CPEN 311: Digital Systems Design

Introduction to Lab 6

2015/2016 Term 1

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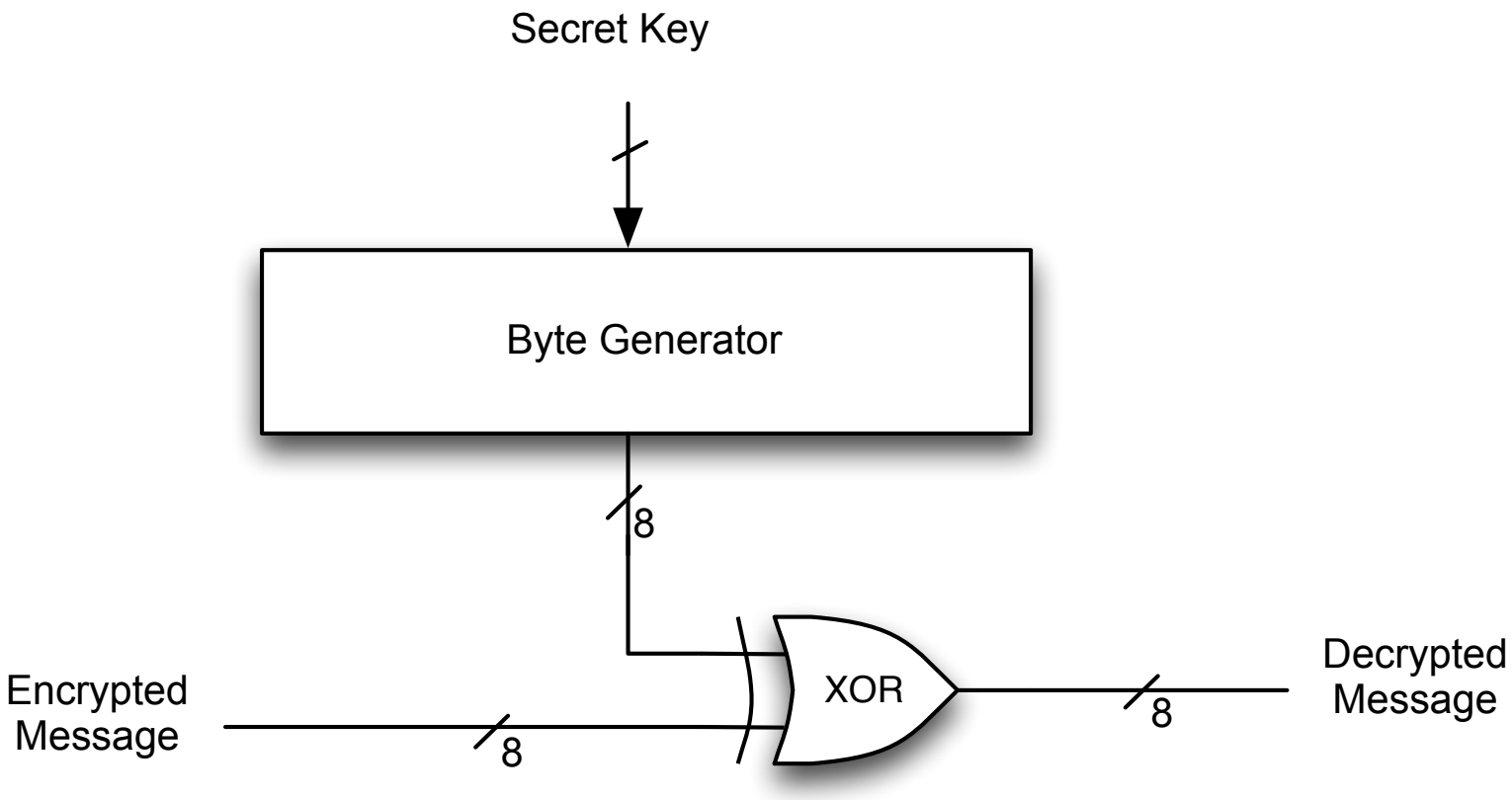
Stream Cipher



```
// Input:
//          secret_key [] : array of bytes that represent the secret key.  In our implementation,
//                          we will assume a key of 24 bits, meaning this array is 3 bytes long
//          encrypted_input []:  array of bytes that represent the encrypted message.  In our
//                          implementation, we will assume the input message is 32 bytes
// Output:
//          decrypted _output []:  array of bytes that represent the decrypted result.  This will
//                          always be the same length as encrypted_input [].

// initialize s array.  You will build this in Task 1
for i = 0 to 255 {
          s[i] = i;
}
// shuffle the array based on the secret key.  You will build this in Task 2
j = 0
for i = 0 to 255 {
          j = (j + s[i] + secret_key[i mod keylength] ) mod 256  //keylength is 3 in our impl.
          swap values of s[i] and s[j]
}
// compute one byte per character in the encrypted message.  You will build this in Task 2
i = 0, j=0
for k = 0 to message_length-1 {   // message_length is 32 in our implementation
          i = (i+1) mod 256
          j = (j+s[i]) mod 256
          swap values of s[i] and s[j]
          f = s[ (s[i]+s[j]) mod 256 ]
          decrypted_output[k] = f xor encrypted_input[k]   // 8 bit wide XOR function
}
```

