The Gapped-Factor Tree

PSC'06

Pierre Peterlongo[1] Julien Allali[1] Marie-France Sagot[2]

[1] Institut Gaspard-Monge, Université de Marne-la-Vallée

[2] Inria Rhône-Alpes, UMR 5558 Biometrie et Biologie Évolutive, Lyon and King's College, London

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Outline

Goal - Motivations

Overview

Preliminaries
- Ukkonen suffix tree construction
- k-factor tree construction (Allali - Sagot)

Construction Algorithm
- Construction
- Complexity

Conclusion

Goal - Motivations

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Ukkonen suffix tree construction

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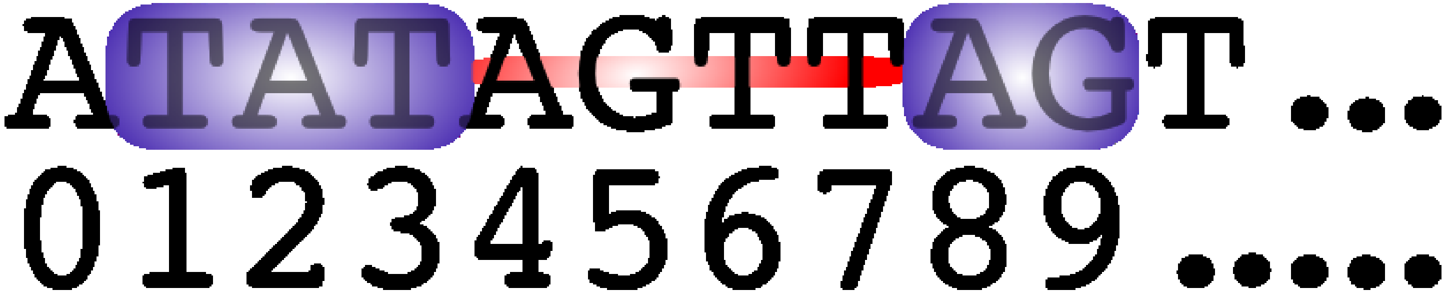
Goal

- Indexation of *gapped-factors* :
  - A k-factor,a gap of length d, and a k'-factor
  - a (k, d, k')-gapped-factor



Motivations

Stringology

- Extensive use of k-factors (q-gram, k-mer)
- Gapped-factors for sets of k-factors
- Indexation structure : interesting application of the suffix tree

Bioinformatics

- Motif inference
- Binding site detection

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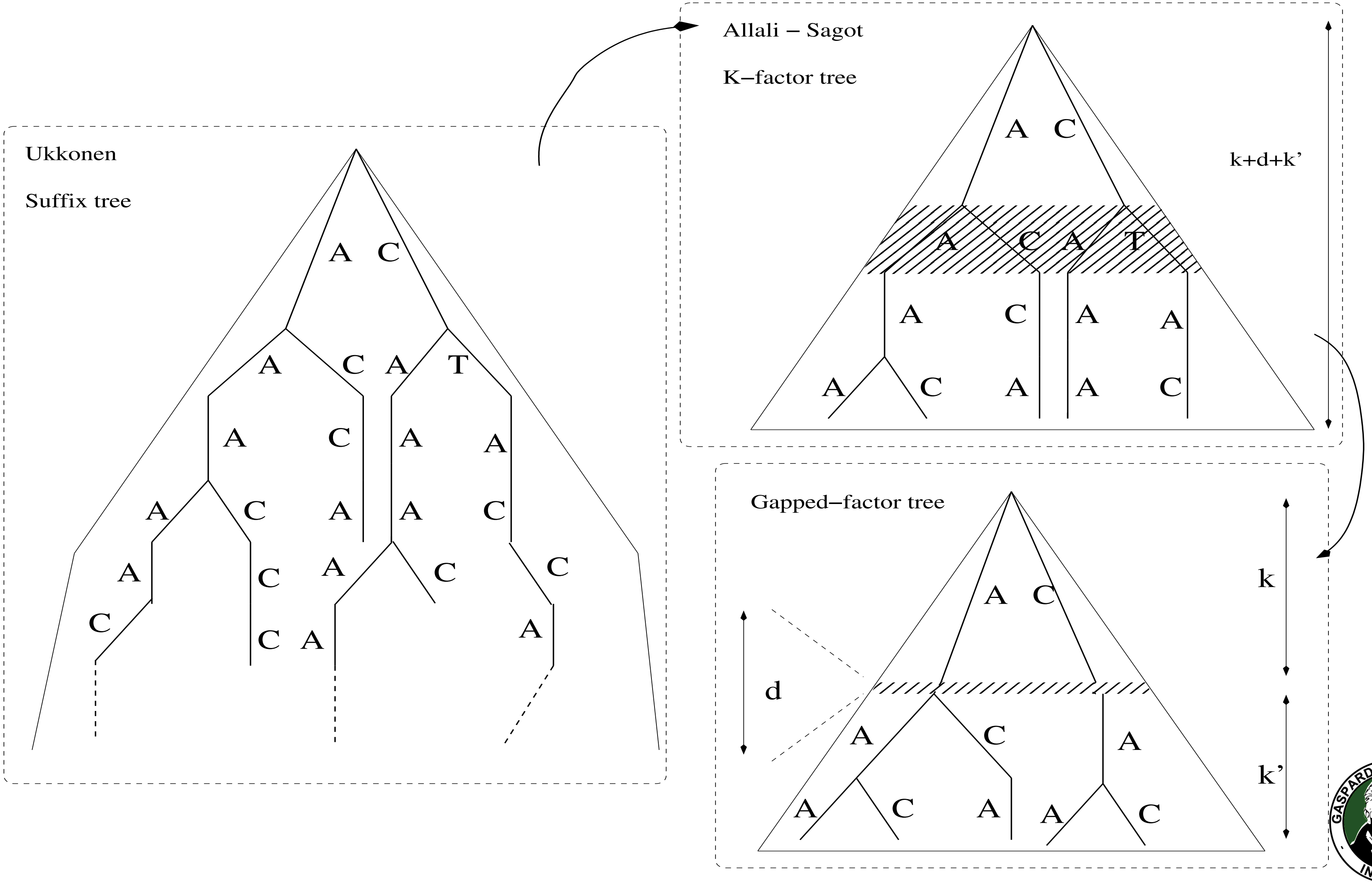

