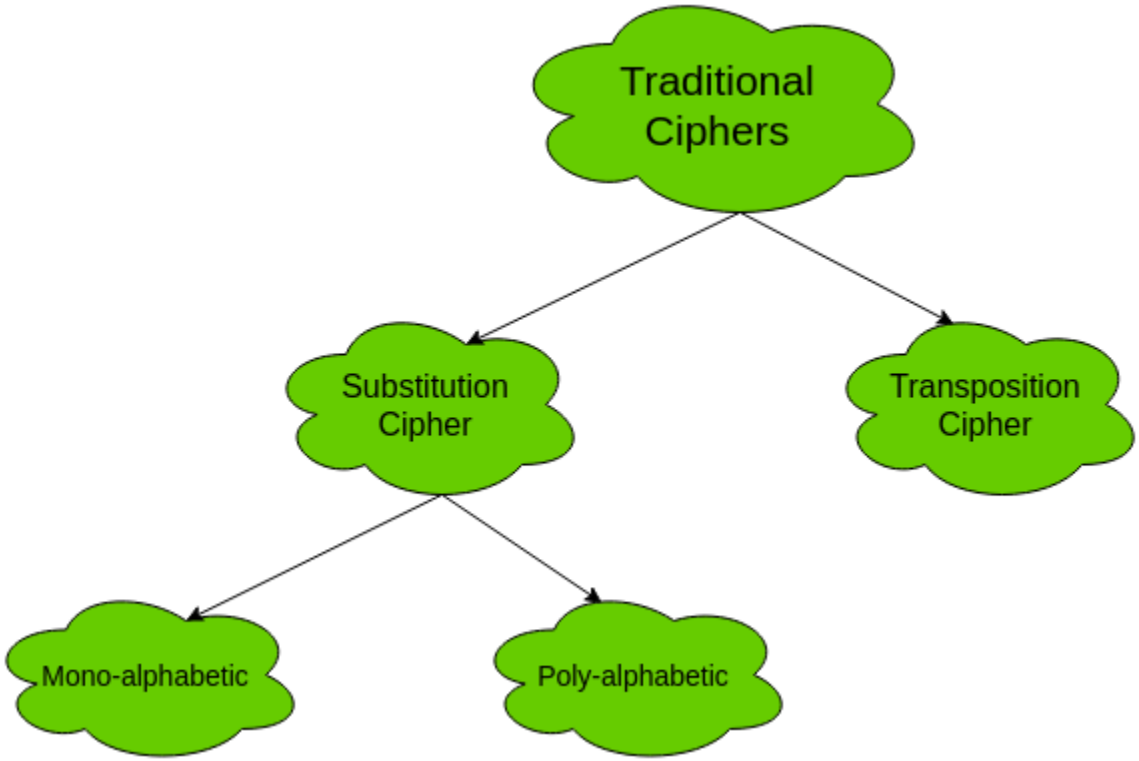
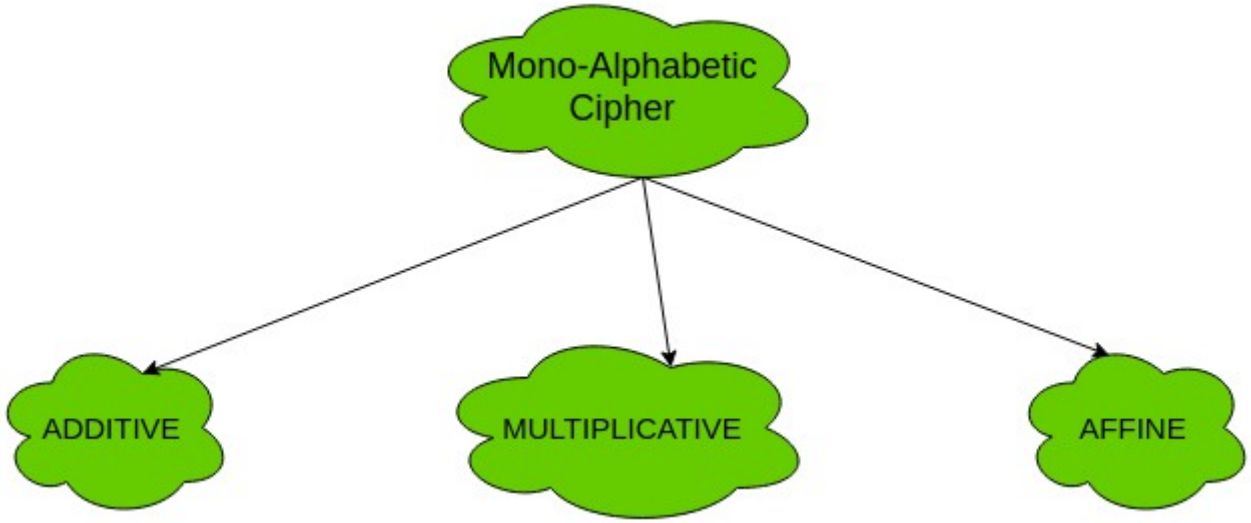
19Z701 - CRYPTOGRAPHY

