

Appendix C Belief Based Trust Evaluation Scheme Results

C.1 Effects of attacks in Trustworthiness level

Trustworthiness is a belief level that one sensor node puts on another node for a specific action according to previous observation of behaviors. Inclusion of malfunction node negatively impact on trustworthiness level which affects on network performance. Table C1 shows the results of trustworthiness in the presence of malicious nodes (10% - 50%) with simulated attacks.

C.2 Trust Detection Rate

Trust detection rate indicates the percentage of the actual number of compromised behavior of malicious nodes (MN) detected by the system. Accurate identification of malicious nodes (MN) depends on the robustness of given algorithm whether it can identify the malicious node or not. Table C2 shows the results of trust detection rate in the presence of malicious nodes (10% - 50%).

C.3 Detection Accuracy

The detection accuracy metric is defined as the accurate percent (%) of successful detection of malicious nodes. Sometimes the trustworthy nodes can be reported as malicious or compromised nodes due to erroneous and low recognition and this results in high false positive rate. Table C3 shows the results of detection accuracy in the presence of malicious nodes (10% - 50%).

C.4 False Positive Rate (FPR)

The False Positive Rate evaluation metric is used to determine the malicious nodes which were wrongly identified as trustworthy due to the impact of trust update intervals. Table C4 shows the results of false positive rate (FPR) in the presence of malicious nodes (10% - 50%).

C.5 Trustworthiness Level

The efficacy of the proposed BTES scheme is evaluated in the absence of malicious nodes. The results indicate the steady performance with the passage of time. Table C5 shows the results of trustworthiness level with the passage of time.

Table C.1: Effect on trustworthiness in comparison with different attacks.

Observation Period (Sec)	Percentage of Malicious Sensor Nodes (10 % - 50%)														
	10			20			30			40			50		
	BBM	On-Off	DoS	BM	On-Off	DoS	BM	On-Off	DoS	BM	On-Off	DoS	BM	On-Off	DoS
200	0.320	0.580	0.680	0.490	0.725	0.810	0.480	0.645	0.750	0.380	0.565	0.780	0.315	0.495	0.750
400	0.470	0.610	0.720	0.610	0.823	0.880	0.580	0.835	0.870	0.490	0.690	0.860	0.395	0.675	0.790
600	0.570	0.690	0.810	0.590	0.810	0.880	0.610	0.840	0.890	0.580	0.730	0.850	0.415	0.695	0.810
800	0.630	0.740	0.850	0.580	0.800	0.870	0.620	0.830	0.890	0.570	0.710	0.820	0.560	0.680	0.800
1000	0.670	0.764	0.890	0.560	0.785	0.830	0.570	0.830	0.880	0.560	0.680	0.800	0.470	0.620	0.770

Table C.2: Trust Detection Rate

Observation Period (Sec)	Percentage of Malicious Sensor Nodes (10 % - 50%)														
	10			20			30			40			50		
	BAF-TNS	Trust-Doe	BTE S	AF-TNS	Trust-Doe	BTE S	AF-TNS	Trust-Doe	BTE S	AF-TNS	Trust-Doe	BTE S	AF-TNS	Trust-Doe	BTE S
200	100	99	100	94.5	98.2	92.4	90.2	94.2	89.2	89.2	80	91	82.3	78.4	85
400	99	98	99.5	93.2	97.5	91.9	91.8	93.8	88.4	88.4	79.6	90.5	81.7	77.9	84.8
600	98	97.4	98.6	92.4	96.7	90.7	90.2	91.9	86.5	86.5	78.8	89.4	80.8	76.7	83.4
800	96	95.6	97.8	90.8	94.9	89.9	88.3	90.9	85.1	85.1	77.6	88.6	78.9	74.5	82.7
1000	95	93.8	96.5	89.4	93.8	88.2	87.1	89.8	84.7	84.7	76.9	87.4	77.1	73.7	81.9

Table C.3: Detection Accuracy

Observation Period (Sec)	Percentage of Malicious Sensor Nodes (10 % - 50%)														
	10			20			30			40			50		
	BAF-TNS	Trust-Doe	BTE S	AF-TNS	Trust-Doe	BTE S	AF-TNS	Trust-Doe	BTE S	AF-TNS	Trust-Doe	BTE S	AF-TNS	Trust-Doe	BTE S
200	90.3	82	100	85.8	77	90	84	74.5	87	80.5	75.3	85	78	74.2	80.6
400	89.7	81.8	98.7	84.2	75	88.9	83.1	73.4	86.8	79.5	73.2	86.1	79	73.1	79.4
600	88.5	80.4	97.6	83.5	76	87.5	82.4	72.8	87.7	78.1	72.4	87	77.8	71.9	78.5
800	87.9	78.6	96.7	82.7	75	86.2	81.6	71.7	85.9	77.7	71.3	84	76.4	70.8	76.7
1000	86.8	77.1	95.5	81.9	72	85.8	80.5	70.9	84.1	76.4	70.5	83	75.5	69.8	75.9

Table C.4: False Positive Rate (FPR)

Observation Period (Sec)	Percentage of Malicious Sensor Nodes (10 % - 50%)														
	10			20			30			40			50		
	BAF-TNS	Trust-Doe	BTE S	AF-TNS	Trust-Doe	BTE S	AF-TNS	Trust-Doe	BTE S	AF-TNS	Trust-Doe	BTE S	AF-TNS	Trust-Doe	BTE S
200	10	18	0	13	19	8	8.67	16.67	7.34	8	5	6	4	4	5
400	10.1	18.1	0	13.1	19.2	8.1	8.72	16.7	7.4	8.08	5.02	6.06	4.05	4.09	5.11
600	10.35	18.4	0.01	13.18	19.45	8.25	8.8	16.79	7.58	8.19	5.14	6.15	4.11	4.16	5.19
800	10.5	18.65	0.03	13.25	19.6	8.4	8.88	16.86	7.7	8.33	5.21	6.34	4.21	4.26	5.28
1000	10.65	18.8	0.45	13.46	19.82	8.6	8.92	16.92	7.9	8.49	5.36	6.48	4.33	4.38	5.36

Table C.5: Trustworthiness Level

Observation Period (Sec)	200			400			600			800			100		
	BAF-TNS	Trust-Doe	BTES	AF-TNS	Trust-Doe	BTES	AF-TNS	Trust-Doe	BTES	AF-TNS	Trust-Doe	BTES	AF-TNS	Trust-Doe	BTES
	0.611	0.601	0.619	0.671	0.650	0.735	0.750	0.731	0.840	0.822	0.809	0.920	0.884	0.861	0.978
	0.618	0.606	0.628	0.682	0.661	0.751	0.763	0.745	0.852	0.831	0.817	0.931	0.891	0.867	0.982
	0.632	0.615	0.637	0.694	0.678	0.767	0.772	0.757	0.867	0.846	0.823	0.948	0.897	0.871	0.989
	0.643	0.622	0.642	0.701	0.685	0.779	0.789	0.779	0.881	0.857	0.832	0.959	0.905	0.879	0.993
	0.651	0.631	0.650	0.712	0.697	0.796	0.795	0.790	0.895	0.870	0.847	0.970	0.912	0.886	0.998