Ukkonen

Suffix tree

Allali – Sagot

K–factor tree

Gapped–factor tree

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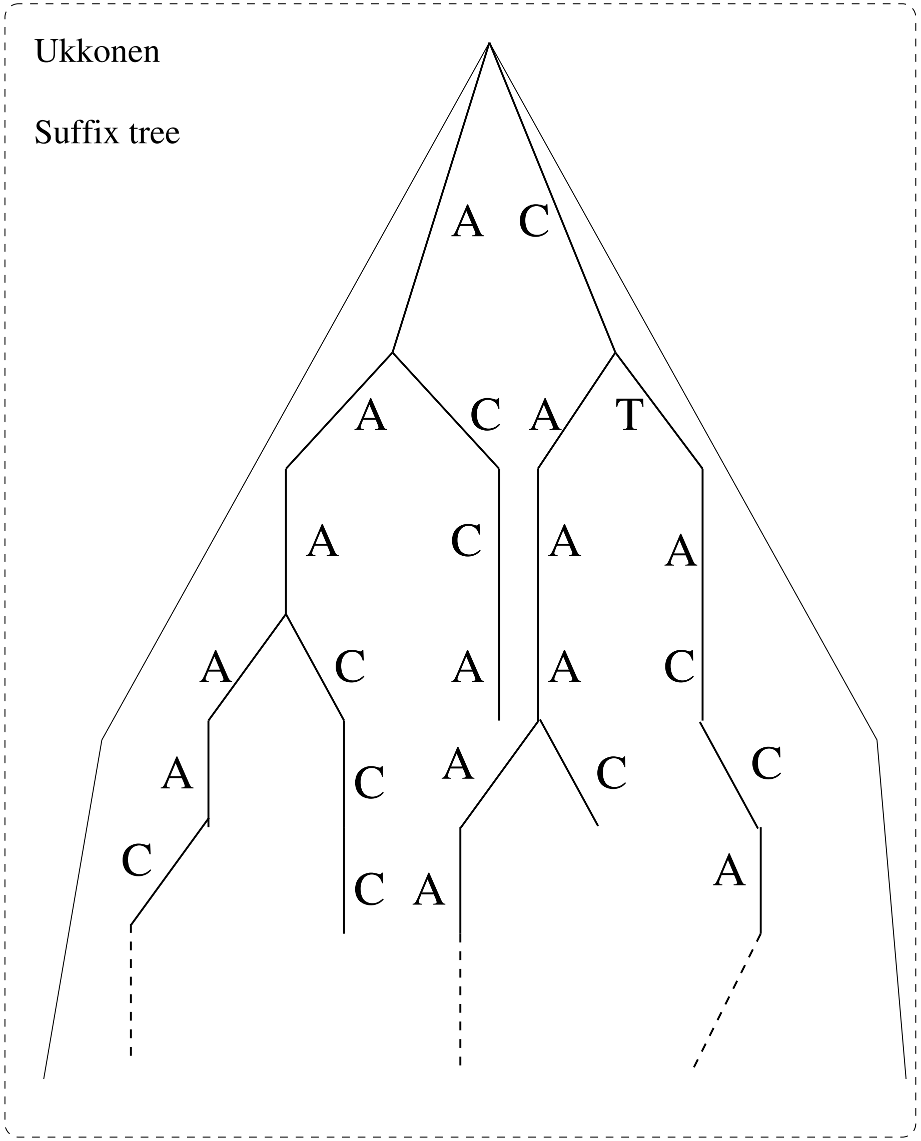
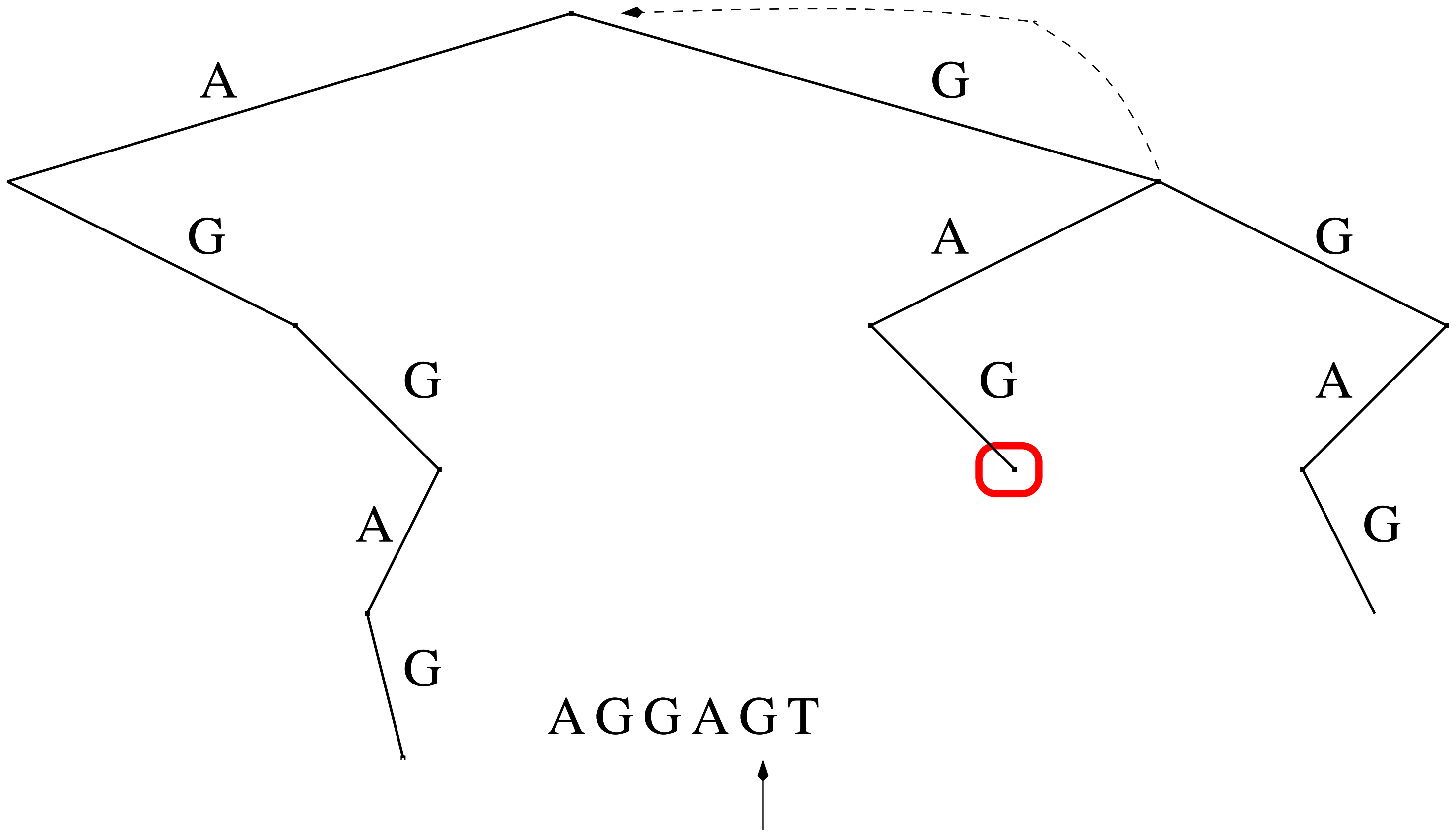