Traditional Symmetric Ciphers

The two types of traditional symmetric ciphers are **Substitution Cipher** and **Transposition Cipher**.
The following flowchart categories the traditional ciphers:



Types of mono-alphabetic ciphers are:

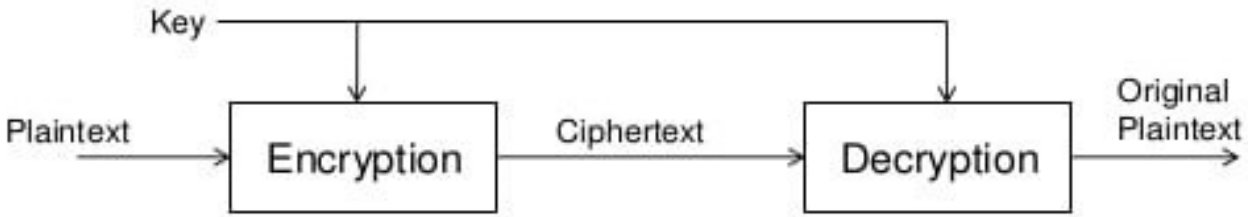


Encryption Algorithm

- Symmetric
  - Same key for encryption and decryption
  - Key distribution problem
- Asymmetric
  - Key pairs for encryption and decryption
  - Public and private keys

SYMMETRIC ALGORITHM

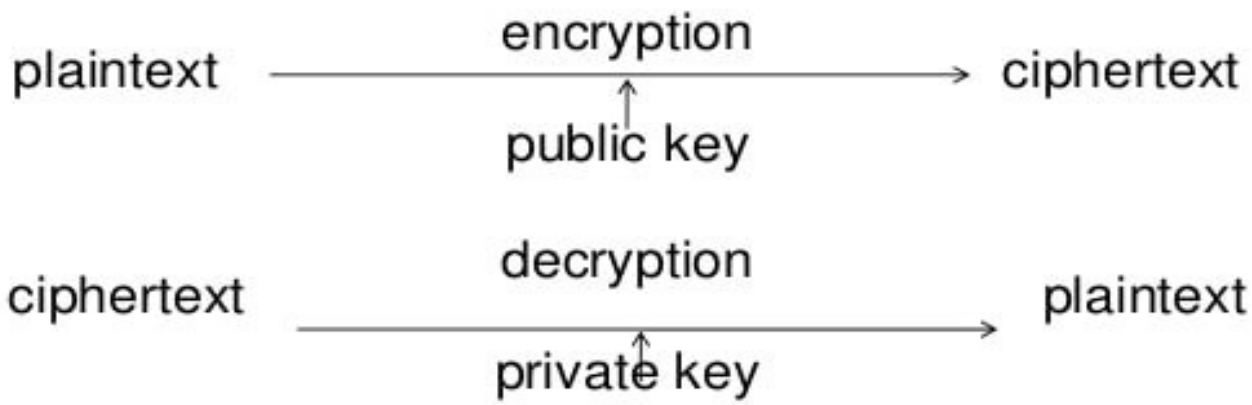
- It is also called as Secret Key Cryptography
  - Single key used for both encrypt & decrypt
  - Key must be known to both the parties



