PAIRED WITH ANOTHER SYSTEM B FOR PHPBB, THE CHART SHOWS THE INDIVIDUAL IDSs, 1002 AND 2002 CONFIGURATIONS WHEN ATTACKS WHERE READ (GET)

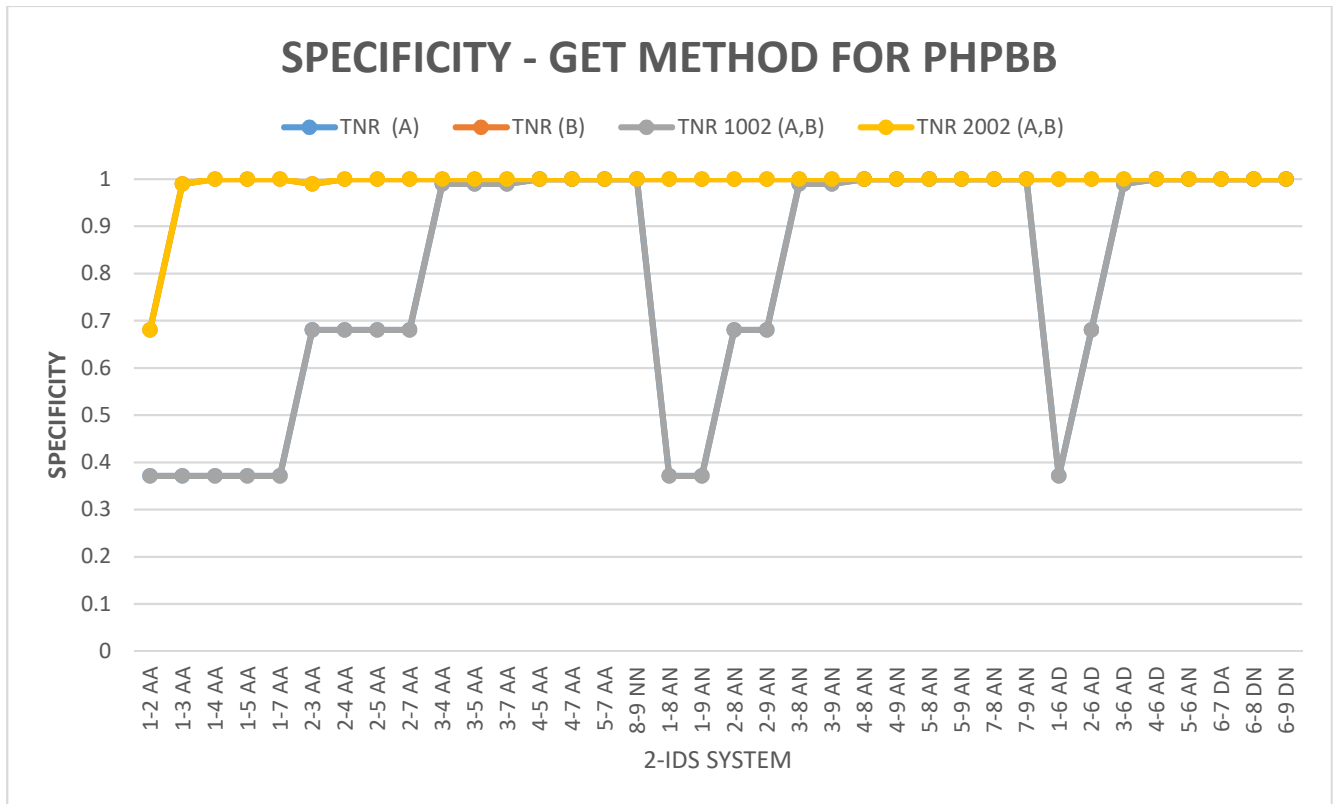


Figure 55 THE SPECIFICITY DIFFERENCE OF 1002 AND 2002 CONFIGURATIONS, COMAPRED WITH THE BEST SINGLE SYSTEM IN THE RESPECTIVE PAIR FOR PHPBB WHEN ATTACKS WHERE READ (GET)

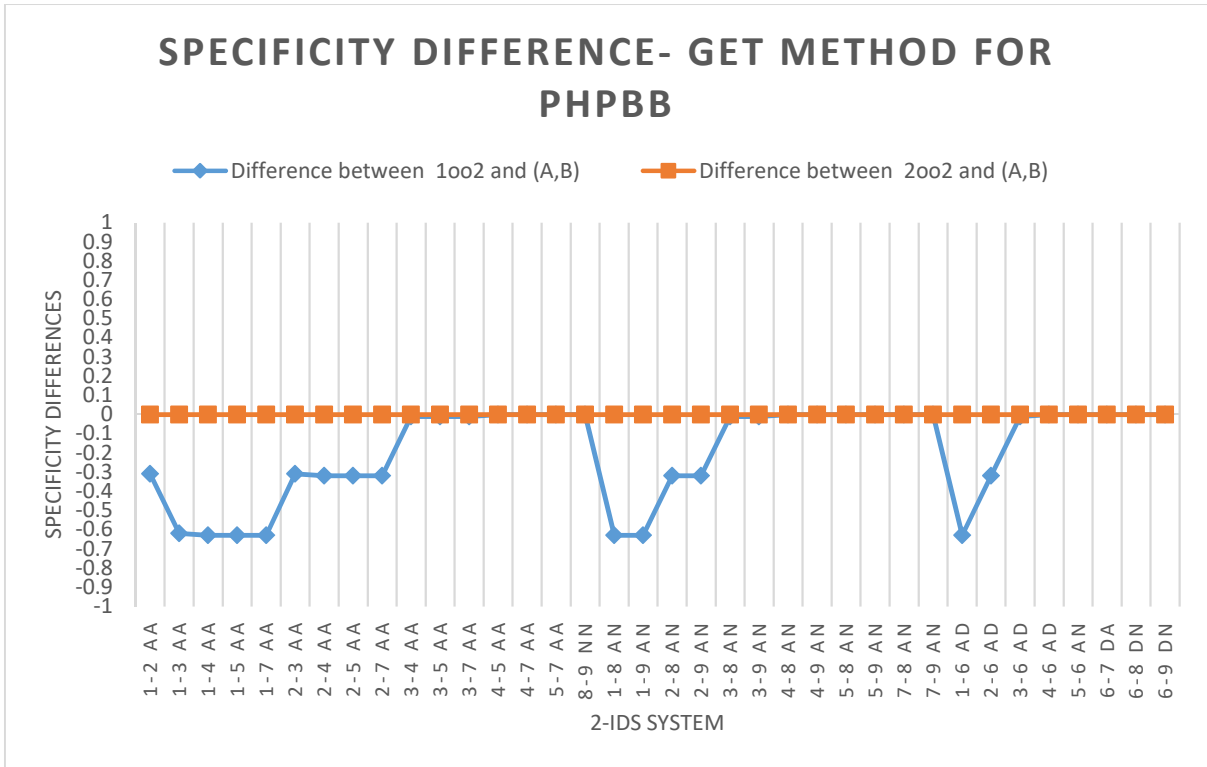


Figure 56 THE SPECIFICITY FOR A GIVEN SYSTEM A WHEN PAIRED WITH ANOTHER SYSTEM B FOR PHPBB, THE CHART SHOWS THE INDIVIDUAL IDSs, 1002 AND 2002 CONFIGURATIONS WHEN ATTACKS WHERE WRITE (POST)

