CLASS 32

14 March 2023 21:00

CLASS-32

Pattern Matching

Str = "abc abc aabbcc"

Ptr = bcab

→ Brute Force :- T.C = O(n*m)

→ LPS Array → T.C = O(n^3)

aabbaa

i = 0 j = 0

[aabbaa]

i++ j--

lps[i]

5

↳ optimized approach

↳ T.C = O(n)

lps[i++] lps[i-1]

Individual Algorithm

→ KMP Algorithm

↳ T.C = O(n+m) linear complexity

→ Rabin-Karp Algorithm

Brute Force

largest window K size window

Str = abc abc b c a a a a a'

T.C = O(n)

Pat = bcbc

bcbc

bccb

Inbuilt

1. Sliding window
2. Find function

Fixed size window

O(1)

s.erase(0), s.insert(a[i])

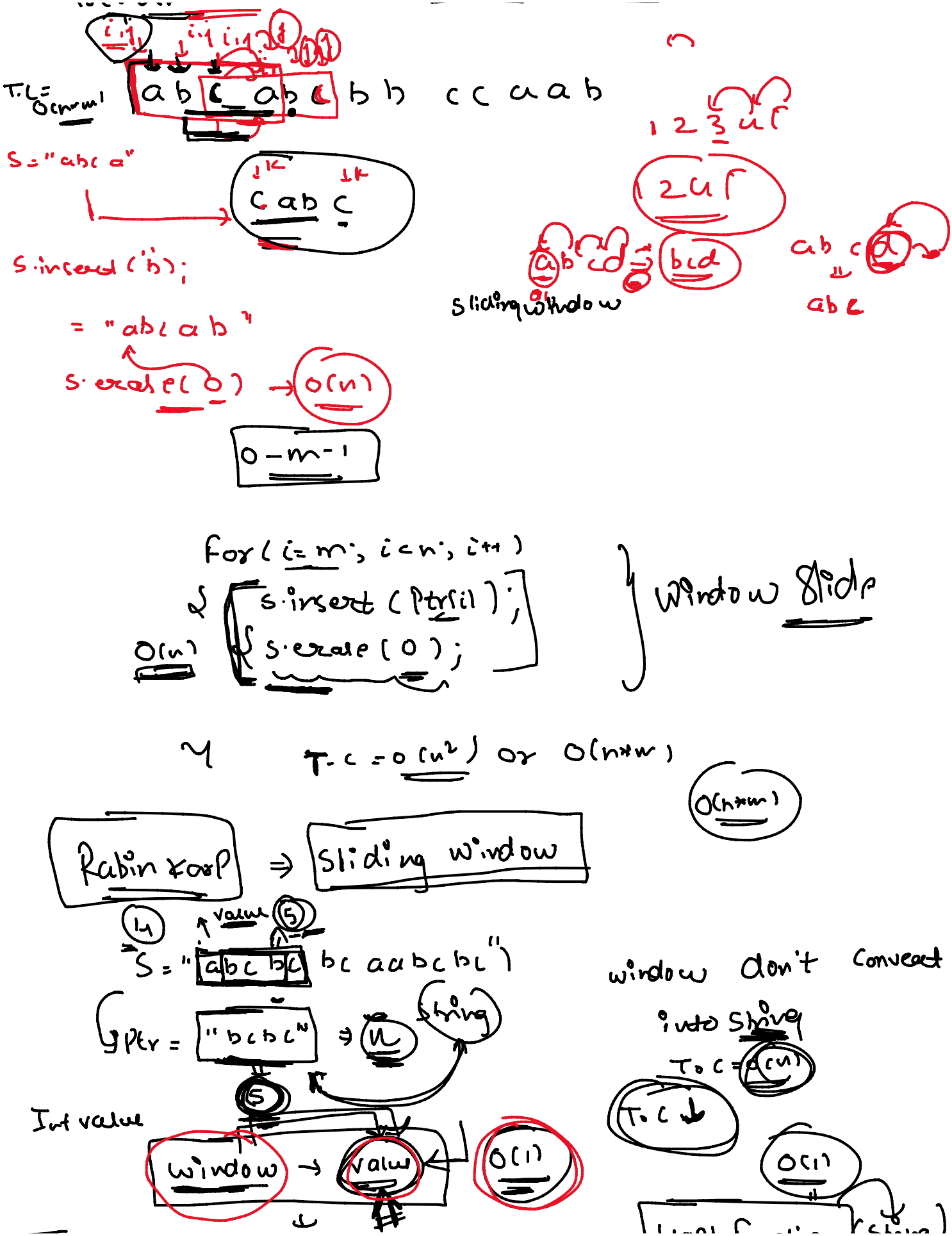
O(n)