Symmetric Cryptosystem

ASYMMETRIC ALGORITHM

- Private keys are used for decrypting.
- Public keys are used for encrypting



Classical Substitution Ciphers

- where letters of plaintext are replaced by other letters or by numbers or symbols

- or if plaintext is viewed as a sequence of bits, then substitution involves replacing plaintext bit patterns with ciphertext bit patterns

Caesar Cipher

- earliest known substitution cipher
- by Julius Caesar
- first attested use in military affairs
- replaces each letter by 3rd letter on
- example:

meet me after the toga party

PHHW PH DIWHU WKH WRJD SDUWB

Caesar Cipher

- can define transformation as:

  a b c d e f g h i j k l m n o p q r s t u v w x y z

  D E F G H I J K L M N O P Q R S T U V W X Y Z A B C

- mathematically give each letter a number

  a b c d e f g h i j k l m n o p q r s t u v w x y z

  0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25

- then have Caesar cipher as:

  $c = E(p) = (p + k) \bmod (26)$

  $p = D(c) = (c - k) \bmod (26)$

Cryptanalysis of Caesar Cipher

- only have 26 possible ciphers
  - A maps to A,B,..Z
- could simply try each in turn
- a **brute force search**
- given ciphertext, just try all shifts of letters
- do need to recognize when have plaintext
- eg. break ciphertext "GCUA VQ DTGCM"

Example Cryptanalysis

- given ciphertext:

```
UZQSOVUOHXMOPVGPOZPEVSGZWSZOPFPESXUDBMETSXAIZ
VUEPHZHMDZSHZOWSFPAPPDTSVPQUZWYMXUZUHSX
EPYEPOPDZSZUFPOMBZWPFUPZHMDJUDTMOHMQ
```

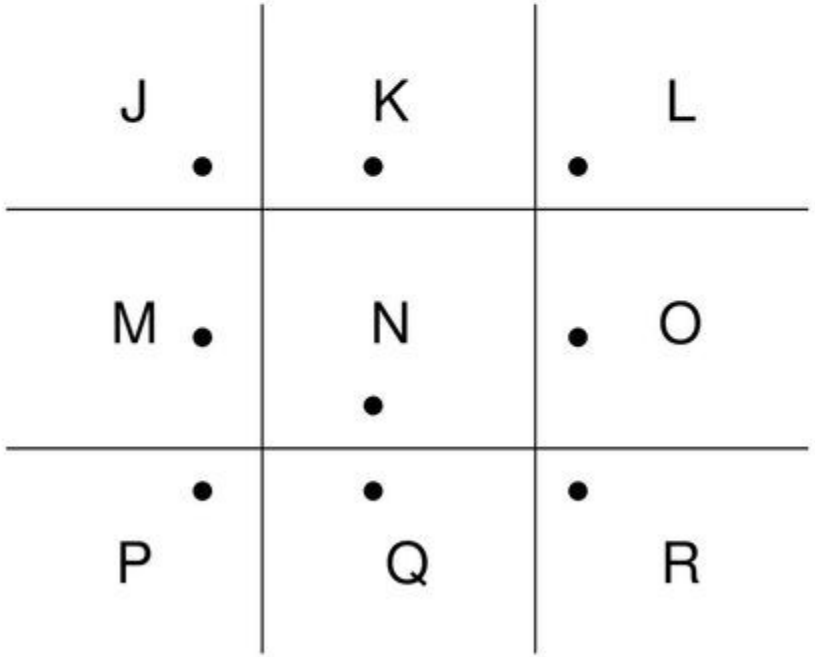
- count relative letter frequencies (see text)
- guess P & Z are e and t
- guess ZW is th and hence ZWP is the
- proceeding with trial and error finally get:

```
it was disclosed yesterday that several informal but
direct contacts have been made with political
representatives of the viet cong in moscow
```