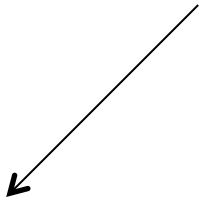
Task 1

Implement first loop of algorithm.

This will give you practice:

- Instantiating memories using MegaWizard
- Writing into memories
- Using the In-System Memory Content Editor

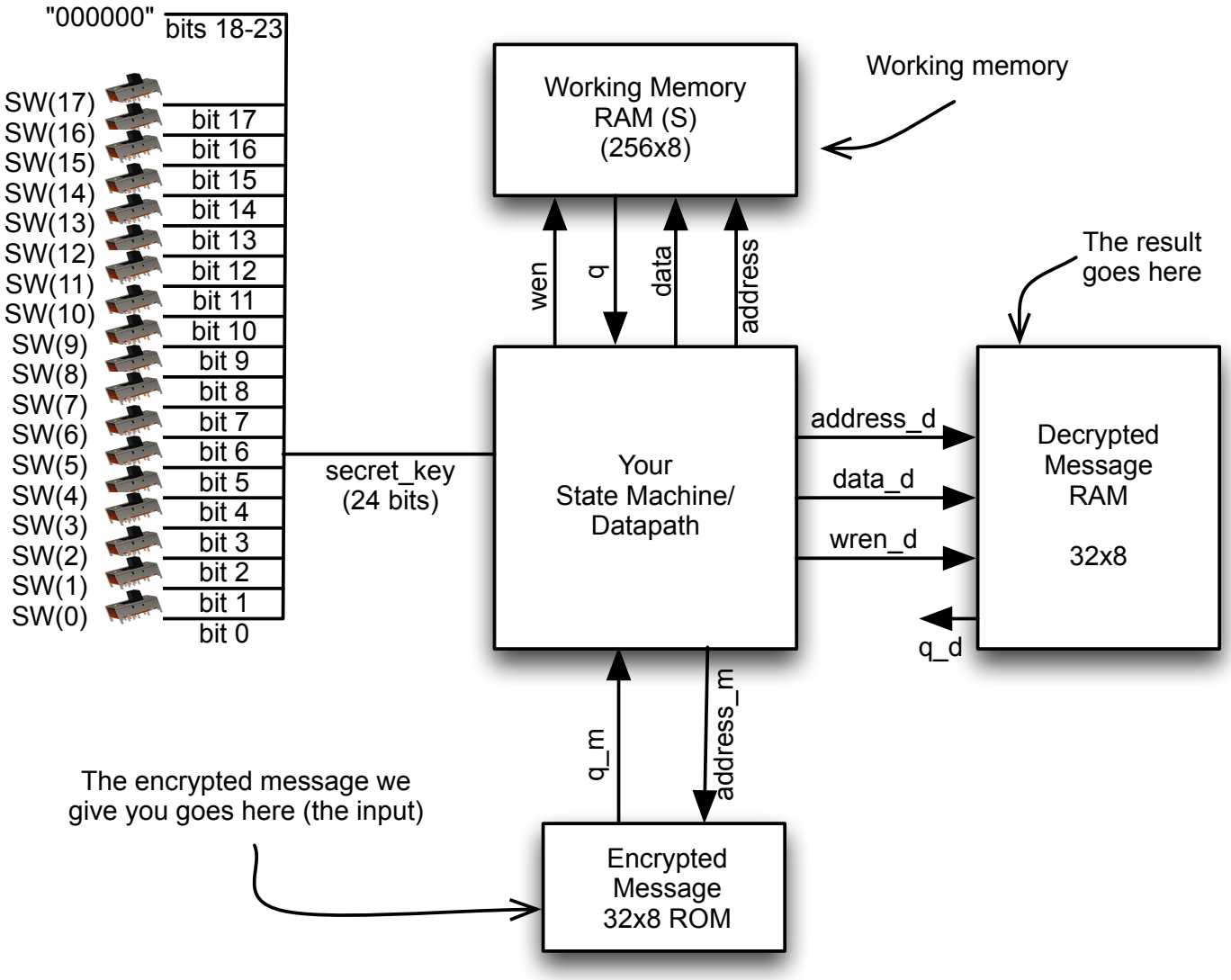
```
for i = 0 to 255 {
        s[i] = i;
}
```