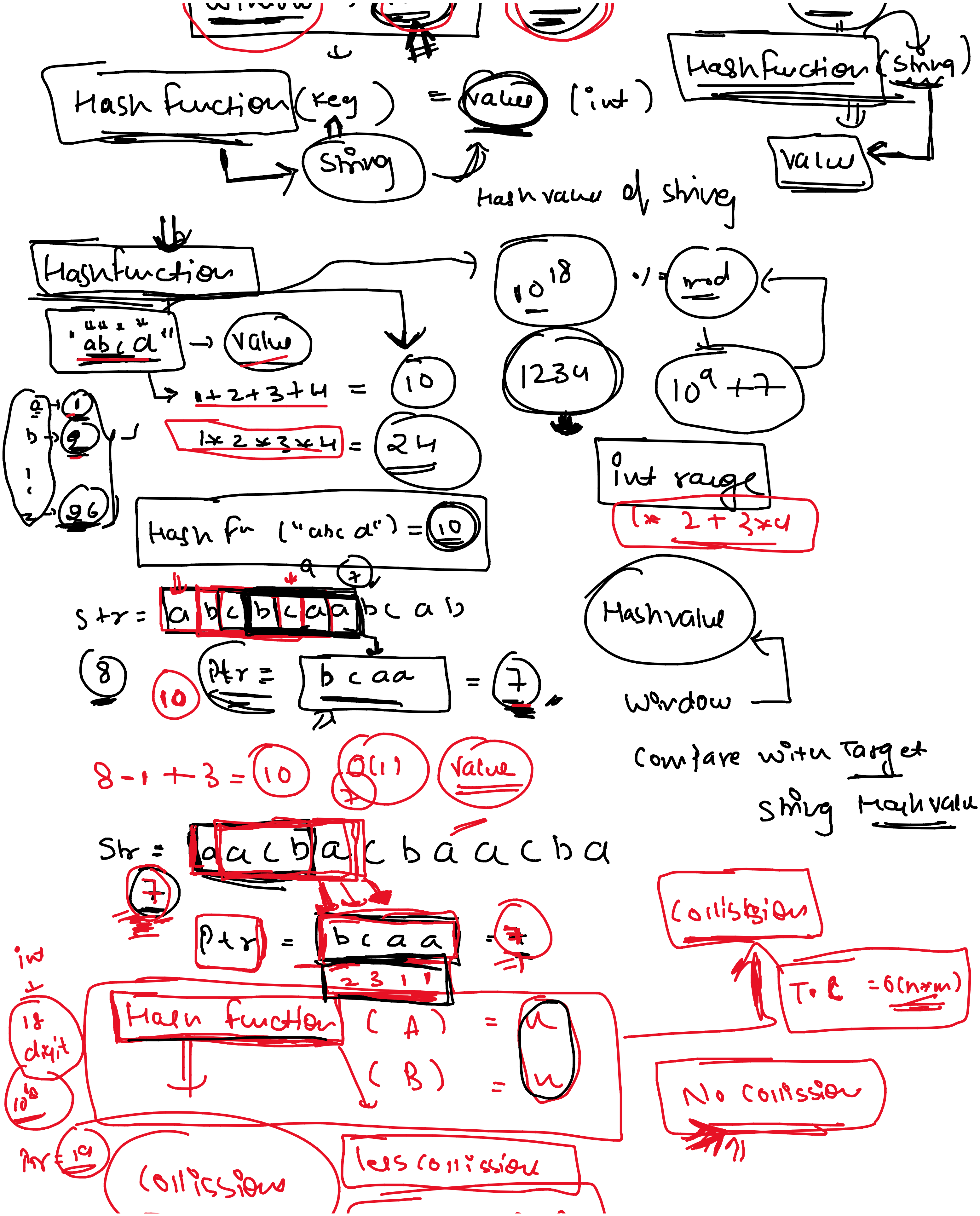
s == target

String = " "

T.C = O(n*m)

i, j i, j i, j


T.C = O(n*m)
a b c a b c b b c c a a b
S = "abc a"
c a b c
S.insert('b');
= "abc a b"
S.erase(0) → O(n)
O - m - 1
1 2 3 4
2 4
a b c d
b c d
Sliding window
a b c
a b c
For (i=m; i<n; i++)
S.insert (Ptr[i]);
S.erase (0);
O(n)
Window Slide
T.C = O(n²) or O(n*m)
O(n*m)
Rabin Karp ⇒ Sliding window
value
S = "a b c b c b c a a b c b c"
ptr = "b c b c"
String
Int value
window → value
O(1)
window don't connect into String
T.C = O(n)
T.C
O(1)