Ukkonen

Suffix tree

Suffix tree construction

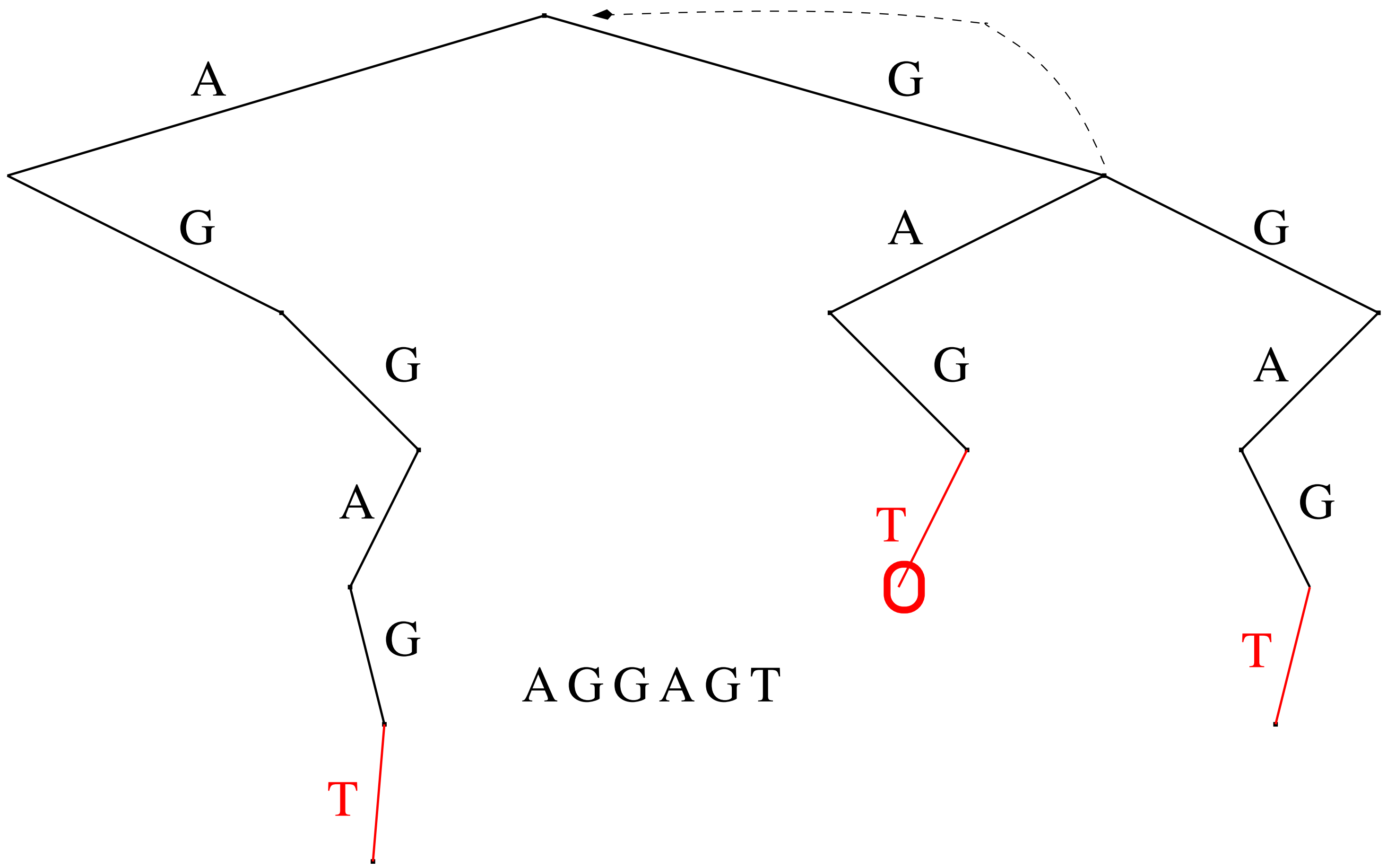
Suffix tree for *AGGAG*, *last_leaf* is marked