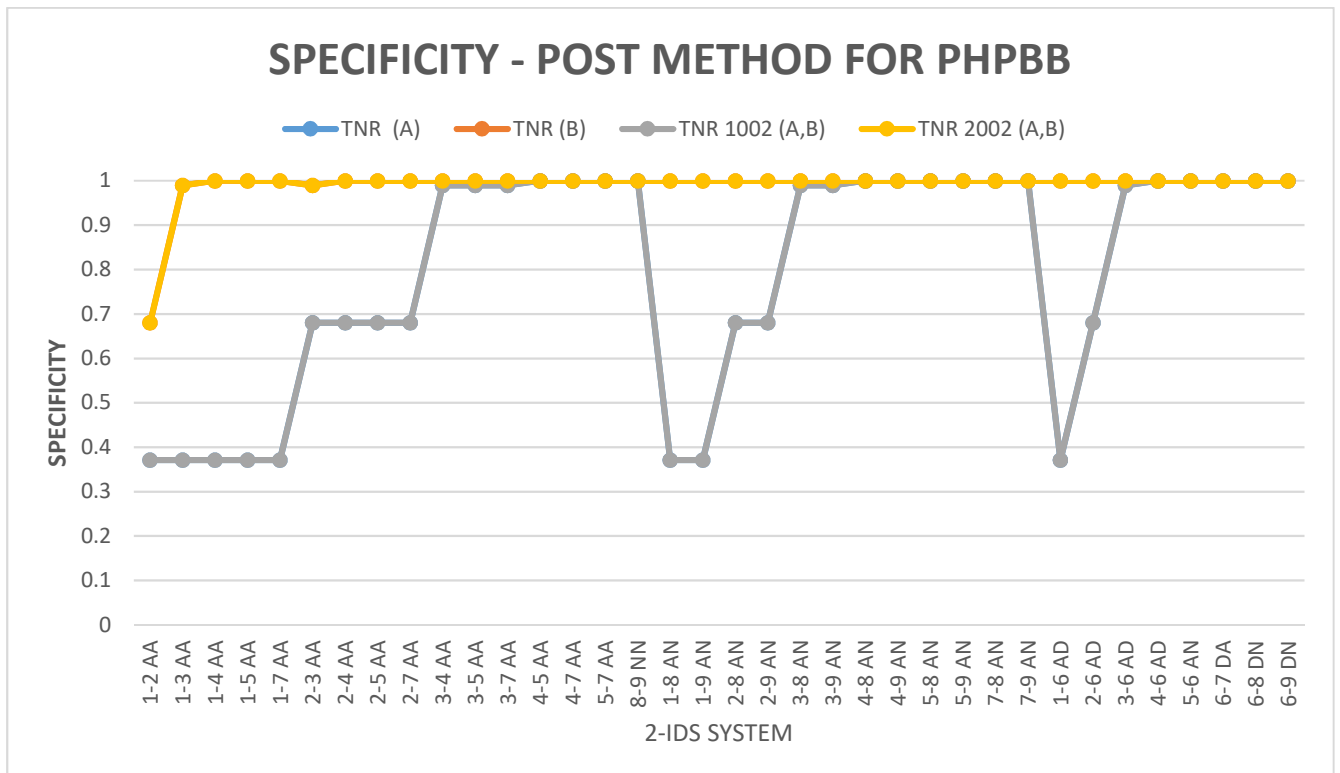
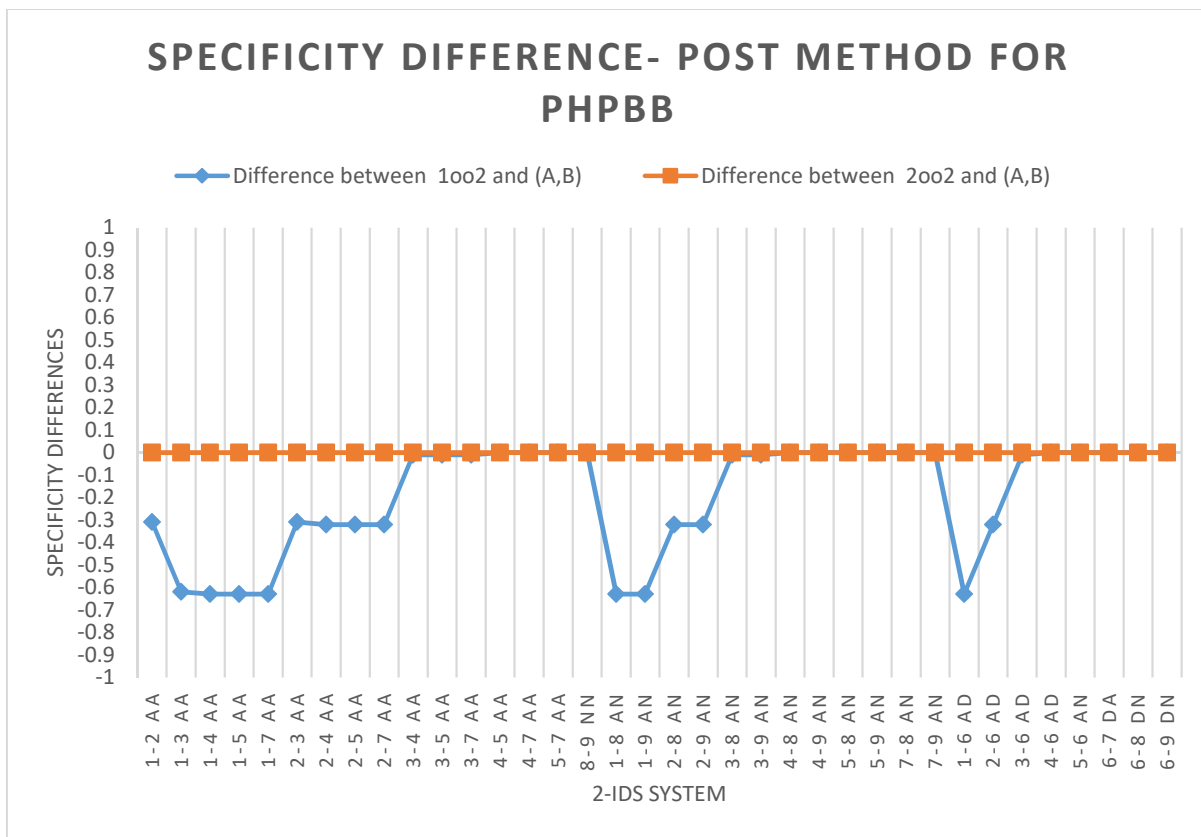


Figure 57 THE SPECIFICITY DIFFERENCE OF 1002 AND 2002 CONFIGURATIONS, COMAPRED WITH THE BEST SINGLE SYSTEM IN THE RESPECTIVE PAIR FOR PHPBB WHEN ATTACKS WHERE WRITE (POST)



2.2.2.2.4 Sensitivity

Figure 58 THE SENSITIVITY FOR A GIVEN SYSTEM A WHEN PAIRED WITH ANOTHER SYSTEM B FOR PHPBB, THE CHART SHOWS THE INDIVIDUAL IDSs, 1002 AND 2002 CONFIGURATIONS WHEN ATTACKS WHERE READ (GET)

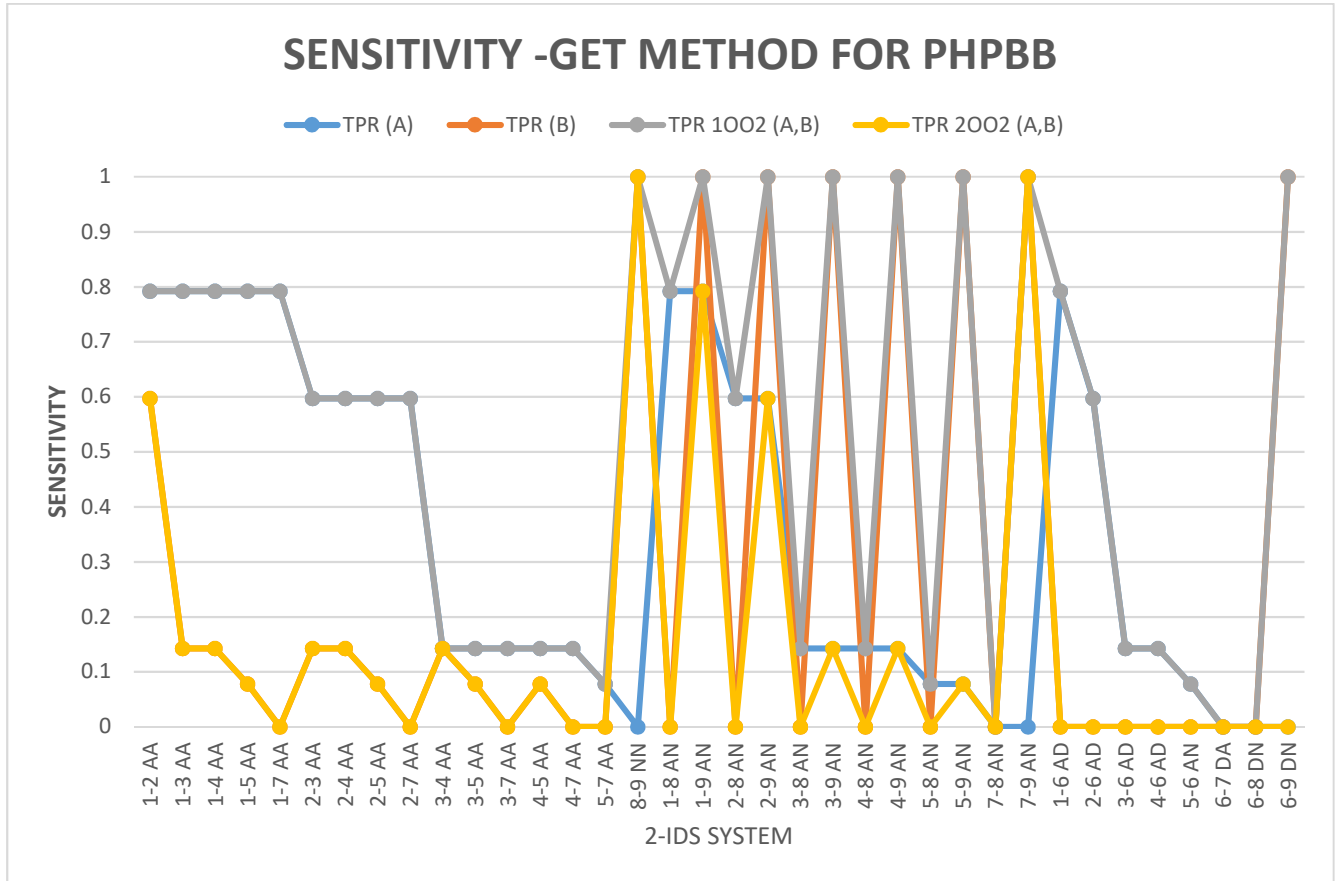


Figure 59 THE SENSITIVITY DIFFERENCE OF 1002 AND 2002 CONFIGURATIONS, COMAPRED WITH THE BEST SINGLE SYSTEM IN THE RESPECTIVE PAIR FOR PHPBB WHEN ATTACKS WHERE READ (GET)

