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Improved ECC based Secured Data Transmission in CRNS

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***Abstract*—Cognitive radio mechanism is demonstrates as a proficient method for sensing the spectrum and make use of the attained data to develop the overall performances of communiqué system. On the other hand, owing to the transmit character of this network; communiqués are subjected to varied attacks. This paper primarily intends to propose a new secured communication approach through the available predicted spectrum channels. Here, channel states are predicted via optimized LSTM. For secured communication, this work deploys improved "Elliptic-curve cryptography (ECC)" that guarantees the security level of data frames. Accordingly, the channel state is predicted by means of Levy Updated Aquila Optimizer (LU-AO). In the end, studies and analysis are done to show the efficacy of LU-AO model.**

***Index Terms*— CRN, Channel state, Improved ECC, optimized LSTM, LU-AO model**.

I. INTRODUCTION

Cognitive Radio (CR) is defined "as a technical paradigm able to adapt itself dynamically to utilize the radio resources in the time, frequency, and space domains". A specific frequency spectrum is split into small frequency bands. Every frequency band is allotted for approved prime users [1] [2] [3]. It was experimentally noticed that most important segments of such bands of frequency stay idle over considerable time interval. The Cognitive radio Networks (CRN) includes the capability to make use of these spectrum holes intelligently and effectively while not commanding prohibited intervention to neighbouring approved prime users [4] [5] [6]. These CRNs also endures from additional challenges like: on neighbour detection in the sensing, spectrum election and radio network, identifying the user locality and become accustomed itself to its requirements etc [7] [8] [9]. Spread spectrum method, owing to its exceptional characteristic to build the data look like noise, is greatly protected in the logic that the interfering and jamming elements are not capable to differentiate the data (mix with noise), which was transmitted over the channel and therefore it might be a potential solution to evade eavesdrop or data leak [10] [11] [12] [6]. Even a variety of encryption schemes like public key encryption (RSA, Elliptic) and private key encryption (DES, Triple DES, Advanced Encryption Standard (AES)) are deployed, together, with CRN to offer a type of secured communiqué [13] [14] [15]. These encryption schemes confirm that the key that is used at the transmitter side should be provided by the receiver (just like the pseudo-arbitrary series deployed in spread spectrum module) for accurate data retrieval and thus guarantees the safety and in addition avoid the malevolent users from captivating control over the scheme, jamming the right of entry to other minor users [6]. The contributions are to develop LU-AO oriented LSTM for predicting the availability of channel states. In addition, deploys improved ECC to guarantee the security of data frame.

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The work is sorted as: Section II reviews related topic. Section III and IV elucidates system model and MPC protocol. Section V portrays about modified ECC. Section VI and VII describes outcomes and conclusion.

II. Literature Survey

In 2019, Kaliappan *et al.* [16] deployed a robust multi-stage detector for strategic CR appliances. The deployed scheme used 2 corresponding detectors for higher and lower bands of SNR. Investigational resultants have shown that the presentation of the deployed model outperformed the compared schemes on accuracy and time. In 2020, Rajput *et al.* [17] simulated extant schemes like energy recognition and MME that were subsequently evaluated with presented "adaptive covariance threshold technique". Furthermore, the influence of signal bandwidth in relationship with observation bandwidth was done for every detector. In 2018, Nafees *et al.* [18] presented RARE scheme, which splitted the network in to several clusters and the arrangement of clusters seemed to be a better crisis of edge biclique. Eventually, the improvement of RARE was confirmed concerning negligible cluster count. In 2018, Li *et al.* [19] established a system to avoid congestion by optimal allotment of channel and time. Eventually, the outcomes have exposed the performances of FMAC concerning time and fairness. In 2018, Manyi *et al.* [20] represented an Adaptive Preamble Sampling-based MAC (APS-MAC) scheme that maintained the evaluation of opportunistic spectra, whilst solving the energy preservation of Cognitive Radio Sensor Network (CRSN). Finally, the outcomes have established the higher of the APS-MAC model.

III. Modelling of System

All available spectra bands are dispersed over a huge frequency range. The CRNs are aware of, "(1) frequency ranges as well as bandwidth of PUs; (2) the level of intervention, which PU could endure; and, (3) minimal SNR required for decoding the receiver signal".

