



Welcome to

PES University

Ring Road Campus, Bengaluru

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PESU Center for Information Security, Forensics and Cyber Resilience



APPLIED CRYPTOGRAPHY

Lecture 10



Perfect secrecy limitations

Can it be achieved!!!

Disadvantages



- Distribution of the key was a challenge
- Adding numbers to the plaintext manually, is a time-consuming task. It is therefore sometimes thought that OTPs are no longer considered practical

Using same key twice



- If c1= K ⊕ m1
- C2= k⊕m2
- Then c1 \bigoplus c2= (k \bigoplus m1) \bigoplus (k \bigoplus m2)=m1 \bigoplus m2
- This leaks information about m1 and m2
- If $m1 \oplus m2 = 0$ shows that m1=m2
- If m1 m2=1 shows m1!=m2
- Using frequency analyser they can decrypt the message

Same key more than once???



Hex	Dec	Char	Hex	Dec	Char	Hex	Dec	Char
0x20	32	Space	0x40	64	- 6	0x60	96	
0x21	33	1	0x41	65	A	0x61	97	a
0x22	34	00	0x42	66	В	0x62	98	b
0x23	35		0x43	67	C	0x63	99	C
0x24	36	\$	0x44	68	D	0x64	100	d
0x25	37	8	0x45	69	E	0x65	101	e
0x26	38		0x46	70	F	0x66	102	£
0x27	39		0x47	71	G	0x67	103	g
0x28	40	(0x48	72	н	0x68	104	h
0x29	41)	0x49	73	I	0x69	105	i
0x2A	42		0x4A	74	3	0x6A	106	j
0x2B	43	+	0x4B	75	K	0x6B	107	k
0x2C	44		0x4C	76	L	0x6C	108	1
0x2D	45	-	0x4D	77	M	0x6D	109	m
0x2E	46		0x4E	78	N	0x6E	110	n
0x2F	47	1	0x4F	79	0	0x6F	111	0
0x30	48	0	0x50	80	P	0x70	112	p
0x31	49	1	0x51	81	0	0x71	113	q
0x32	50	2	0x52	82	R	0x72	114	r
0x33	51	3	0x53	83	S	0x73	115	s
0x34	52	4	0x54	84	T	0x74	116	t
0x35	53	5	0x55	85	U	0x75	117	u
0x36	54	6	0x56	86	v	0x76	118	v
0x37	55	7	0x57	87	W	0x77	119	W
0x38	56	8	0x58	88	x	0x78	120	×
0x39	57	9	0x59	89	Y	0x79	121	y
0x3A	58	:	0x5A	90	Z	0x7A	122	
0x3B	59	:	0x5B	91	1	0x7B	123	(
0x3C	60	<	0x5C	92	1	0x7C	124	1
0x3D	61	-	0x5D	93	1	0x7D	125	1
0x3E	62	>	0x5E	94		0x7E	126	-
0x3F	63	2	0x5F	95		0x7F	127	DEL

- Letters all begin with 01...
- The space character begins with 00...
- XOR of two letters gives 00...
- XOR of letter and space gives 01...
- Easy to identify XOR of letter and space!

The Binary Version of One-Time Pad

```
Plaintext space = Ciphtertext space = Keyspace = {0,1}<sup>n</sup>
Key is chosen randomly
For example:
```

- Plaintext is 11011011
- Key is 01101001
- Then ciphertext is 10110010

Bit Operators

Bit AND

$$0 \wedge 0 = 0$$

$$0 \wedge 1 = 0$$

$$0 \land 0 = 0$$
 $0 \land 1 = 0$ $1 \land 0 = 0$ $1 \land 1 = 1$

Bit OR

$$0 \lor 0 = 0$$

$$0 \lor 1 = 1$$

$$0 \lor 0 = 0$$
 $0 \lor 1 = 1$ $1 \lor 0 = 1$ $1 \lor 1 = 1$

Addition mod 2 (also known as Bit XOR)

$$0 \oplus 0 = 0$$

$$0 \oplus 1 = 1$$

$$0 \oplus 0 = 0$$
 $0 \oplus 1 = 1$ $1 \oplus 0 = 11 \oplus 1 = 0$

- 1's compliment
- Left shift <<
- Right shift >>
- Can we use operators other than Bit XOR for binary version of One-Time Pad?

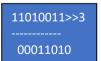
Bitwise Operators - Examples







~11010011 -----00101100



11010011<<3 ------10011000

Key Randomness in One-Time Pad

- One-Time Pad uses a very long key, what if the key is not chosen randomly, instead, texts from, e.g., a book are used as keys.
 - this is not One-Time Pad anymore
 - this does not have perfect secrecy
 - this can be broken
 - How?
- The key in One-Time Pad should never be reused.
 - If it is reused, it is Two-Time Pad, and is insecure!
 - Why?

Usage of One-Time Pad

- To use one-time pad, one must have keys as long as the messages.
- To send messages totaling certain size, sender and receiver must agree on a shared secret key of that size.
 - typically by sending the key over a secure channel
- This is difficult to do in practice.
- Can't one use the channel for send the key to send the messages instead?
- Why is OTP still useful, even though difficult to use?

Usage of One-Time Pad

 The channel for distributing keys may exist at a different time from when one has messages to send.

- The channel for distributing keys may have the property that keys can be leaked, but such leakage will be detected
 - Such as in Quantum cryptography

Summary



- Cryptology
 - Cryptography
 - Cryptanalysis
- Classical cryptography
 - Substitution ciphers
 - Transposition ciphers
- Steganography
- Cryptographic attack
- Probability and Shannon's theorem
- Perfect secret system



Next Class

Mandatory reading for the next class

https://ieeexplore.ieee.org/document/7562224



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