Design and Implementation of AES Data Security Protocol

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ABSTRACT

Data Security is in top priority when we transmit the data through internet. In this paper AES (Advanced Encryption Standard) algorithm is implemented using FPGA for security of IoT data. We used symmetric key block cipher for data encryption and decryption. The power consumption and area required for FPGA implementation is less. The Xilinx FPGA device Xc7v285tl-1L ffg 1157 is used for implementation

KEY WORDS: AES, FPGA, IOT, ENCRYPTION, DECRYPTION, XILINX.

INTRODUCTION

Security is one of the most important concerns of data transmission through Internet. The internet security protocols take care of the issues related to data security. In IoT [1] through its own architecture and devices it gives the solution to the data security. The data security solution has direct relation to the cost and time to market. However, every solution has its own strength and weaknesses. Thus every IoT solution does not require the entire IoT security protocols. The main focus of this paper is to implement the AES [2][3] algorithm using FPGA for security of IoT data. The paper is divided into four different section, the first section gives the introduction

whereas second, third and fourth section focuses on the hardware implementation, result and conclusion.

2. Hardware implementation: The Encryption and Decryption process in each round is as per the fig-1.

a. AddSubbytes: Each entry in the S box is replaced by the add sub byte. Non linearity in the cipher is also provided by add sub byte. To derive the S-box multiplicative inverse iGF (28) is used. The combination of inverse function with an invertible transformation gives S-box. While designing the decryption process the inverse of subbytes is used.

b. Shiftrows: In this, the bytes in rows shifted left cyclically. Every row is shifted with respect to the subsequent rows. In AES algorithm the shifting operation will be performed from the second row. The rows are shifted as follows:

2nd row is shifted by 1

3rd row is shifted by 2

4th row is shifted by 3 and so on

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Figure 1: Flow Chart of Encryption and Decryption Process

Figure 2: Proposed FPGA Implementation Module [6]

c. Mixcolumns: Each column is multiplied by the fixed polynomial. By using an invertible linear transformation the four bytes of each column of the state are combined.

d. Addround key: The XOR operation [4] will be performed between each and every state and 8 bit data of round sub key. The output is combined with the subkey. The subkey is added with each byte of the state. It is done by using XORing operation. A required subkey is derived from the main key.

e. Keyexpansion: The key expansions are based on ROTWORD, SUBWORD, RCON and XOR. The key expansion algorithm is used to generate linear array of 44 words i.e 176 bytes. The input to the algorithm is a four word (16 bytes) for generating this. It provides four-word round key which is used for initial operation of AddRoundKey and each of the 10 rounds of the cipher. The key is copied into the first four words of the expanded key to derive the S-box. [5]. The S-Box is

the output of the combination of inverse function and invertible transformation. The Decryption operation is exactly reverse operation of Encryptions

RESULTS

Input = 32 43 f6 a0 88 5a 30 8d 31 31 98 a2 e0 37 07 34

Cipher Key = 2b 7e 15 16 28 ae d2 a6 ab f7 15 88 09 cf 4f 3c

32	88	31	e0													2b	28	ab	09
43	5a	31	37													7e	ae	f7	cf
f6	30	98	07													15	d2	15	4f
a8	8d	a2	34													16	a6	88	3c

19	a0	9a	e9	d4	e0	b8	1e	d4	e0	be	b8	04	e0	48	29	A0	88	23	2a
3d	f4	31	37	27	bf	b4	41	bf	b4	41	1e	66	cb	F8	06	fa	54	A3	6c
e3	e2	8d	48	11	98	5d	52	5d	52	11	27	81	19	D3	26	fe	2c	29	70
Be	2b	2a	08	ae	f1	e5	30	30	ae	f1	98	e5	9a	7a	4e	17	B1	39	05

Output

39	02	dc	19
25	dc	11	6a
84	09	85	0b
1d	fb	97	32

a. Result after subbytes and shift rows

Messages		
/M_SubBytes16/in	193de3bea0f4e22b5	193de3bea0f4e22b59ac68d2ae5f84808
/M_SubBytes16/out	d42711aee0bf98f1b	d42711aee0bf98f1b8b45de51e415230

Messages		
/M_Shift_Rows/S_B...	d42711aee0bf98f1b	d42711aee0bf98f1b8b45de51e415230
/M_Shift_Rows/Shif...	d4bf5d30e0b452aet	d4bf5d30e0b452aeb84111f1e2798e5

b. Results after mix columns

Messages		
/M_MixedColumns128Bit/DataIn	d4bf5d30e0b452aet	d4bf5d30e0b452aeb84111f1e2798e5
/M_MixedColumns128Bit/DataOut	046681e5e0cb199a	046681e5e0cb199a48f8d37a2806264c
/M_MixedColumns128Bit/word1/a	11010100	11010100
/M_MixedColumns128Bit/word1/b	10111111	10111111
/M_MixedColumns128Bit/word1/c	01011101	01011101
/M_MixedColumns128Bit/word1/d	00110000	00110000
/M_MixedColumns128Bit/word1/out	0000010001100110	0000010001100110100000111100101
/M_MixedColumns128Bit/word1/...	11010100	11010100
/M_MixedColumns128Bit/word1/...	10111111	10111111
/M_MixedColumns128Bit/word1/...	01011101	01011101
/M_MixedColumns128Bit/word1/...	00110000	00110000
/M_MixedColumns128Bit/word1/...	00000100	00000100
/M_MixedColumns128Bit/word1/...	01101011	01101011
/M_MixedColumns128Bit/word1/...	01101101	01101101

c. Result after adding round key

Messages		
/M_Add_round_key...	046681e5e0cb199a	046681e5e0cb199a48f8d37a2806264c
/M_Add_round_key...	a0fafe1788542cb12	a0fafe1788542cb123a339392a6c7605
/M_Add_round_key...	a49c7ff2689f352b6b	a49c7ff2689f352b6b5bea4302a5049