Hash fuction (key) = value (int)
string
Hashfuction (string)
value
Hash value of string
Hashfunction
10^18 % mod
1234
10^9 + 7
"abcd" → value
1+2+3+4 = 10
1*2*3*4 = 24
int range
1* 2+ 3*4
Hash fn ("abcd") = 10
str = abcbcaabcab
ptr = bcaa = 7
Hashvalue
window
8-1+3 = 10
O(1)
value
Compare with Target
string Hashvalue
Str = aacbacbaacba
ptr = bcaa = 7
2 3 1 1
Hash function (A) = u
(B) = u
Collission
T.C = O(n*m)
No Collission
less collission
Collission
18 digit
10^18

Collission

less collission

Hash value O(1)

n = a a c b c a a a a b c b c a a

Hash function

less No of Collision

m = b c a a

int hPtr = 0;

int htxt = 0;

for (i = 0; i < m; i++)

{ - - - - Hash fn Algo

}

window

if (hPtr == htxt)

if (txt.substr(0, m) == ptr)

return true;

}

for (i = m; i < n; i++) // window slides

{ // calculate Hashvalue of window (New window Hashvalue)

if (htxt == hPtr)

{ if (txt.substr(i-m, m) == Ptr)

return true;

}

worst case O(m*n)

Average case O(m+n)

Hash Function

Average case O(m*n)

n

Hash Function =

a a a a a a

aa

aabcccaa

ccaa

Hash Function

Rabin karp

Rabin-karp Algorithm

a, b, c ... d → 26 ≥ Prime No

[a b c d]

a → 97 (1)

a = 97 int

z = 122

$[97 * (n)^3 + 98 * (n)^2 + 99 * (n) + 100] \% q$

n = 26, 31

n ≥ 122

(31, 123)

n = 26, 31

a - 1 ... z - 26

q = Prime No

10^9+7

Hashing

Rabin karp

26, 31

"abcdef"

$= [1*(26)^6 + 2*(26)^5 + 3(26)^4 + \dots 6] \% q;$

10^9+7

Total character → 26 → 256 10^9+7

n-1 a a b c d a b c d O(1)

$\Rightarrow 1*(26)^3 + 1*(26)^2 + 2*(26)^1 + 3$

$- 1*(26)^3$

$\rightarrow [1*(26)^2 + 2*(26)^1 + 3] * 26$

$\rightarrow 1*(26)^3 + 2*(26)^2 + 3*(26)^1 + 4$

$(1*(26)^3 + 2*(26)^2 + 3*(26)^1 + 4$

O(1)

Collission

Average Case $\Rightarrow$ O(n+m) S.C = O(1)

KMP Rabin Karp Collission O(n*m)

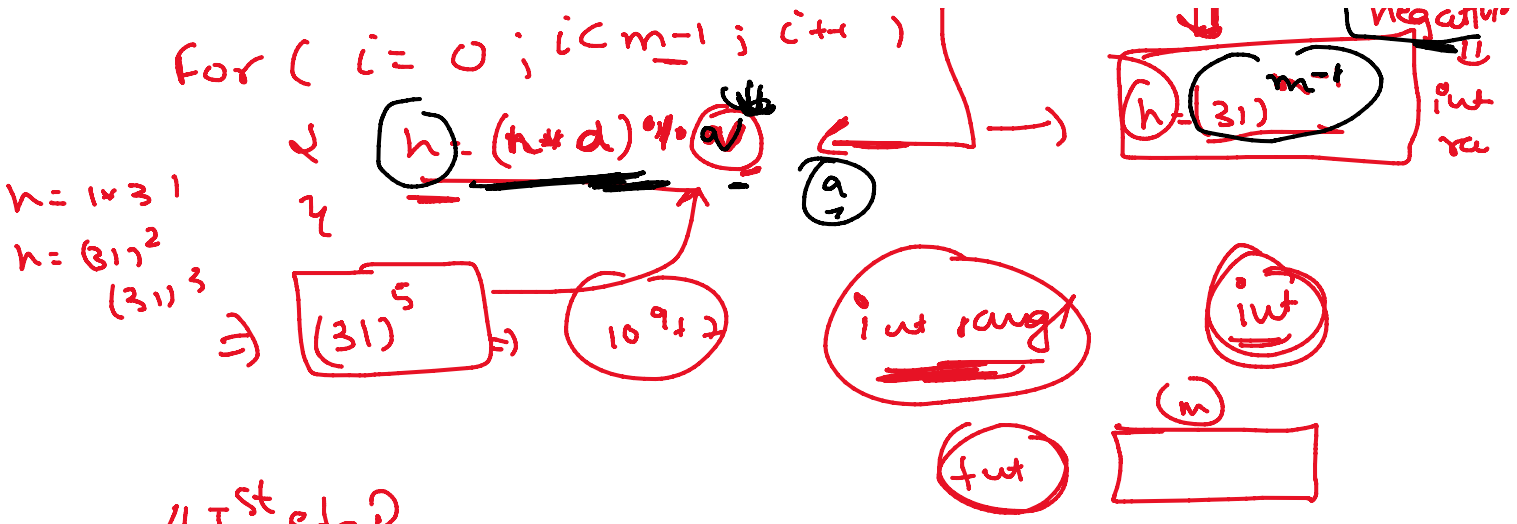
```
int m = Pat.size();
int n = txt.size();
int p = 0;   // Hash value of Ptrn
int t = 0;   //  "    "    "  window
int h = 1;
int q = 10^9+7;
int d = 31;
// 1st step
for ( i = 0 ; i < m-1 ; i++ )
```