Instance 0: S

000000	00	01	02	03	04	05	06	07	08	09	0A	0B	0C	0D	0E	0F	10	11	12	13	.....
000014	14	15	16	17	18	19	1A	1B	1C	1D	1E	1F	20	21	22	23	24	25	26	27	..... !"#$%&'
000028	28	29	2A	2B	2C	2D	2E	2F	30	31	32	33	34	35	36	37	38	39	3A	3B	()*+,-./0123456789:;
00003c	3C	3D	3E	3F	40	41	42	43	44	45	46	47	48	49	4A	4B	4C	4D	4E	4F	<=>?@ABCDEFGHIJKLMNO
000050	50	51	52	53	54	55	56	57	58	59	5A	5B	5C	5D	5E	5F	60	61	62	63	PQRSTUVWXYZ[\]^_`abc
000064	64	65	66	67	68	69	6A	6B	6C	6D	6E	6F	70	71	72	73	74	75	76	77	defghijklmnopqrstuvw
000078	78	79	7A	7B	7C	7D	7E	7F	80	81	82	83	84	85	86	87	88	89	8A	8B	xyz{|}~.....
00008c	8C	8D	8E	8F	90	91	92	93	94	95	96	97	98	99	9A	9B	9C	9D	9E	9F	.....
0000a0	A0	A1	A2	A3	A4	A5	A6	A7	A8	A9	AA	AB	AC	AD	AE	AF	B0	B1	B2	B3	.....
0000b4	B4	B5	B6	B7	B8	B9	BA	BB	BC	BD	BE	BF	C0	C1	C2	C3	C4	C5	C6	C7	.....
0000c8	C8	C9	CA	CB	CC	CD	CE	CF	D0	D1	D2	D3	D4	D5	D6	D7	D8	D9	DA	DB	.....
0000dc	DC	DD	DE	DF	E0	E1	E2	E3	E4	E5	E6	E7	E8	E9	EA	EB	EC	ED	EE	EF	.....
0000f0	F0	F1	F2	F3	F4	F5	F6	F7	F8	F9	FA	FB	FC	FD	FE	FF					.....

Task 2


"000000"
bits 18-23
SW(17)
SW(16)
SW(15)
SW(14)
SW(13)
SW(12)
SW(11)
SW(10)
SW(9)
SW(8)
SW(7)
SW(6)
SW(5)
SW(4)
SW(3)
SW(2)
SW(1)
SW(0)
bit 17
bit 16
bit 15
bit 14
bit 13
bit 12
bit 11
bit 10
bit 9
bit 8
bit 7
bit 6
bit 5
bit 4
bit 3
bit 2
bit 1
bit 0
secret_key
(24 bits)
Working Memory
RAM (S)
(256x8)
Working memory
wen
q
data
address
The result
goes here
Your
State Machine/
Datapath
address_d
data_d
wren_d
q_d
Decrypted
Message
RAM
32x8
q_m
address_m
The encrypted message we
give you goes here (the input)
Encrypted
Message
32x8 ROM

Task 3

RC-4 Cracking:

Cycle through all keys. For each key, if the message is something readable, you have cracked the message!

To make this feasible, you will assume 24 bit keys

- My implementation takes about 10 minutes to cycle through
- In the lab, bits 24 and 23 are both 0 -> 2.5 minutes

Scaling to a real implementation: 40 bits

$(10 \text{ min}) * 2^{(40-24)} = 455 \text{ days}$

We can probably fit about 8 of these on a chip -> 56 days

If the 20 groups in a lab got together -> 2.8 days

Challenge Task

Implement multiple “cores” on the chip

- When one finds the solution, all should stop