

Problem (redo): Given a string S , find shortest string x such that xS is a palindrome.

claims: 1. $|x| \leq |S|$. — because S^R is a feasible answer.

2. Let P be longest prefix of S such that P is a palindrome.

$$S = P \cdot P'$$

$$x = P'R$$

— Equivalent problem: Find longest palindromic prefix of S .

3. If P is a palindrome, and $A \subseteq P$ is a prefix of P and $A \supseteq P$ is also a suffix of P , and $|A| \leq \frac{|P|}{2}$, then A is a palindrome.

4. Let $\#$ be a character not in S . Let $T = S\#S^R$. Find $\Pi[]$ of T — KMP prefix function. No proper prefix of T that includes $\#$ is a suffix of T . $\Pi[T.length] = \text{Length of longest prefix of } S \text{ that is a suffix of } S$.

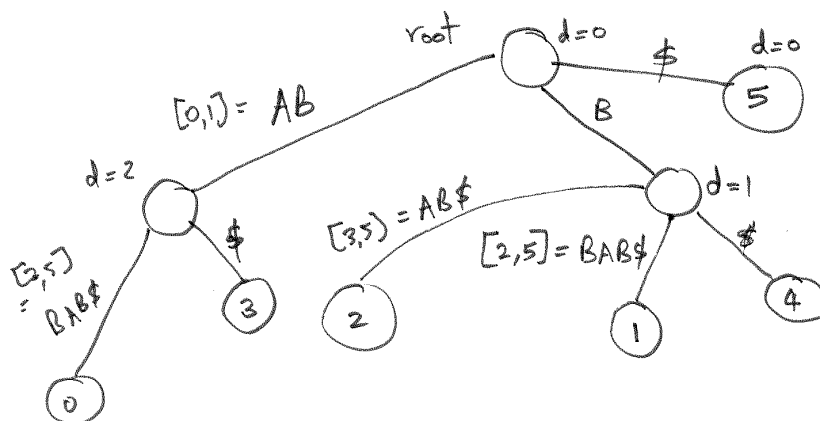
Suffix Trees — a compressed Trie

A tree that captures all suffixes of a given string.

$|S| = k$, then tree has $k+1$ leaves, one for each suffix of S .

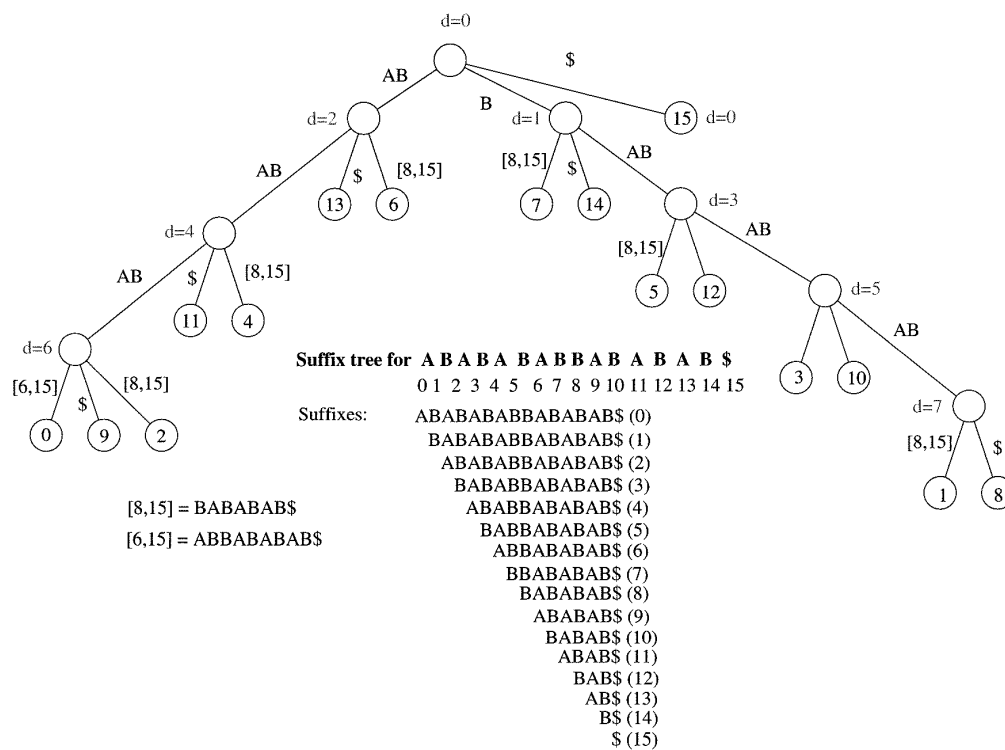
Ex: $ABBAB\#$ ← end of string marker.
 index: 0 1 2 3 4 5