IV. Channel Allotment via MPC Protocol

The crisis to be resolved is explained as: By PU channel list with its preceding T transmitting states, the ProMAC forecasted the transmission state of PU for following TI time slots. In addition, the idle or busy state of PU channel relies on if the related PU transfers or not. Assume M channels related with PUs are indicated by $\{Y_1, Y_2, ...Y_M\}$, and s_j^i indicate Y_i position in time period j. For ts time period, the history polynomial HP_i related to Y_i is exposed by (1).

$$HP^i(x) = \sum_{j=ts-S}^{ts-1} s_j^i * x^{j-ts+S}, \quad s_j \in \{0,1\}$$
$$s_j^i = \begin{cases} 1, & if\ Y_i is\ busy\ at\ timeslot\ ts \\ 0, & else \end{cases} \qquad (1)$$

The suggested scheme concerns on secured broadcast of data via forecasted channel states using LU-AO based LSTM.

A. Optimized LSTM

It [21] includes "forget gate, the input gate, and the output gate. Let M and C be hidden and cell state. (X_t, C_{t-1}, M_{t-1}) and (M_t, C_t) designate input and output layer. At time t, the output, input and forget gate implies O_t, I_t, F_t". Here, F_t is modelled in (2).

$$F_t = \sigma(G_{IF} X_t + B_{IF} + G_{MF} M_{t-1} + B_{MF}) \qquad (2)$$

In (2), "(G_{MF}, B_{MF}) and (G_{IF}, B_{IF}) imply weight and bias parameter to map hidden and input layers to forget gate and activation function is implied by σ".

Input gate of LSTM is in (3) - (5), where, "(G_{MG}, B_{MG}) and (G_{IG}, B_{IG}) imply weight and bias parameter to map hidden and input layers to cell gate correspondingly. (G_{MI}, B_{MI}) and (G_{II}, B_{II}) imply weight and bias parameter to map hidden and input layers to I_t".

$$T_t = \tanh(G_{IG} X_t + B_{IG} + G_{MG} M_{t-1} + B_{MG}) \qquad (3)$$
$$I_t = \sigma(G_{II} X_t + B_{II} + G_{MI} M_{t-1} + B_{MI}) \qquad (4)$$
$$C_t = F_t C_{t-1} + I_t T_t \qquad (5)$$

$$O_t = \sigma\left(G_{IO} X_t + B_{IO} + G_{MO} M_{t-1} + B_{MO}\right) \quad (6)$$

$$M_t = O_t \tanh\left(C_t\right) \quad (7)$$

LSTM gets the output hidden layer as in (6) and (7), "wherein $\left(G_{MO}, B_{MO}\right)$ and $\left(G_{IO}, B_{IO}\right)$ implies weight and bias to map the hidden and input layer to O_t". Accordingly, the LSTM weights G are chosen by LU-AO scheme as shown in Fig. 1, Nl → total weights of LSTM. The objective is given by (8).

$$Obj = Min\left(Error\right) \quad (8)$$

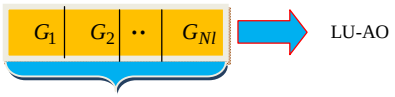


Figure 1. Solution Encoding

B. LU-AO Algorithm

Aquila Optimizer (AO) [22] has high exploring capacity but low exploitation capacity. Hence, specific modification is done in AO. Self-enhancement is competent in conservative optimization models [23].

Initialization: Aquila is a populace oriented scheme. The best attained solution is the finest solution. In (9), the set of present candidate solutions $A_{i,j}$, are randomly created. Here, "A_i → i^{th} solution's position, S refers to count of solution, and Dim refers to the dimensional size, ran → randomized number, lb_j and ub_j → lower & upper bounds".

$$A_{i,j} = ran \times (ub_j - lb_j) + lb_j, i = 1,2,...S \quad j = 1,2....Dim \quad (9)$$

Step I: *Extended exploration (P_1):* Aquila chooses the optimum hunting area that is precisely defined in (10), where, "$\mathrm{P_{best}}(\mathrm{t}^{\gamma})$ → Finest location attained as yet, $\mathrm{P_M}(\mathrm{t}^{\gamma})$ → Total Aquila's average position in current iteration, t^{γ} → Present iteration, T → Total count of iterations, S → Population size and $\mathrm{a_1}$ → Randomized number between (0, 1)". $P_M(t)$ is defined in (11).