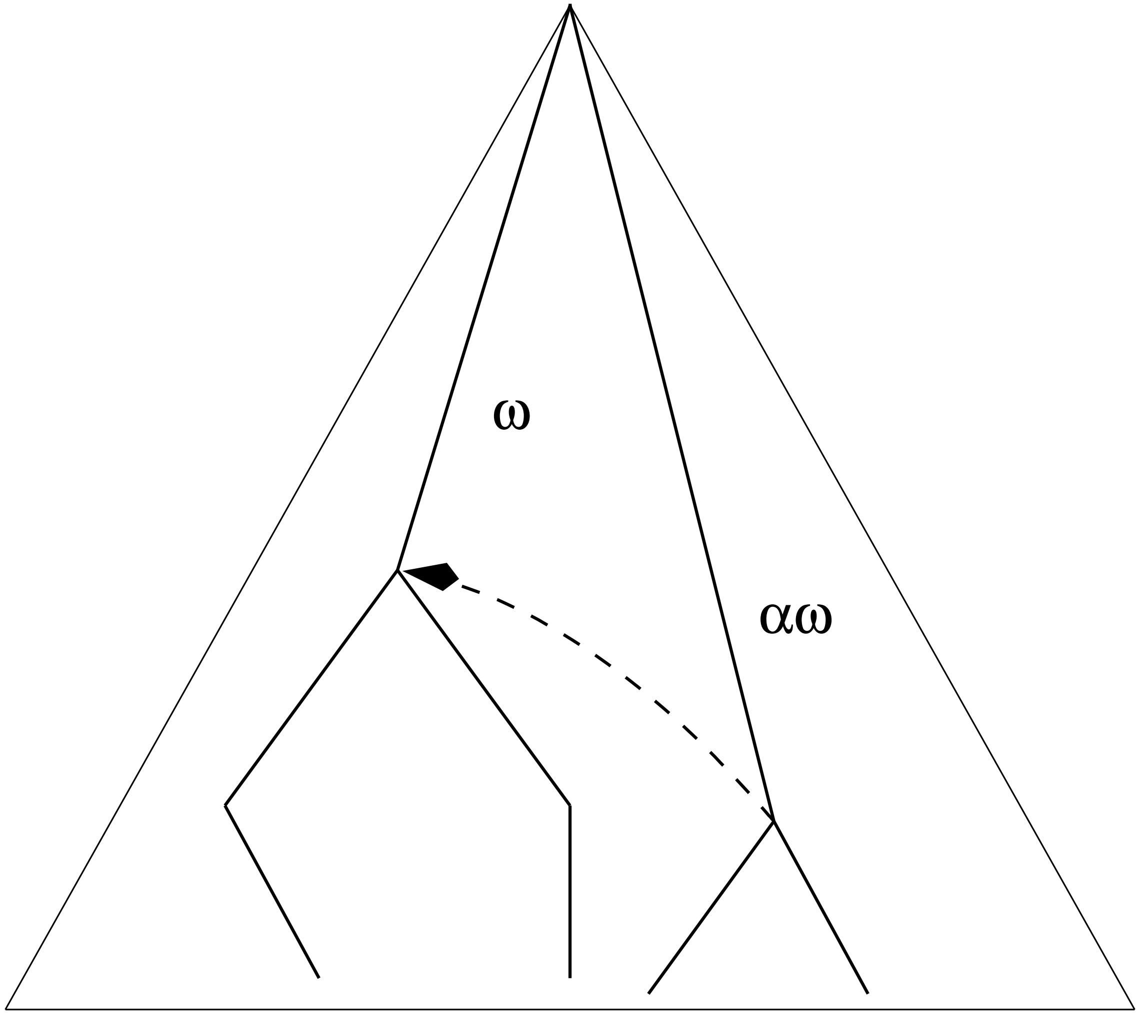
Suffix tree construction

Adding T to $AGGAG$, implicit extention of all leaves

$[Start\ \text{-}\ End] \Rightarrow end$: global variable