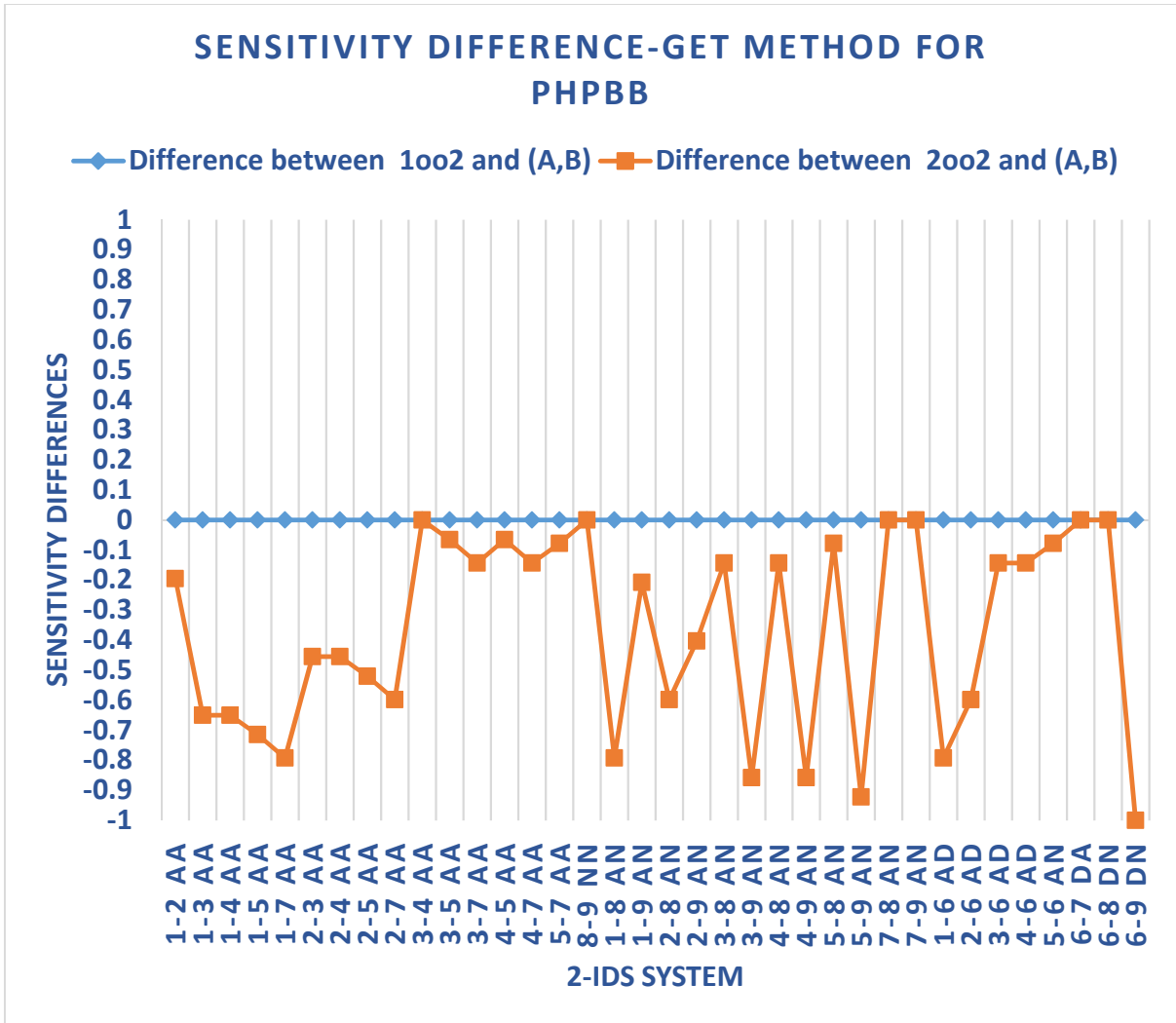


Figure 60 THE SENSITIVITY FOR A GIVEN SYSTEM A WHEN PAIRED WITH ANOTHER SYSTEM B FOR PHPBB, THE CHART SHOWS THE INDIVIDUAL IDSs, 1002 AND 2002 CONFIGURATIONS WHEN ATTACKS WHERE WRITE (POST)

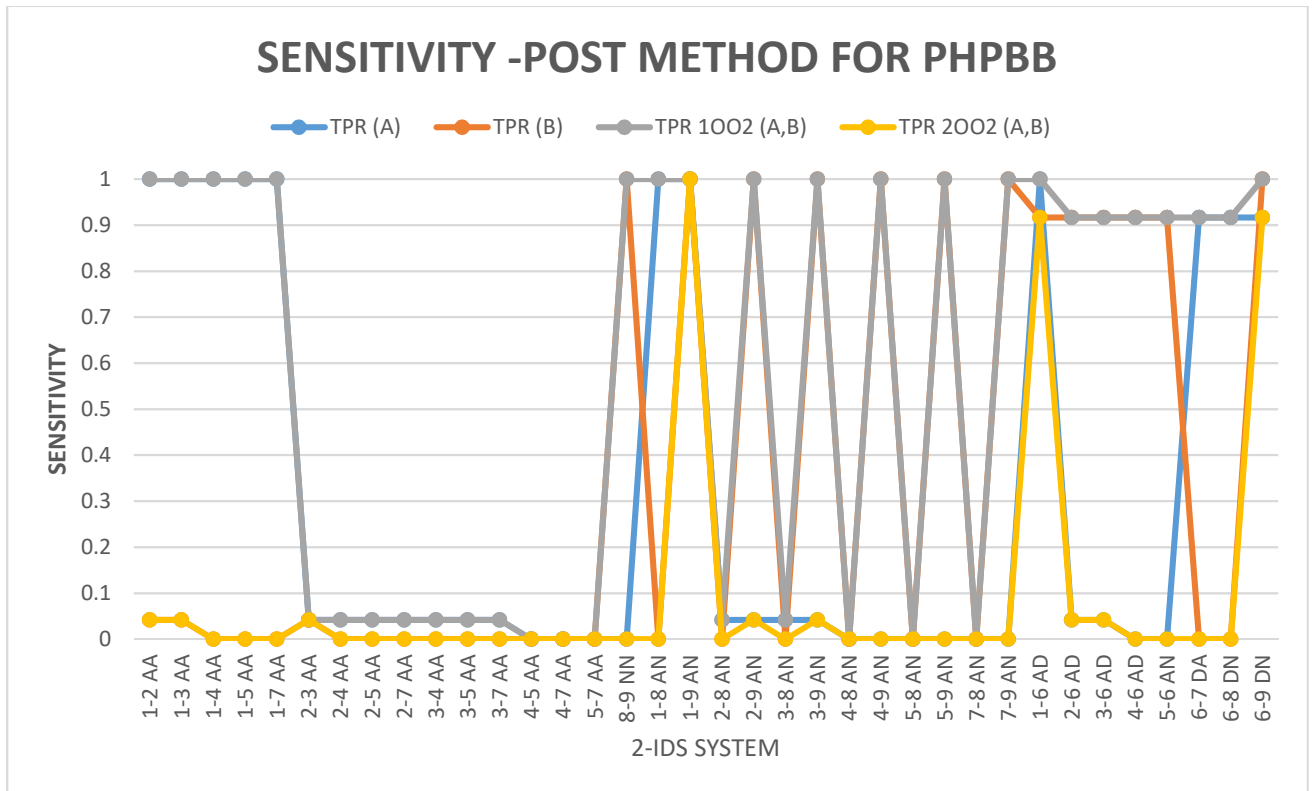
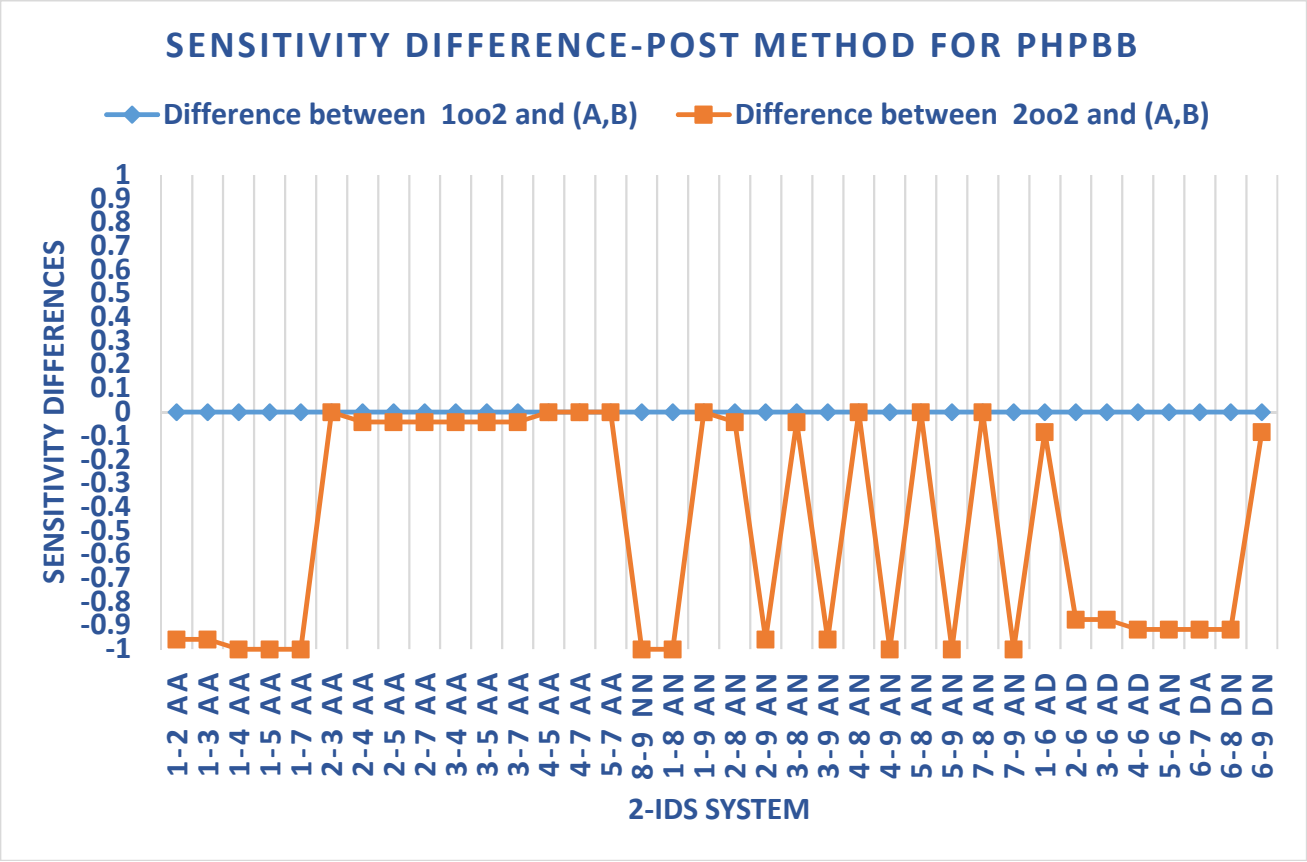


Figure 61 THE SENSITIVITY DIFFERENCE OF 1002 AND 2002 CONFIGURATIONS, COMAPRED WITH THE BEST SINGLE SYSTEM IN THE RESPECTIVE PAIR FOR PHPBB WHEN ATTACKS WHERE WRITE (POST)



2.2.2.3 TikiWiki

2.2.2.3.1 ROC

Figure 62 THE ROC PLOT SHOWING THE INDIVIDUAL IDSs, 1002 AND 2002 CONFIGURATIONS FOR TIKIWIKI WHEN ATTACKS WHERE READ (GET)