(pow(31, m-1)) % q

Math

Pow(31, 6) $\Rightarrow 31^6$ % q

negative



// I st step

```
for ( i = 0; i < m; i++ )
    P = (d*P + ptr[i]) % mod;
    t = (d*t + txt[i]) % mod;
```

d = 31

ptr = a b c d

P = 31 * 0 + 1 = 1

P = (31 * 1 + 2)

P = (31 * (31 * 1 + 2)) + 3

= 1 * (31)^2 + 2 * (31) + 3

= 31 * (1 * (31)^2 + 2 * (31) + 3) + 4

= 1 * (31)^3 + 2 * (31)^2 + 3 * 31 + 4

```
vector <int> v(m-1, 0);
```

v[0] = 1 v[2] = (31)^2

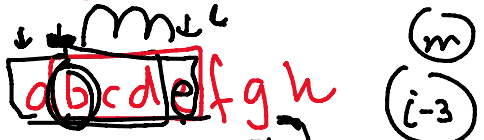
v[1] = (31)^1 v[3] = (31)^3

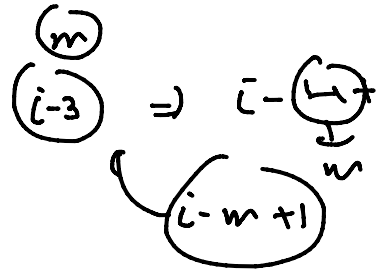
Or

```
For ( i=0; i<m ; i++ )
{  p=(p + txt[i] * r[m-i-1] ) %q;
}
```

2nd step

```
if ( p==t )
{ if ( txt.substr(0,m) == ptr )
    cout << " we Found the Pattern"
}
```





3rd step $\left[t - txt[i-m] * (31)^{m-1} \right]$

```
for ( i=m; i<n; i++ )
{ // calculate Hash value of new window
```

$$t = \left(d * \left[t - txt[i-m] * h \right] + txt[i] \right) \% q$$

$txt[i-m] - 'a' + 1$; $'a' - 'a'$; $a_7 - a_7 = 0 + 1$

$txt[i-m] - 'a' + 1$; $'a' - 'a'$

$d = 123$

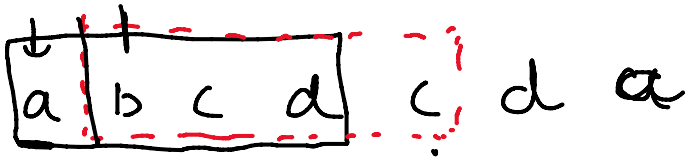
```
if (p==t)
{ if ( txt.substr( i-m+1, m) == ptr )
    cout << "  ";
}
```

$'b' - 'a' + 1$; $a_8 - a_7 + 1 = 2$

$$\Rightarrow 2*(31)^3 + 3*(31)^2 + 4*(31)^1 + 3$$

ptr = b c d C

Hash value



$h = 1*(31)^3 + 2*(31)^2 + 3*(31)^1 + 4$

$-1*(31)^3$

$h \Rightarrow (2*(31)^2 + 3*(31)^1 + 4) * 31$

$\Rightarrow 2*(31)^3 + 3*(31)^2 + 4*31 + 3$

$h < 0$

$h \% a$

$h + a$

$98(31)^3 + 2*(31)^2 + 3*(30)^1 + 4$

$- 98(31)^3$