$$\mathrm{P_1}(\mathrm{t}^{\gamma}+1) = \mathrm{P_{best}}(\mathrm{t}^{\gamma}) \times (1 - \frac{\mathrm{t}^{\gamma}}{\mathrm{T}}) + (P_M(\mathrm{t}^{\gamma}) - P_{best}(\mathrm{t}^{\gamma}) \times ran) \quad (10)$$

$$P_M(t) = \frac{1}{S}\sum_{i=1}^{S} P_i(\mathrm{t}^{\gamma}) \quad (11)$$

Step II: *Narrow exploration (P_2):*In this phase, the location is updated by (12), in which, $Levy(\mathrm{N})$ → levy flight distribution function that is computed as in (13). Conventionally, t in (12) is set as 001. As per LU-AO model, t is computed as in (14).

$$P_2(\mathrm{t}^{\gamma}+1) = P_{best}(\mathrm{t}^{\gamma}) \times Levy(\mathrm{N}) + P_R(\mathrm{t}^{\gamma}) + (l - m) \times ran \quad (12)$$

Here, $\mathrm{P_R}(\mathrm{t})$ → Random position

$$Levy(\mathrm{N}) = t \times \frac{u \times \sigma}{|y|^{\frac{1}{\beta}}} \quad (13)$$

$$t = 2 * \left(1 - \frac{\mathrm{t}^{\gamma}}{T}\right) \quad (14)$$

$$\sigma = \left(\frac{\Gamma(1+\beta) \times \sin(\frac{\pi\beta}{2})}{\Gamma(\frac{1+\beta}{2}) \times \beta \times 2^{(\frac{\beta-1}{2})}}\right) \quad (15)$$

Here, β =1.5, & u, y → arbitrary integer (0, 1), σ is evaluated as in (16), here a_3 → search cycle count, $\mathrm{N_1}$ → integers among 1 and N , $\omega = 0.005$.

$$\begin{cases} l = a \times \sin(\theta) \\ m = a \times \cos(\theta) \\ a = a_3 + 0.00565 \\ \theta = -\omega \times \mathrm{N_1} + \frac{3 \times \pi}{2} \end{cases} \quad (16)$$

Step III: Extended exploitation (P_3): This phase is modelled as in (17), wherein, α' and δ' denotes exploitation adjustment variables between (0.1).

$$P_3(t^{\gamma}+1)=(P_{best}(t)-p_M(t^{\gamma}))\times\alpha'-ran+((ub-lb)\times ran+lb)\times\delta' \quad (17)$$

Step IV: Narrowed exploitation (P_4): This phase is modelled as in (21), wherein, qf implies quality factor, V_1 implies a variety of motions of AO and V_2 implies flight slope that decreases from 2 to 0" and, V_2 is computed as in (20). Conventionally, qf is computed as in (18). As per LU-AO model, qf is computed as in (19), wherein, ran is computed using logistic chaotic map.

$$qf\left(t^{\gamma}\right)=t^{\gamma}\frac{2\times ran-1}{(1-T)^2} \quad (18)$$

$$qf\left(t^{\gamma}\right)=t^{\gamma}\frac{2\times ran-1}{\left(1-\frac{t^{\gamma}}{T}\right)^2} \quad (19)$$

$$V_2=2*\left(1-\frac{1}{T}\right) \quad (20)$$

$$P_4(t^{\gamma}+1)=qf\times P_{best}(t)-\left(V_1\times P\left(t^{\gamma}\right)\times ran\right)-V_2\times levy(N)+ran\times V_1 \quad (21)$$

V. Modified ECC for Secured Data Transmission

A. Channel Sensing Phase

The beacon epoch starts with sensing phase, wherein the channel state of PU is noted by every SU node. The SUs evades false alarms [24] triggered by CR waveforms. The channel sensing phase discovers the band holes amongst Tx - Rx pairs. To get latest sensing data, ProMAC integrate channel sensing for MAC layer [25]. The adopted approach forecasts a set of idle channel for both CCRN and DCRN.

B. Contention Phase

The SUs strive for and avoid motionless PU channel as per MA scheme in "IEEE 802.11 DCF" [21]. All pairs of Tx - Rx reserved at utmost single data channel. While deploying the CTS / RTS technique, the Multichannel Hidden Terminal Problem (MHTP) crisis is solved. This phase is the testing phase for MPC oriented ProMAC. The state of all sensed channels is provided to ProMAC. Thus, the ProMAC gained knowledge of the predicted outcomes. Eventually, it reduces the possibility of associated contentions happening in the following beacon time stage.