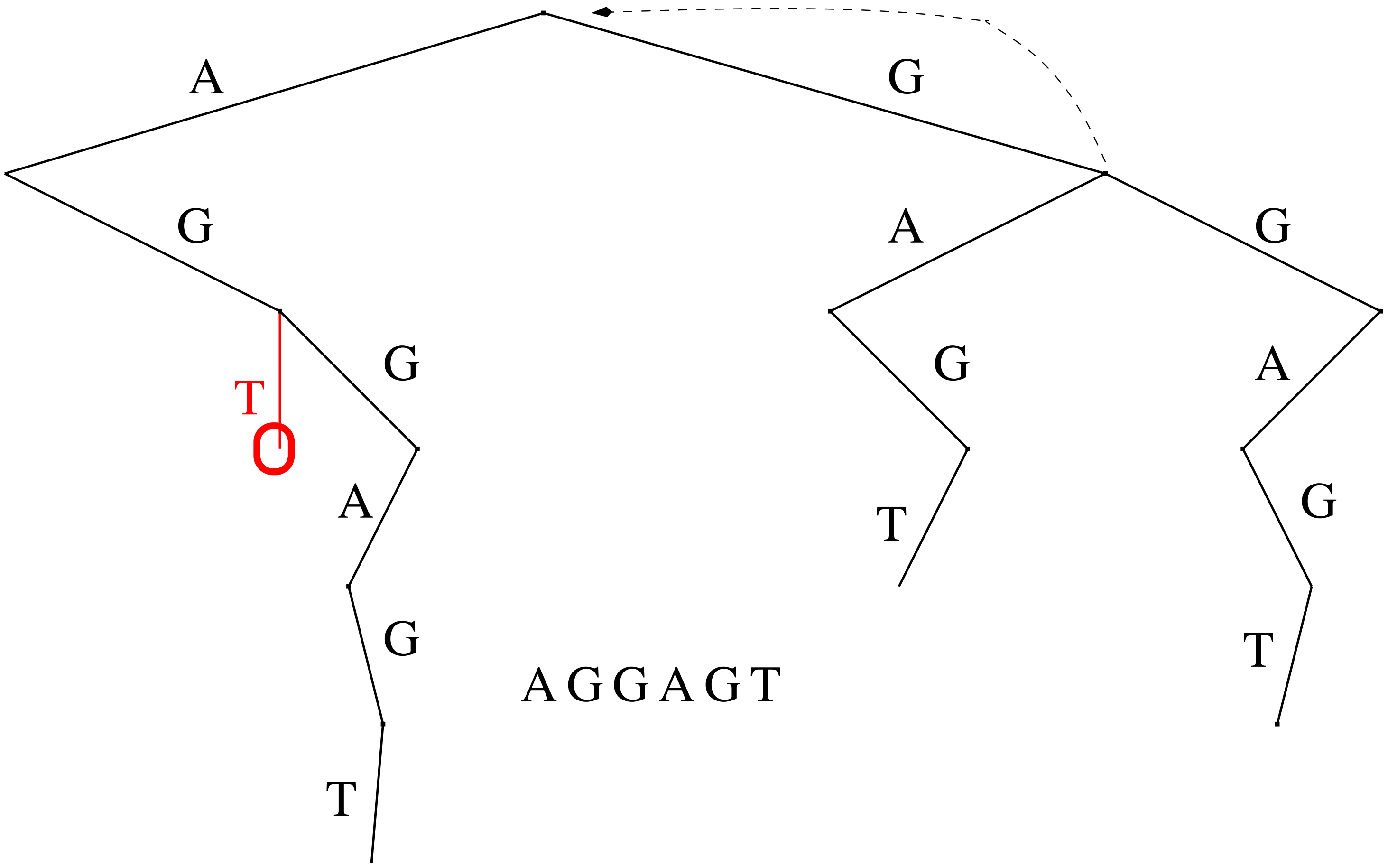


Suffix tree construction



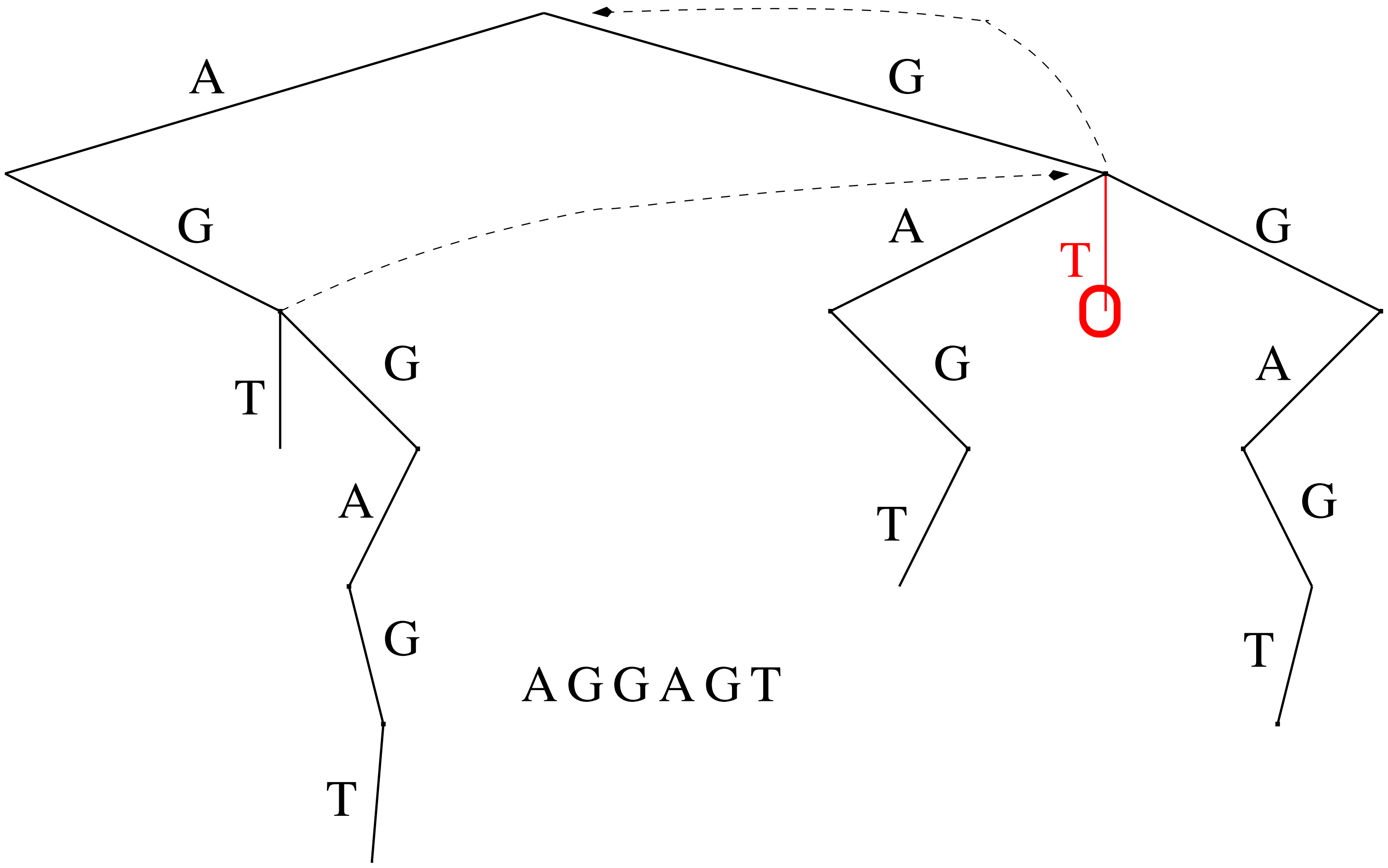
Suffix tree construction