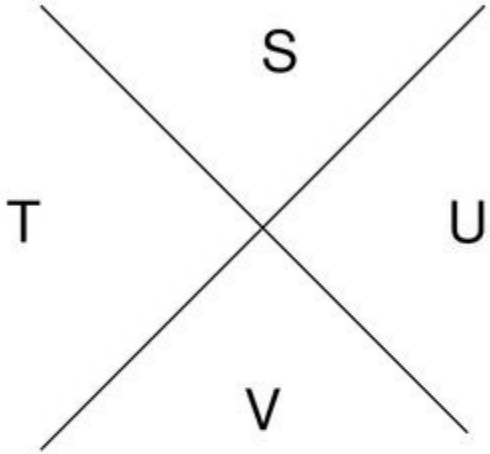
Pigpen Cipher

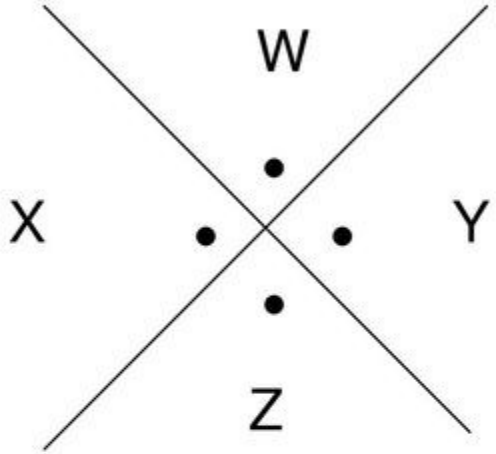
- Pigpen cipher is a variation on letter substitution
- Alphabets are arranged as follows:

A	B	C
D	E	F
G	H	I



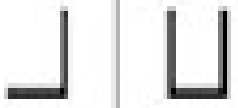
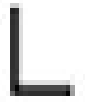
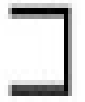
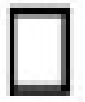
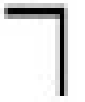
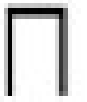
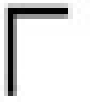
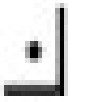
Pigpen Cipher diagram (cont'd

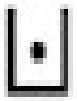
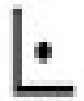
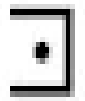
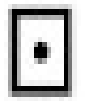
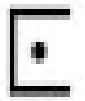
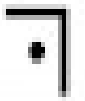
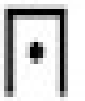
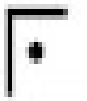
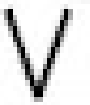


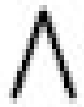


Pigpen Cipher

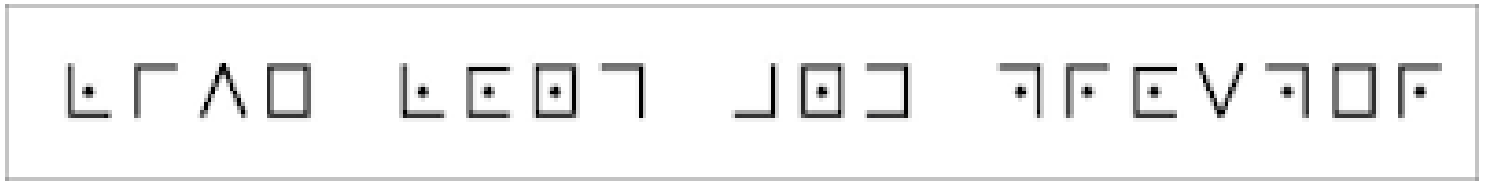
- Alphabets will be represented by the corresponding diagram
- E.g., WAG would be 
- This is a weak cipher

a	b	c	d	e	f	g	h	i	j
									

k	l	m	n	o	p	q	r	s	t
									

u	v	w	x	y	z				
									

Decode the following pigpen ciphertext:



Encode the following message using the pigpen cipher:

the truth is out there

ADFGVX Cipher

- This is a variation on substitution cipher and is a strong cipher

	A	D	F	G	V	X
A	8	p	3	d	1	n
D	l	t	4	o	a	h
F	7	k	b	c	5	z
G	j	u	6	w	g	m
V	x	s	v	i	r	2
X	9	e	y	0	f	q