C. Data transmission Phase

While transmitting data, the SU node starts transmitting data to receiver via retained channel. All transmissions occurs in parallel, as Tx - Rx pairs are broadcasted on various channels. In this phase, if Tx - Rx pair comes with PU intercession, the broadcast gets blocked and SU node moves away. If Tx - Rx contain any errors, a break with PU occurs [26]. The affected Tx- Rx pairs undergo contention and sensing stages at following beacon period. Thus, only a particular beacon time is drained throughout collision.

D. Improved ECC

The arithmetical design of improved ECC is exposed in (22) - (28), wherein, b and a → integers, x denotes plain text.

$$x^2=y^3+by+a \quad (22)$$

In improved ECC, 3 kinds of keys are generated.

a. Public key, *puk*
b. Private key, *prk*
c. Secret key, *srk*

Consider Bs as the base point upon curve. For private key *prk* , instead of choosing random integer, chaotic number is chosen via cubic map that lies among 0 and 1. Chaotic map is shown in (23), wherein, $y_k\in(0,1)$ and $\rho=2.5g$.

$$y_{k+1}=\rho y_k\left(1-y_k^2\right) \quad (23)$$

Thus, prk is estimated by means of above function. The public key, puk is computed as in (24).

$$puk = prk + Bs \tag{24}$$

Then secret key, srk is generated using (25), where, srk is the weighted average of puk, prk & Bs and the weights are arbitrary integers among 0 and 1. After key generation, encryption is done.

$$srk = \frac{w_1 * puk + w_2 * prk + w_3 * Bs}{w_1 + w_2 + w_3} \tag{25}$$

Encryption: During encryption, the original data is encoded that encompasses 2 CTs as shown in (26) and (27), wherein, R_1 and R_2 refers to CTs and O_d → original message and U_1 refers to arbitrary integer.

$$R_1 = U_1 \times Bs + srk \tag{26}$$

$$R_2 = O_d + (U_1 \times puk) + srk \tag{27}$$

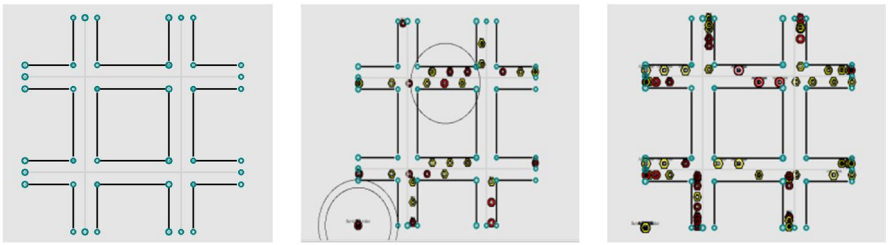
Decryption: The encrypted data is decrypted at receiver side as shown in (28).

$$O_d = ((R_2 - prk) * R_1) - srk \tag{28}$$

VI. Results and Discussion

A. Simulation Setup

The employed scheme in CRN by means using LU-AO + LSTM was done in NS2. 2 experiments were done, "where the 1st one was implemented by using 100 vehicles, and the next experimentation was done by using 200 vehicles". Here, the supremacy of LU-AO + LSTM was established over Convolutional Neural Network (CNN), Deep Belief Network (DBN), Bidirectional Gated Recurrent Unit (Bi-GRU), Bidirectional LSTM (Bi-LSTM), AO + LSTM, PRO+ LSTM, Cat and Mouse based Optimization (CMBO) + LSTM, SSO + LSTM and ROA + LSTM for varied SU and PU. The sample image of (communiqué and movement of vehicle with SU) at (i) start phase (ii) middle phase was shown in Fig. 2.



(a) (b) (c)

Figure 2. Sample depiction of (a) Start stage (b) and (c) middle stage when interacting with SU

B. Analysis on Time

The study on diverse time factors (Encryption and Decryption) for 2 experiments are shown in Table I-II. The improved ECC is calculated over ECC, RSA, blowfish and AES schemes for 2 experiments. Here, time is considered in seconds. Actually, the time for encryption, and decryption should be least for enhanced of system performance. This objective is well attained by improved ECC over ECC, RSA, blowfish and AES schemes for 2 experiments.