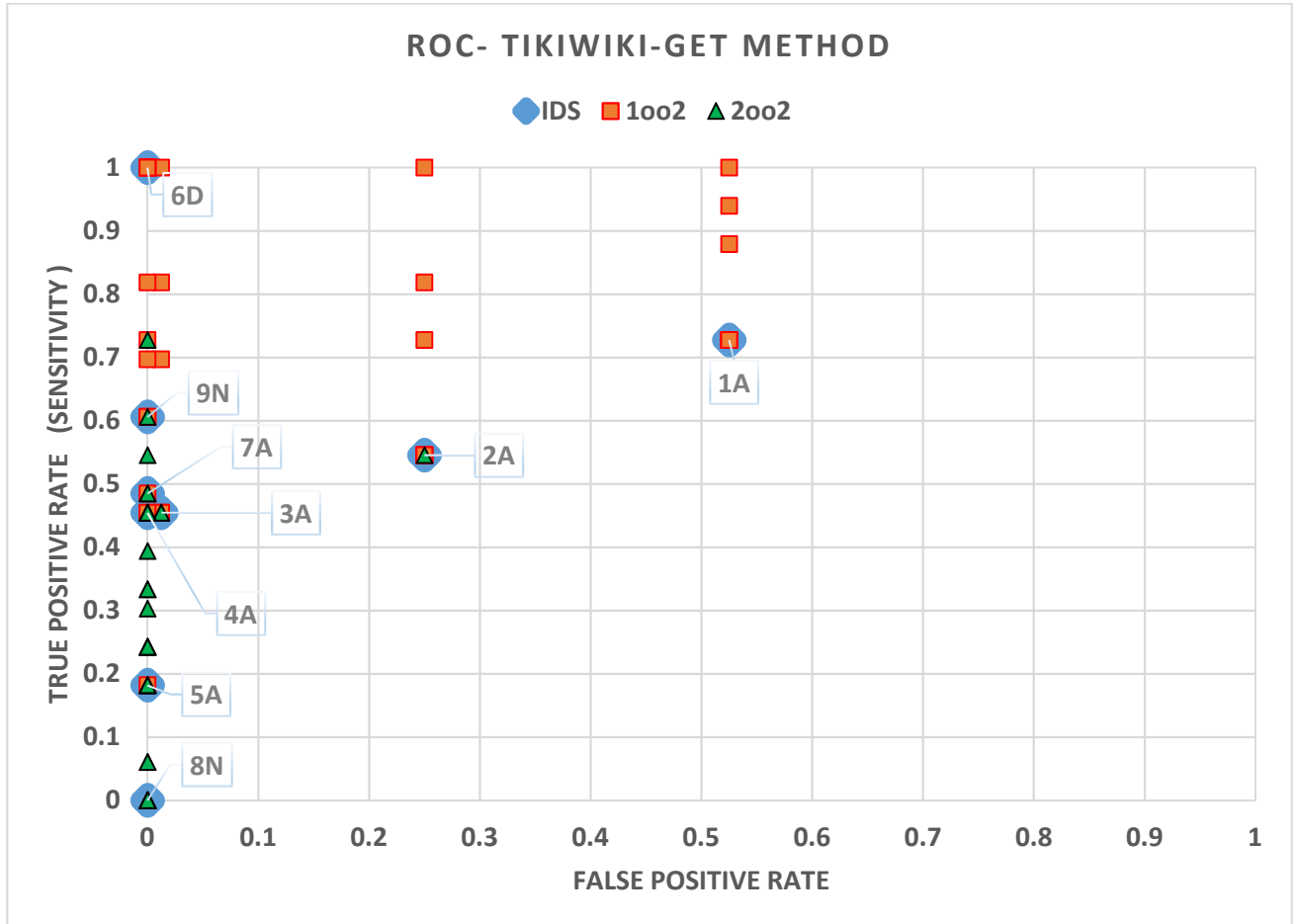
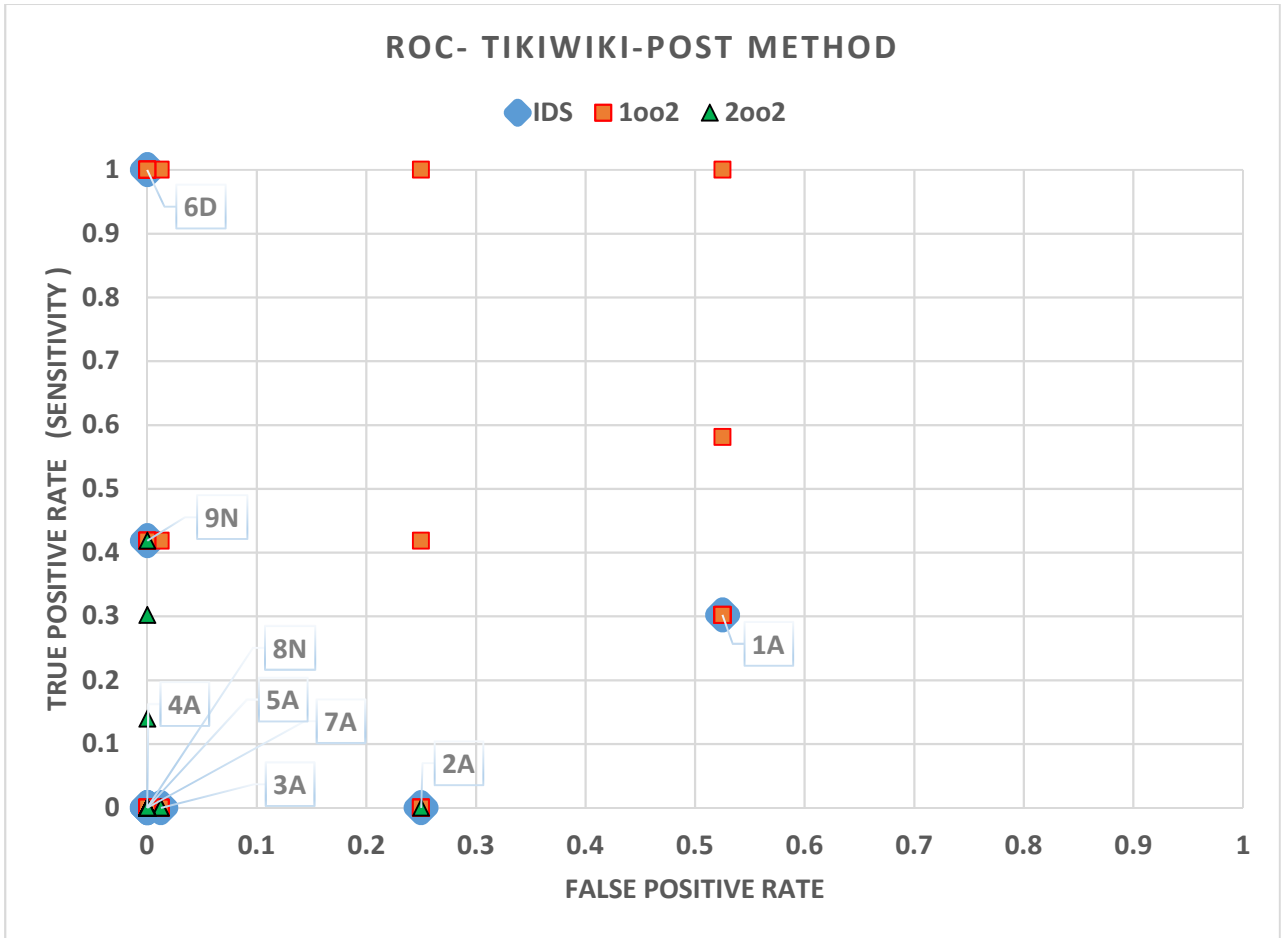


Figure 63 THE ROC PLOT SHOWING THE INDIVIDUAL IDSs, 1002 AND 2002 CONFIGURATIONS FOR TIKIWIKI WHEN ATTACKS WHERE WRITE (POST)



2.2.2.3.2 Accuracy

Figure 64 THE ACCURACY FOR A GIVEN SYSTEM A WHEN PAIRED WITH ANOTHER SYSTEM B FOR TIKIWIKI, THE CHART SHOWS THE INDIVIDUAL IDSs, 1002 AND 2002 CONFIGURATIONS WHEN ATTACKS WHERE READ (GET)

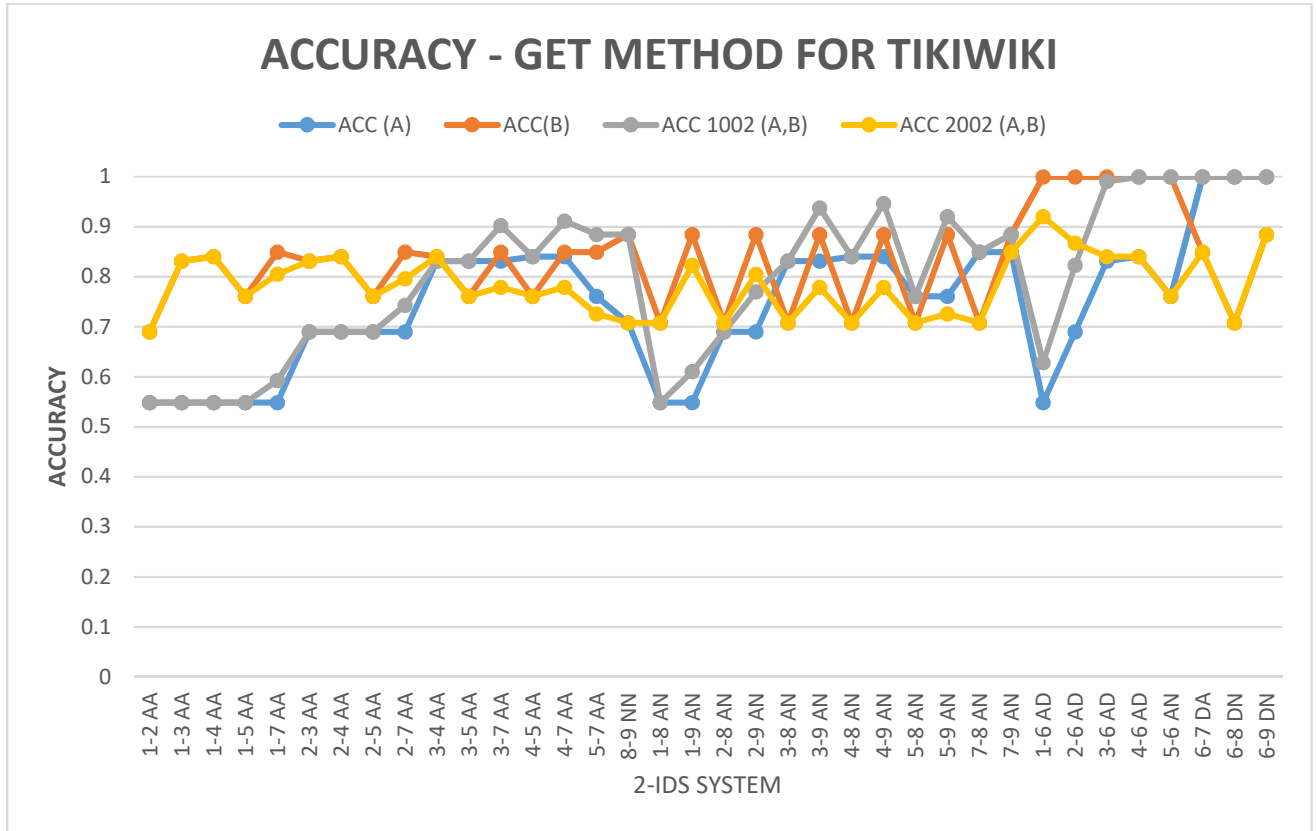


Figure 65 THE ACCURACY DIFFERENCE OF 1002 AND 2002 CONFIGURATIONS, COMAPRED WITH THE BEST SINGLE SYSTEM IN THE RESPECTIVE PAIR FOR TIKIWIKI WHEN ATTACKS WHERE READ (GET)