Adding T to $AGGAG$, fast insertion of AGT from the root



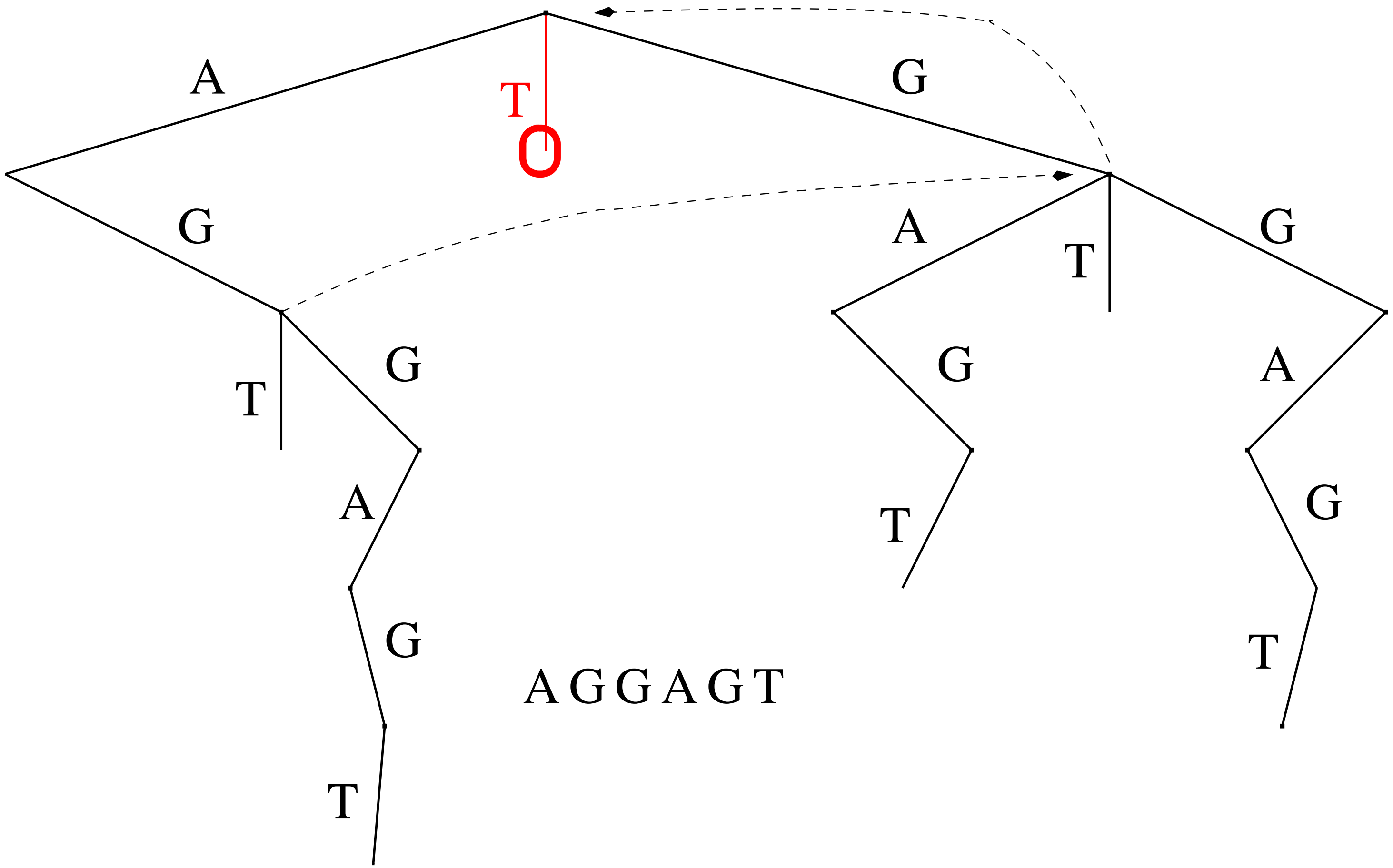
Suffix tree construction

Adding T to $AGGAG$, fast insertion of GT from the root