C. Analysis on Backoffs

Table III-IV demonstrates the results on back-off evaluation for 1st experiment for varied SU and PU, while, Table V-VI demonstrates the results on back-off evaluation for 2nd experiment for varied SU and PU. The examination is made by changing the SUs and Pus from 20, 40, 60, 80 and 100. The back-off rate has to be negligible to ensure protected system. As needed, the improved ECC has achieved lesser back-offs than existing models for both experiments. Thus, the efficiency of Improved ECC is proven with the integration of improved ECC concept.

D. Channel Utilization Analysis

The channel utilization analysis of LU-AO + LSTM over traditional models for diverse counts of SUs and Pus is described in Fig. 3. "The channel utilization represents the ability to sustain equal loads on each error-free channel". In graphs, the channel utilization is less at initial count of SU and Pus. With raise in the count of SU

TABLE I. ENCRYPTION TIME OF IMPROVED ECC OVER EXTANT MODELS

	1st experimentation				
Key size	ECC	RSA	Blowfish	AES	Improved ECC
16	0.18659	0.1465	0.09297	0.08073	0.07090
32	0.19773	0.1770	0.16711	0.12419	0.10978
48	0.20208	0.1932	0.18603	0.16008	0.12405
64	0.24085	0.2295	0.21253	0.16633	0.14161
80	0.25660	0.2366	0.23463	0.22140	0.19049
2nd experimentation					
Key size	Key size	Key size	Key size	Key size	Key size
16	0.0685	0.0858	0.06981	0.11410	0.05077
32	0.1437	0.1459	0.14569	0.15230	0.07202
48	0.1568	0.1631	0.15904	0.17031	0.15220
64	0.1768	0.1865	0.18569	0.2087	0.159052
80	0.2261	0.2393	0.23263	0.24259	0.21812

TABLE II. DECRYPTION TIME OF IMPROVED ECC OVER EXTANT MODELS

	1st experimentation				
Key size	ECC	RSA	Blowfish	AES	Improved ECC
16	0.0631	0.08081	0.07091	0.09461	0.05579
32	0.0787	0.10800	0.09559	0.12595	0.05946
48	0.1058	0.13742	0.11726	0.15649	0.08068
64	0.1435	0.19265	0.17655	0.19392	0.09870
80	0.1653	0.20309	0.19268	0.21702	0.14859
2nd experimentation					
Key size	ECC	RSA	Blowfish	AES	Improved ECC
16	0.0656	0.07270	0.07031	0.0752	0.055714
32	0.1174	0.1511	0.12766	0.1549	0.09456
48	0.1585	0.1780	0.17675	0.1803	0.137501
64	0.1949	0.2031	0.19651	0.2032	0.185861
80	0.1994	0.2043	0.20351	0.2052	0.19614

TABLE III. BACKOFF ANALYSIS OF LU-AO + LSTM OVER EXTANT MODELS FOR 1ST EXPERIMENT REGARDING VARIED SU

Number of SUs	CNN	DBN	Bi-GRU	BI-LSTM	AO+LSTM	PRO+LSTM	CMBO + LSTM	SSO + LSTM	ROA+ LSTM	LU-AO + LSTM
20	0.37406	0.436948	0.394058	0.371257	0.39372	0.335458	0.293979	0.278907	0.264637	0.256362
40	0.443127	0.524308	0.469078	0.429137	0.367845	0.374087	0.353428	0.326206	0.28743	0.273431
60	0.489344	0.486826	0.518391	0.465755	0.45425	0.454237	0.434746	0.409143	0.35812	0.298254
80	0.578789	0.580953	0.578881	0.56029	0.559876	0.50185	0.481834	0.460923	0.3947	0.313749
100	0.595906	0.598655	0.596201	0.594522	0.589941	0.564652	0.512682	0.504137	0.488062	0.326231

TABLE IV. BACKOFF ANALYSIS OF LU-AO + LSTM OVER EXTANT MODELS FOR 1ST EXPERIMENT REGARDING VARIED PU

Number of PUs	CNN	DBN	Bi-GRU	BI-LSTM	AO+LSTM	PRO+LSTM	CMBO + LSTM	SSO + LSTM	ROA+ LSTM	LU-AO + LSTM
20	0.37904	0.401433	0.378159	0.315739	0.346026	0.390832	0.315462	0.311175	0.285693	0.280534
40	0.451272	0.483338	0.499265	0.387767	0.38901	0.376412	0.383285	0.362898	0.362896	0.349499
60	0.505965	0.511093	0.432474	0.464901	0.474051	0.488676	0.464109	0.452246	0.406587	0.385099
80	0.545623	0.546475	0.536231	0.511247	0.513894	0.517441	0.505479	0.476109	0.474426	0.418942
100	0.591002	0.593113	0.584878	0.546119	0.55254	0.578889	0.54494	0.519648	0.504672	0.487945