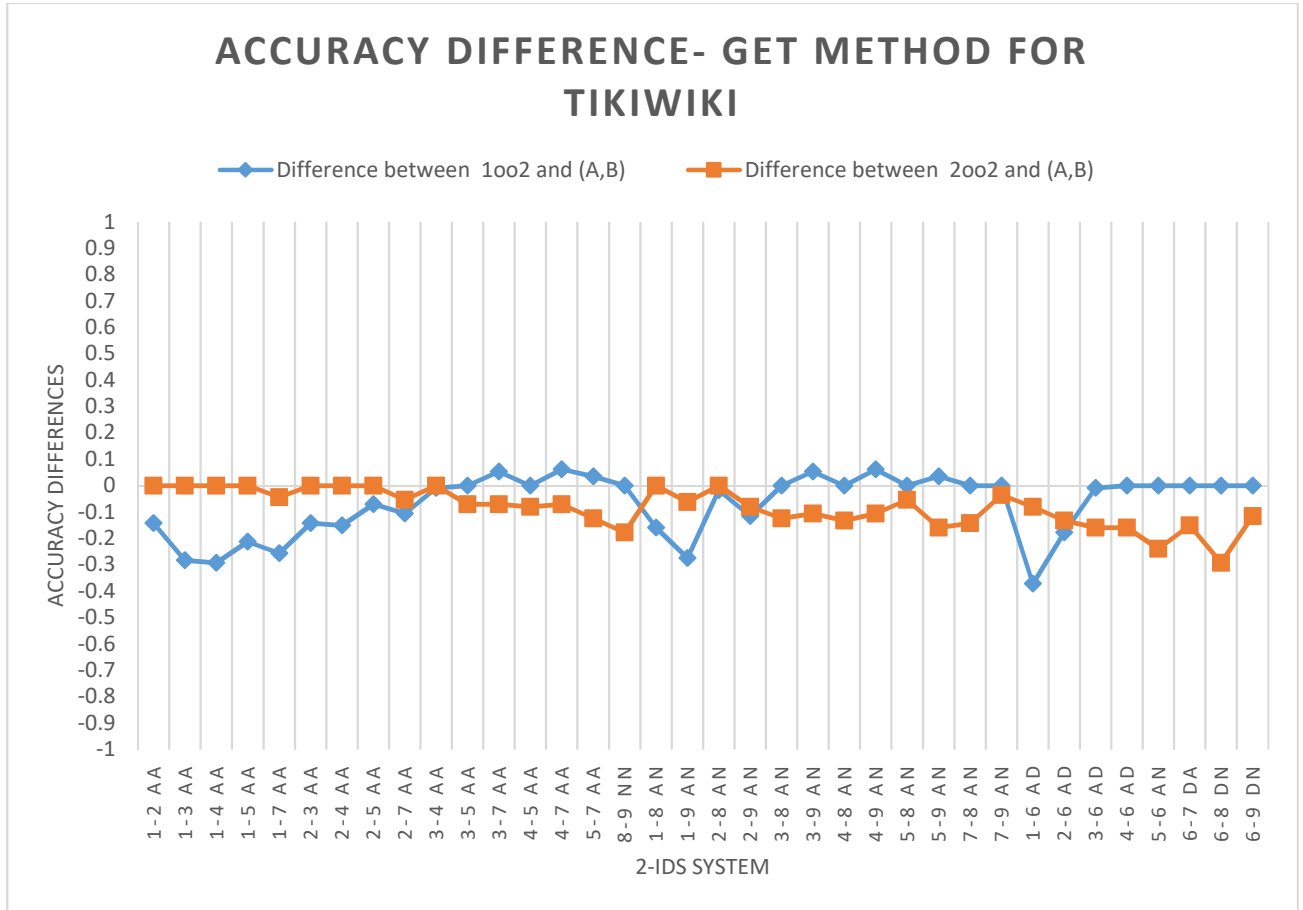


Figure 66 THE ACCURACY FOR A GIVEN SYSTEM A WHEN PAIRED WITH ANOTHER SYSTEM B FOR TIKIWIKI, THE CHART SHOWS THE INDIVIDUAL IDSs, 1002 AND 2002 CONFIGURATIONS WHEN ATTACKS WHERE WRITE (POST)

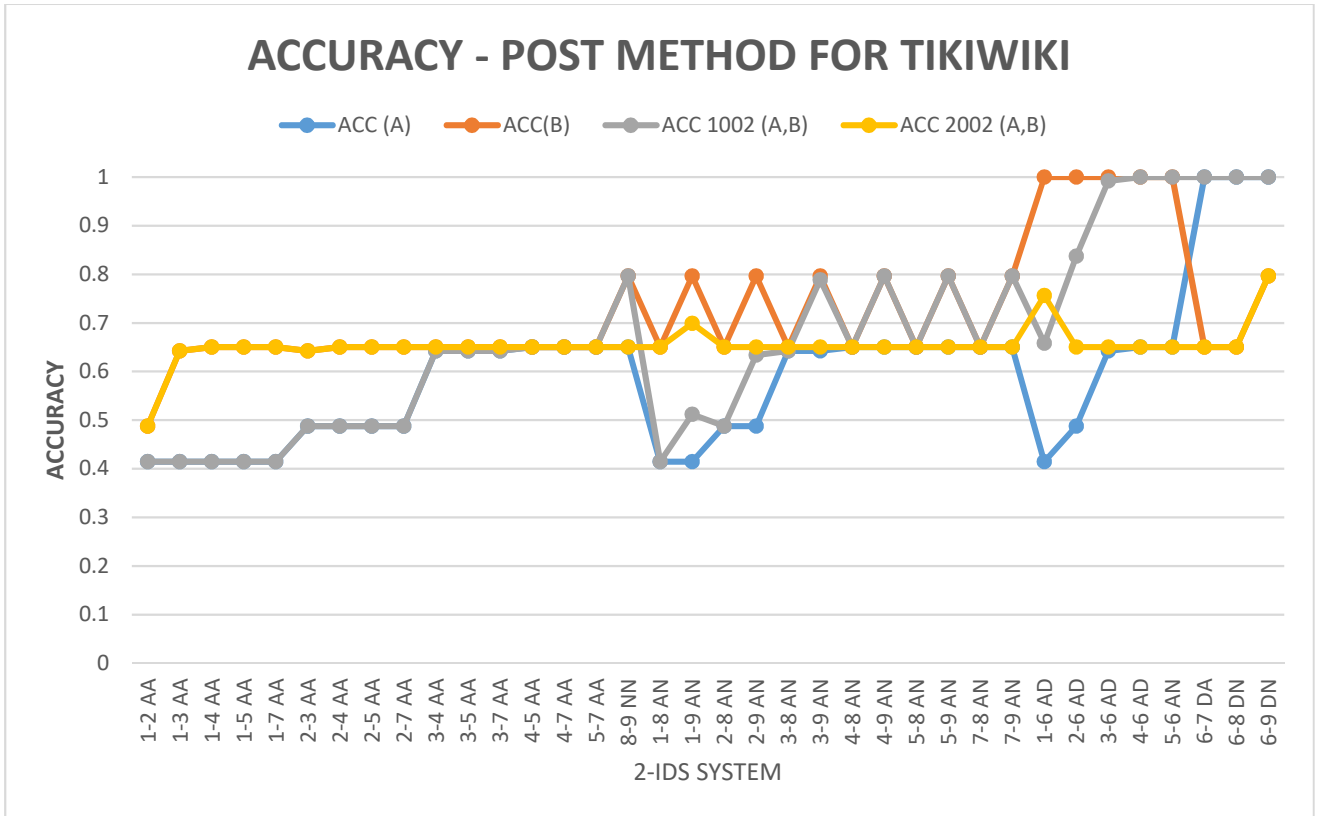
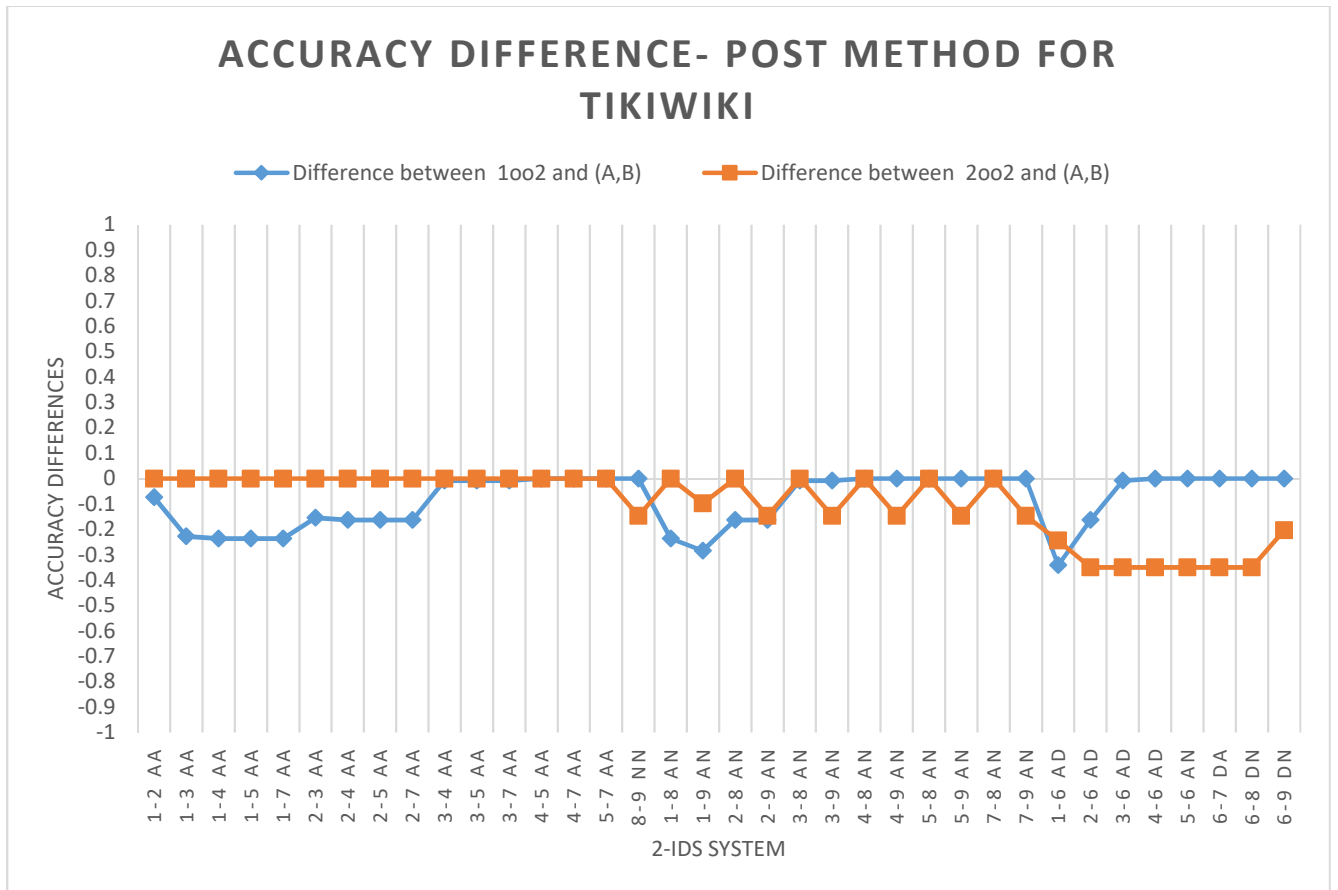