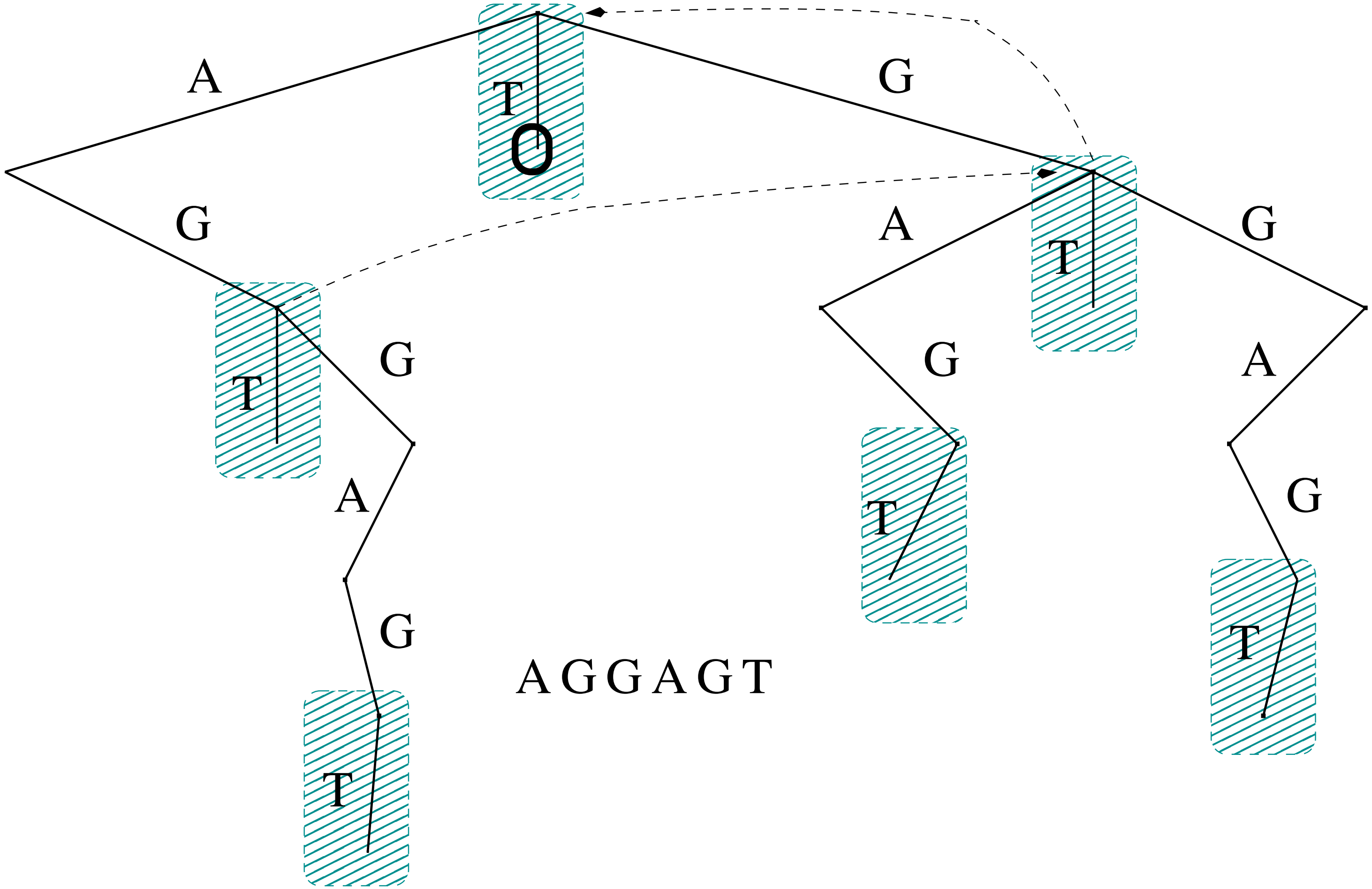
Suffix tree construction

Adding T to $AGGAG$, fast insertion of T from the root



Suffix tree construction