Suffixes:



0 $ABBAB\#$
 1 $BBAB\#$
 2 $BAB\#$
 3 $AB\#$
 4 $B\#$
 5 $\#$

$O(n)$ algorithm due to Ukkonen ~~is~~ is known — complicated.



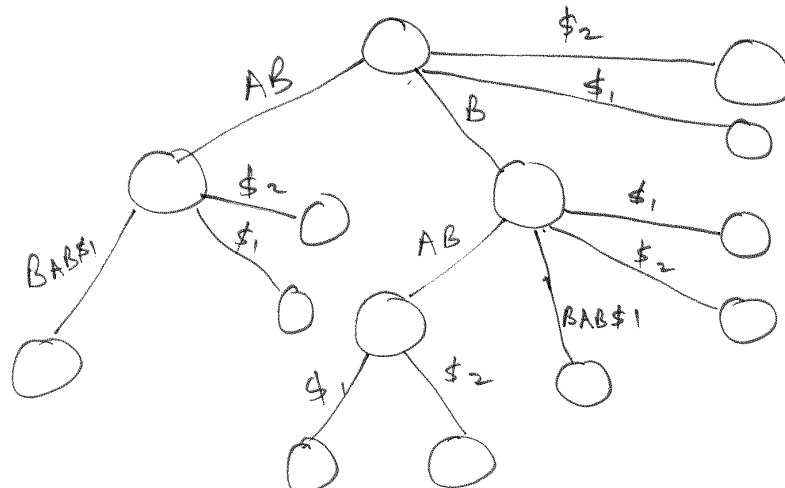
Generalized suffix trees

Given strings S_1, S_2, \dots, S_k , build a ^{generalized} suffix tree for them.

End markers $\$, \$2, \dots, \$k$

All suffixes of $S_1 \dots S_k$, do the suffix tree construction.

Ex: $ABBA B \$1$, $BAB \$2$



Problems:

1. Given text $T[1..n]$, Patterns $P_1[1..m_1], P_2[1..m_2], \dots, P_k[1..m_k]$
Search for each pattern in text.

KMP: $O(n + m_1 + n + m_2 + \dots + n + m_k) = O(nk + \sum_{i=1}^k m_i)$

Suffix trees: Build a suffix tree for $T - O(n)$

search for each pattern $- O(m_1 + m_2 + \dots + m_k)$

2. Given a string S , find a longest repeating substring of S .
Find a node at maximum depth with 2 or more leaves under it.
More generally, find a longest substring that appears at least k times in S .

3. Longest common substring of $T_1[1..n_1], T_2[1..n_2]$

Build a generalized suffix tree with T_1, T_2 .

Find a ~~node~~ node at max depth that has leaves that are suffixes of both strings.

4. Given T_1, \dots, T_k , find longest substring that appears in at least q strings.

Multi-threaded programming (in 10 mins)

(i) how. Interface: Runnable — one method:
void run()

```
class MyClass implements Runnable {  
    → Create a thread, call start() method of thread class.  
    public void run() {  
    }  
}
```

}

(ii) rules?

All threads share the same memory,

Multiple threads update same objects, unpredictable results are possible.

Solution: Synchronization.

(OS: Monitor, Mutual exclusion, ...)

Read up about: Synchronized, Semaphores, Monitors,
Messages between threads, CountDown ...