Figure 67 THE ACCURACY DIFFERENCE OF 1002 AND 2002 CONFIGURATIONS, COMPARED WITH THE BEST SINGLE SYSTEM IN THE RESPECTIVE PAIR FOR TIKIWIKI WHEN ATTACKS WHERE WRITE (POST)



2.2.2.3.3 Specificity

Figure 68 THE SPECIFICITY FOR A GIVEN SYSTEM A WHEN PAIRED WITH ANOTHER SYSTEM B FOR TIKIWIKI, THE CHART SHOWS THE INDIVIDUAL IDSs, 1002 AND 2002 CONFIGURATIONS WHEN ATTACKS WHERE READ (GET)

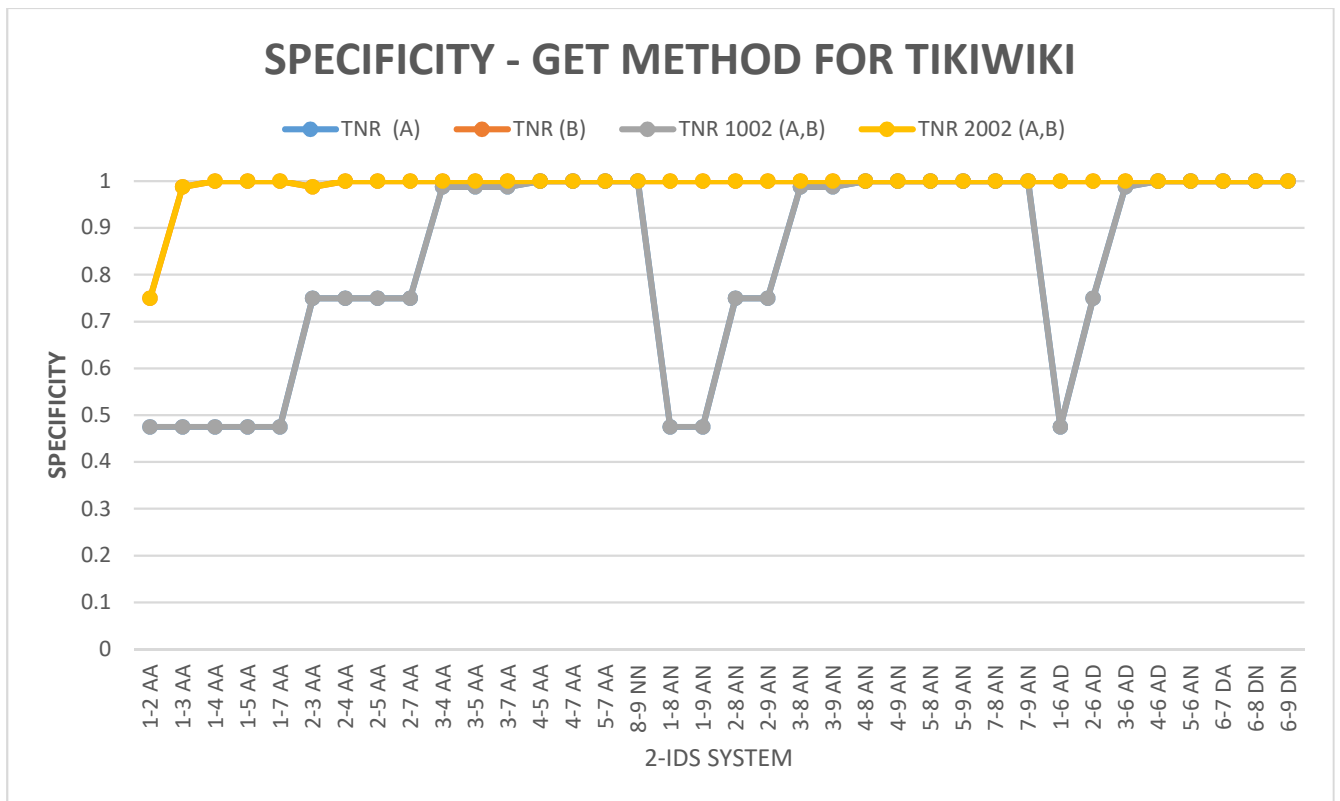


Figure 69 THE SPECIFICITY DIFFERENCE OF 1002 AND 2002 CONFIGURATIONS, COMPARED WITH THE BEST SINGLE SYSTEM IN THE RESPECTIVE PAIR FOR TIKIWIKI WHEN ATTACKS WHERE READ (GET)

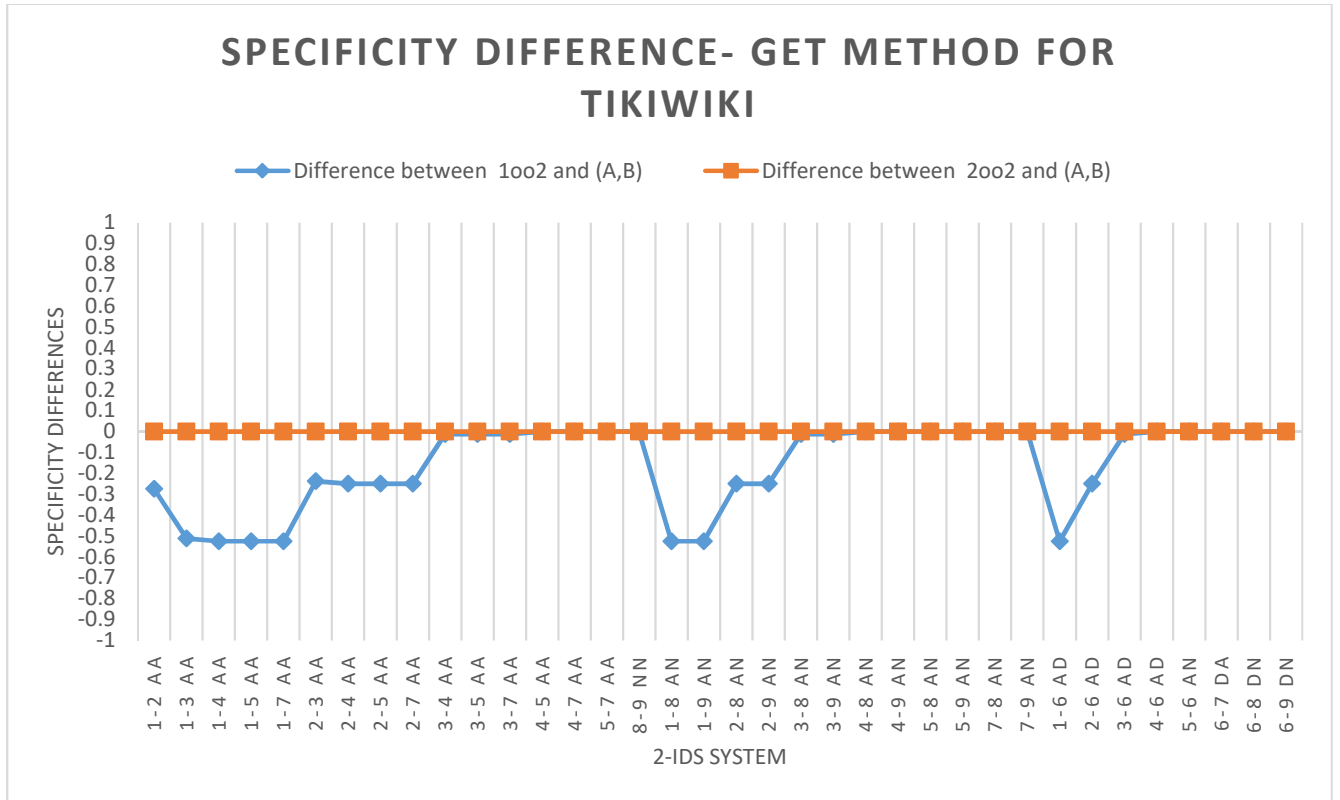


Figure 70 THE SPECIFICITY FOR A GIVEN SYSTEM A WHEN PAIRED WITH ANOTHER SYSTEM B FOR TIKIWIKI, THE CHART SHOWS THE INDIVIDUAL IDSs, 1002 AND 2002 CONFIGURATIONS WHEN ATTACKS WHERE WRITE (POST)