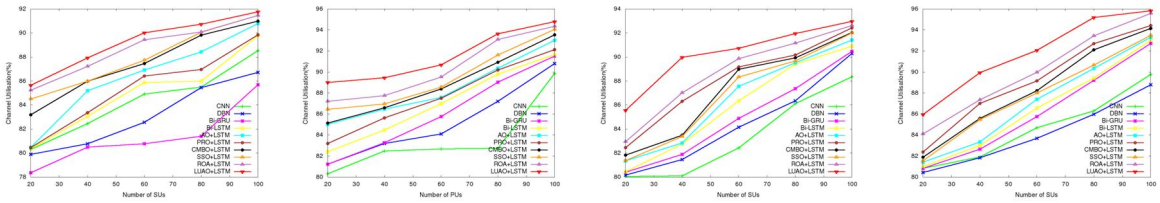
TABLE V. BACKOFF ANALYSIS OF LU-AO + LSTM OVER EXTANT MODELS FOR 2ND EXPERIMENT REGARDING VARIED SU

Number of SUs	CNN	DBN	Bi-GRU	BI-LSTM	AO+LSTM	PRO+LSTM	CMBO + LSTM	SSO + LSTM	ROA+ LSTM	LU-AO + LSTM
20	0.412747	0.410068	0.331487	0.306116	0.314033	0.322055	0.308629	0.305705	0.304381	0.296548
40	0.489389	0.488027	0.475268	0.356462	0.406407	0.442811	0.377668	0.35433	0.331364	0.318517
60	0.562127	0.523316	0.516821	0.393245	0.456462	0.500895	0.425667	0.381269	0.368621	0.34176
80	0.6176	0.588452	0.560192	0.511459	0.534856	0.540228	0.519538	0.461285	0.408323	0.402766
100	0.621433	0.620806	0.606214	0.588197	0.593835	0.603733	0.590612	0.565791	0.535396	0.427187

TABLE VI. BACKOFF ANALYSIS OF LU-AO + LSTM OVER EXTANT MODELS FOR 2ND EXPERIMENT REGARDING VARIED PU

Number of PUs	CNN	DBN	Bi-GRU	BI-LSTM	AO+LSTM	PRO+LSTM	CMBO + LSTM	SSO + LSTM	ROA+ LSTM	LU-AO + LSTM
20	0.481099	0.436294	0.434995	0.412411	0.358706	0.343208	0.309032	0.331544	0.307116	0.295319
40	0.43549	0.525876	0.461306	0.444324	0.421373	0.407944	0.327174	0.364118	0.316543	0.309157
60	0.526233	0.529894	0.500819	0.470842	0.465777	0.460072	0.422576	0.444432	0.367754	0.34185
80	0.556639	0.573624	0.539652	0.538672	0.526433	0.498355	0.484349	0.493859	0.479276	0.446189
100	0.611373	0.618458	0.583662	0.574332	0.568604	0.553689	0.518197	0.534856	0.517474	0.490908

and Pus, the channel utilization values also rises. For all count of SU and Pus, the LU-AO + LSTM has performed better over CNN, DBN, Bi-GRU, Bi-LSTM, AO + LSTM, PRO+ LSTM, CMBO + LSTM, SSO + LSTM and ROA + LSTM. Thus, the development of LU-AO + LSTM is proved over others.



(a) (b) (c) (d)

Figure 3. Channel Utilization under (a) and (b) SU and PU for Experiment 1 (c) and (d) SU and PU for Experiment 2

VII. CONCLUSION

This paper proposed a new secured communication approach through the available predicted spectrum channels. Here, channel states were predicted via optimized LSTM. For secured communication, this work deployed improved ECC that guaranteed the security level of data frames. Accordingly, the channel state was predicted by means of LU-AO. On noting the outcomes, LU-AO + LSTM has gained lower sensing delay values of 0.07 for varied PU for 2nd experiment. This was much better than CNN, DBN, Bi-GRU, Bi-LSTM, AO + LSTM, PRO+ LSTM, CMBO + LSTM, SSO + LSTM and ROA + LSTM for both experiments. Thus, the LU-AO + LSTM model was proven with improved ECC over others.

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