ADFGVX Cipher

- Rules:
  - Remove spaces and punctuation marks from message
  - For each letter or number substitute the letter pair from the column and row heading
  - Next, use a transposition operation on the pair of letters using a key word (which the receiver knows)
  - Rearrange the columns of the new arrangement in alphabetical order
  - Finally, arrange the letters from consecutive columns

ADFGVX Cipher

- E.g., Message = SEE ME IN MALL
  - SEEMEINMALL
  - VDXDXDGXXDVGAXGXDVDADA
  - Use keyword of INFOSEC
  - Arrange the stage 1 ciphertext characters in a fresh grid with keyword as the column heading
  - Ciphertext is written in column order from left to right

ADFGVX Cipher

I	N	F	O	S	E	
V	D	X	D	X	D	
X	X	D	V	G	A	
G	X	D	V	D	A	

ADFGVX Cipher

C	E	F	I	N	O	S
G	D	X	V	D	D	X
X	A	D	X	X	V	G
V	A	D	G	X	V	D

ADFGVX Cipher

- Ciphertext is:
  GXVDAAXDDVXGDXXDVVXGD
- Recipient reverses the process using the same keyword and gets the plaintext
- Reason for this cipher using the name ADFGVX is that in Morse code these characters all have dissimilar patterns of dots and dashes

Multiplicative Cipher

- The multiplicative cipher is similar to additive cipher except the fact that the key bit is multiplied to the plain-text symbol during encryption. Likewise, the cipher-text is multiplied by the multiplicative inverse of key for decryption to obtain back the plain-text.

$C = (M * k) \bmod n$
$M = (C * k^{-1}) \bmod n$

- where,
  k^{-1} -> multiplicative inverse of k (key)
- The key space of multiplicative cipher is 12. Thus, it is also not very secure.

Multiplicative Cipher

If multiplication is used to convert to cipher text, it is called a **wrap-around** situation. Consider the letters and the associated numbers to be used as shown below −

0	1	2	3	4	5	6	7	8	9	10	11	12
A	B	C	D	E	F	G	H	I	J	K	L	M
13	14	15	16	17	18	19	20	21	22	23	24	25
N	O	P	Q	R	S	T	U	V	W	X	Y	Z

The numbers will be used for multiplication procedure and the associated key is 7. The basic formula to be used in such a scenario to generate a multiplicative cipher is as follows −

```
(Alphabet Number * key)mod(total number of alphabets)
```

Plaintext Symbol	Number	Encryption with Key 7	Ciphertext Symbol
A	0	(0 * 7) % 26 = 0	A
B	1	(1 * 7) % 26 = 7	H
C	2	(2 * 7) % 26 = 14	O
D	3	(3 * 7) % 26 = 21	V
E	4	(4 * 7) % 26 = 2	C
F	5	(5 * 7) % 26 = 9	J
G	6	(6 * 7) % 26 = 16	Q
H	7	(7 * 7) % 26 = 23	X
I	8	(8 * 7) % 26 = 4	E
J	9	(9 * 7) % 26 = 11	L
K	10	(10 * 7) % 26 = 18	S
L	11	(11 * 7) % 26 = 25	Z
M	12	(12 * 7) % 26 = 6	G
N	13	(13 * 7) % 26 = 13	N
O	14	(14 * 7) % 26 = 20	U
P	15	(15 * 7) % 26 = 1	B
Q	16	(16 * 7) % 26 = 8	I
R	17	(17 * 7) % 26 = 15	P
S	18	(18 * 7) % 26 = 22	W
T	19	(19 * 7) % 26 = 3	D
U	20	(20 * 7) % 26 = 10	K
V	21	(21 * 7) % 26 = 17	R
W	22	(22 * 7) % 26 = 24	Y
X	23	(23 * 7) % 26 = 5	F
Y	24	(24 * 7) % 26 = 12	M
Z	25	(25 * 7) % 26 = 19	T