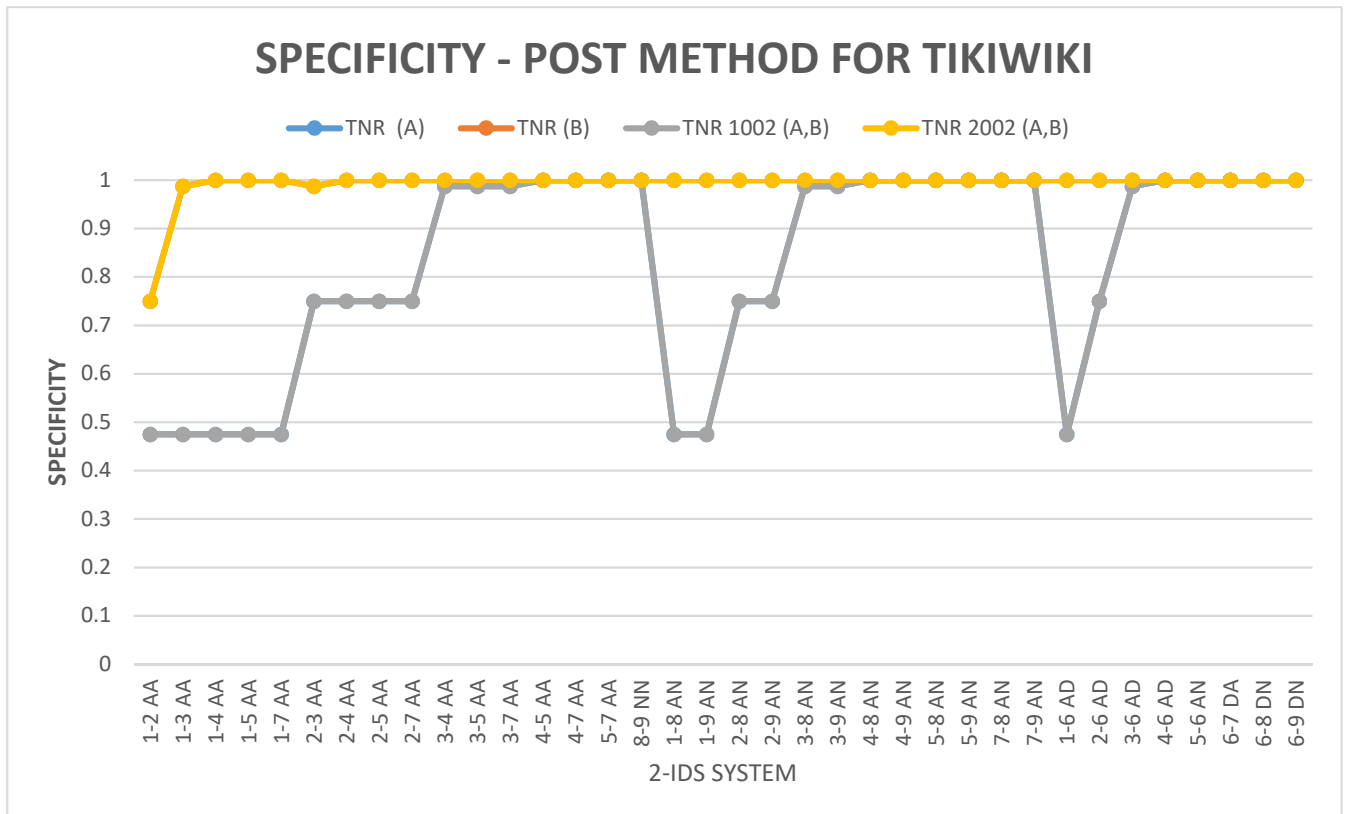
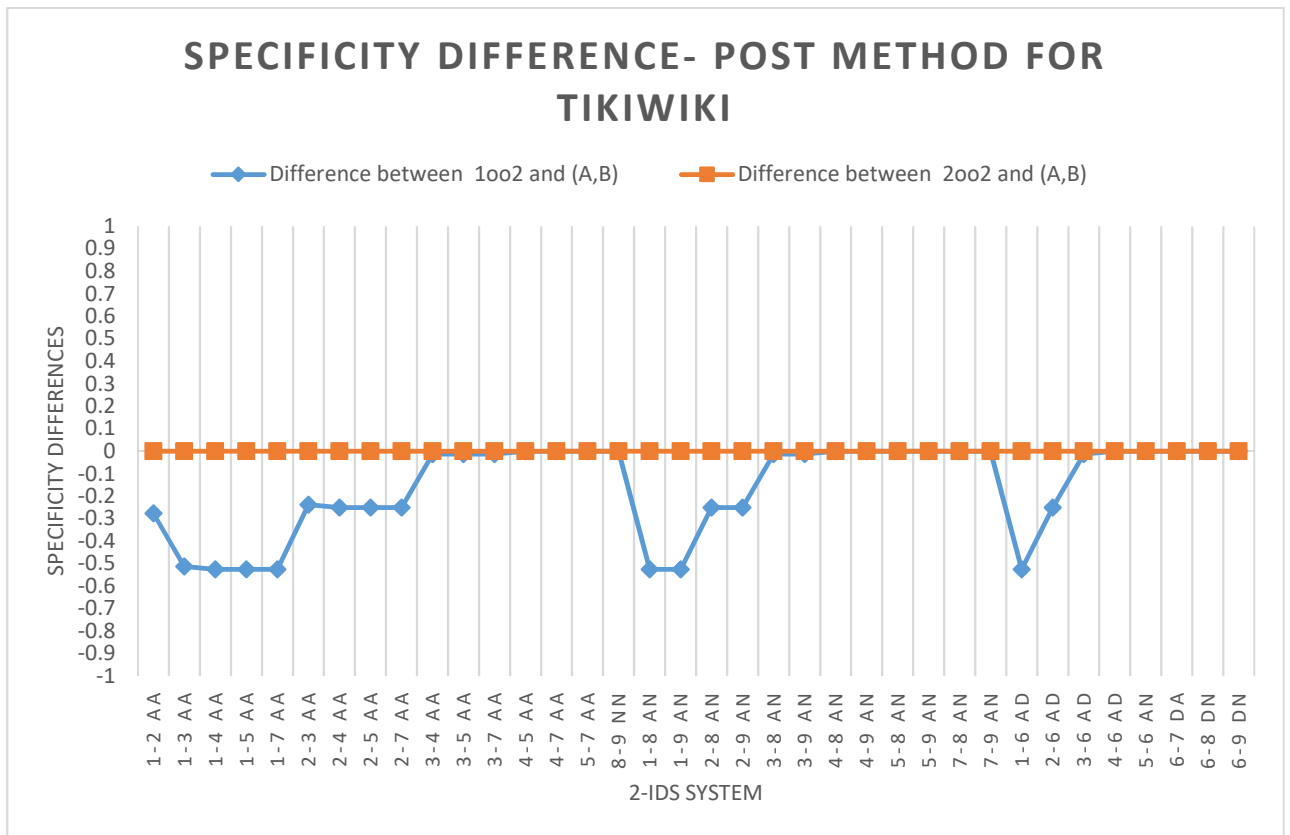


Figure 71 THE SPECIFICITY DIFFERENCE OF 1002 AND 2002 CONFIGURATIONS, COMPARED WITH THE BEST SINGLE SYSTEM IN THE RESPECTIVE PAIR FOR TIKIWIKI WHEN ATTACKS WHERE WRITE (POST)



2.2.2.3.4 Sensitivity

Figure 72 THE SENSITIVITY FOR A GIVEN SYSTEM A WHEN PAIRED WITH ANOTHER SYSTEM B FOR TIKIWIKI, THE CHART SHOWS THE INDIVIDUAL IDSs, 1002 AND 2002 CONFIGURATIONS WHEN ATTACKS WHERE READ (GET)

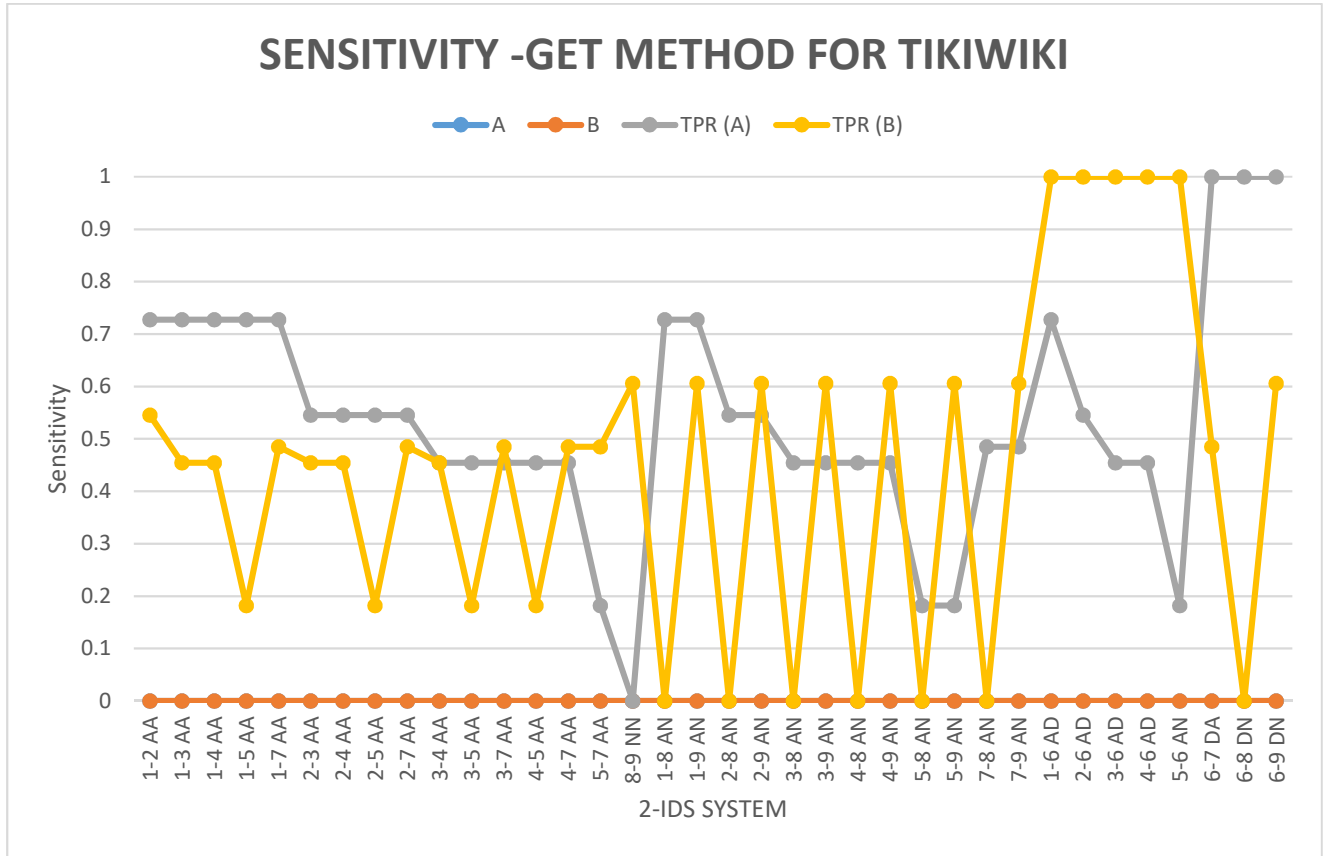


Figure 73 THE SENSITIVITY DIFFERENCE OF 1002 AND 2002 CONFIGURATIONS, COMAPRED WITH THE BEST SINGLE SYSTEM IN THE RESPECTIVE PAIR FOR TIKIWIKI WHEN ATTACKS WHERE READ (GET)

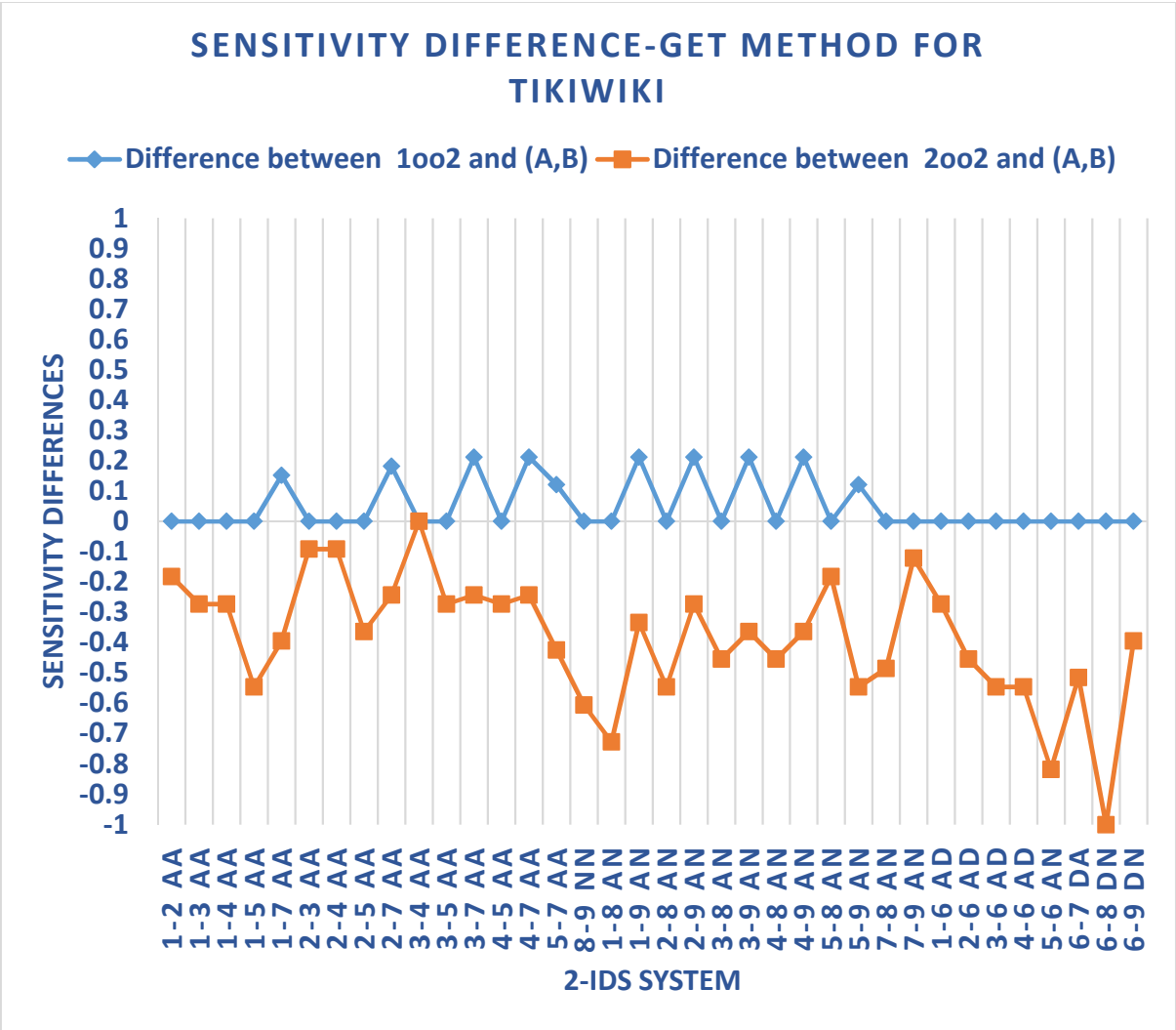


Figure 74 THE SENSITIVITY FOR A GIVEN SYSTEM A WHEN PAIRED WITH ANOTHER SYSTEM B FOR TIKIWIKI, THE CHART SHOWS THE INDIVIDUAL IDSs, 1002 AND 2002 CONFIGURATIONS WHEN ATTACKS WHERE WRITE (POST)

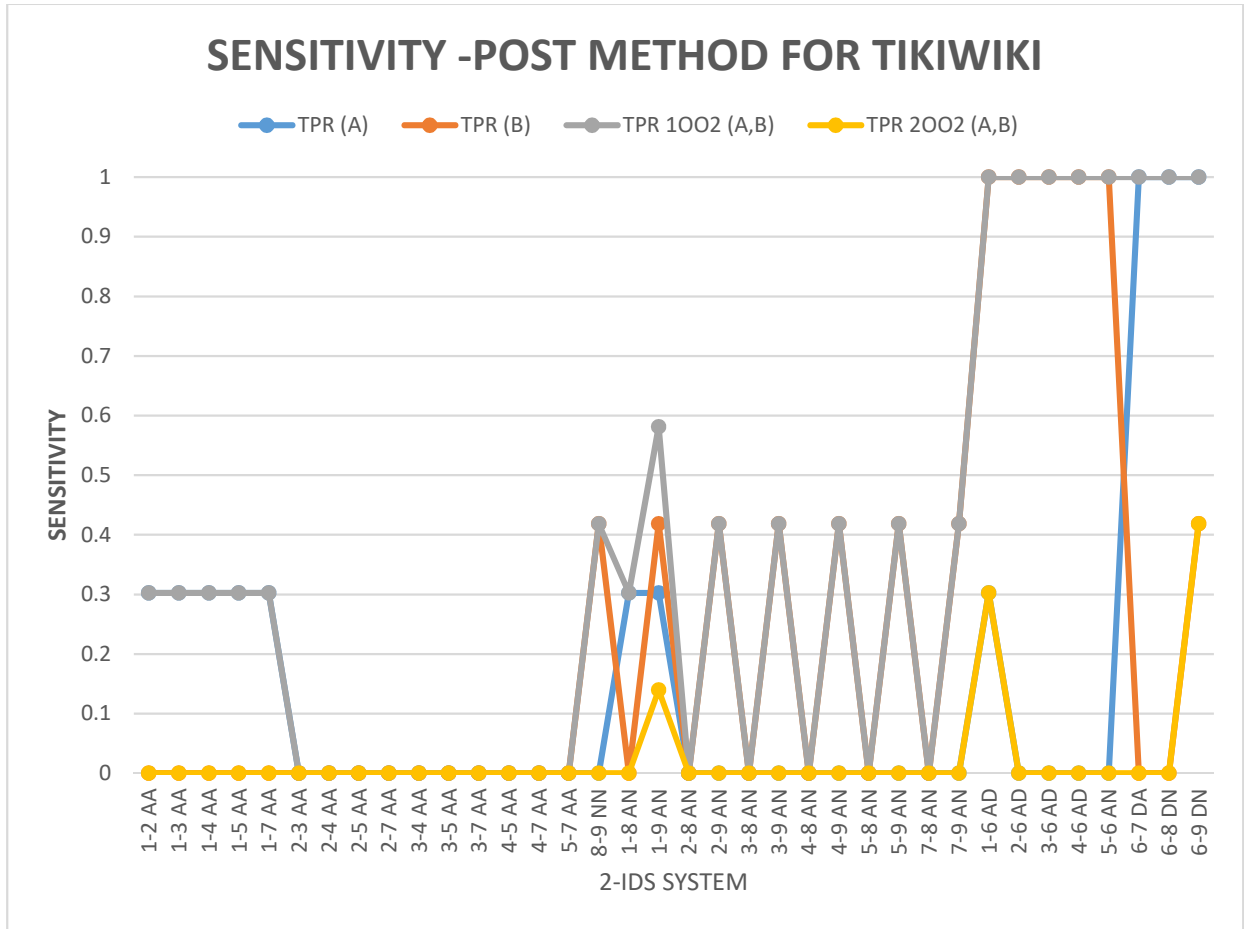


Figure 75 THE SENSITIVITY DIFFERENCE OF 1002 AND 2002 CONFIGURATIONS, COMPARED WITH THE BEST SINGLE SYSTEM IN THE RESPECTIVE PAIR FOR TIKIWIKI WHEN ATTACKS WHERE WRITE (POST)