remark : leaves are consecutively created at each level



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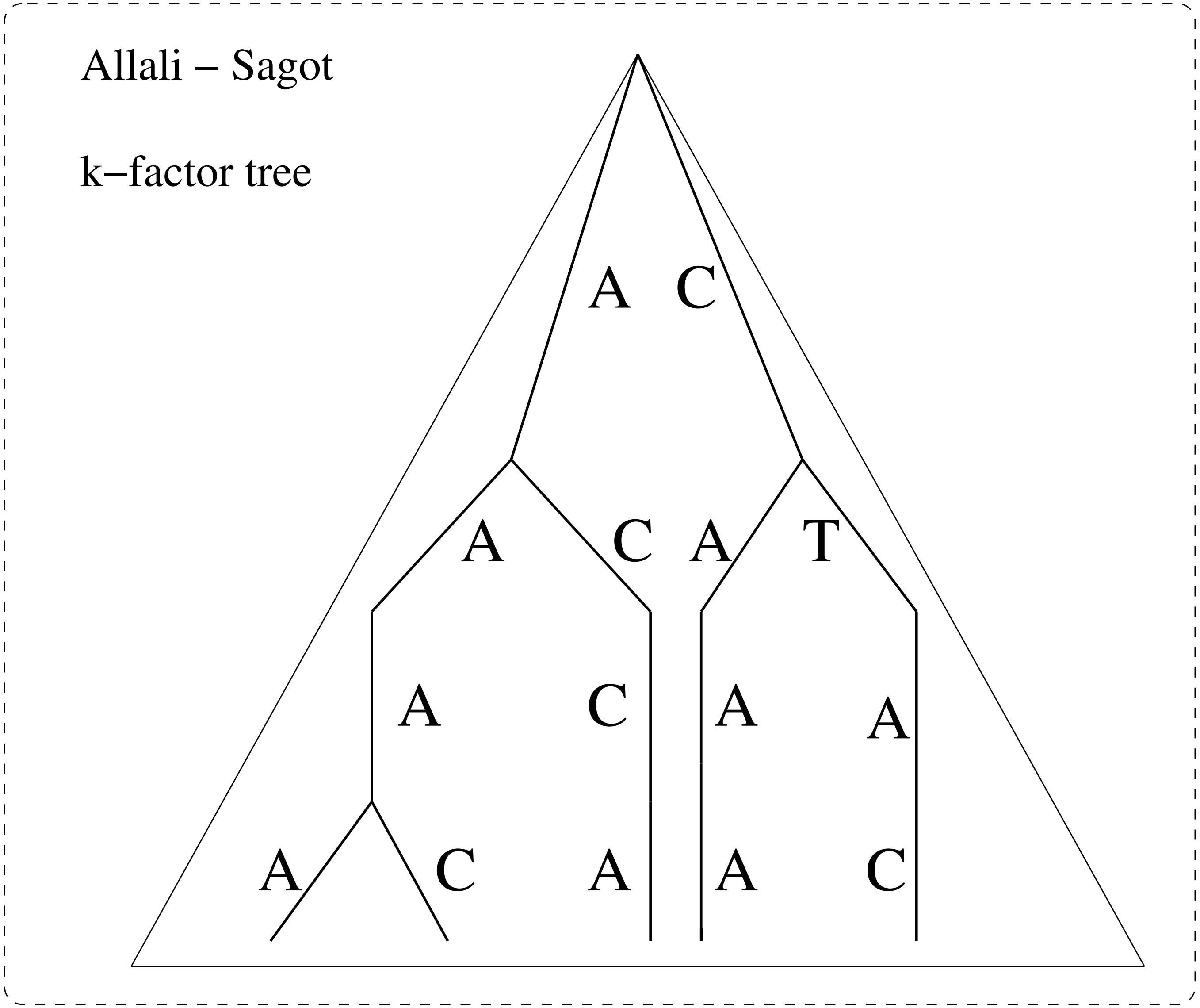
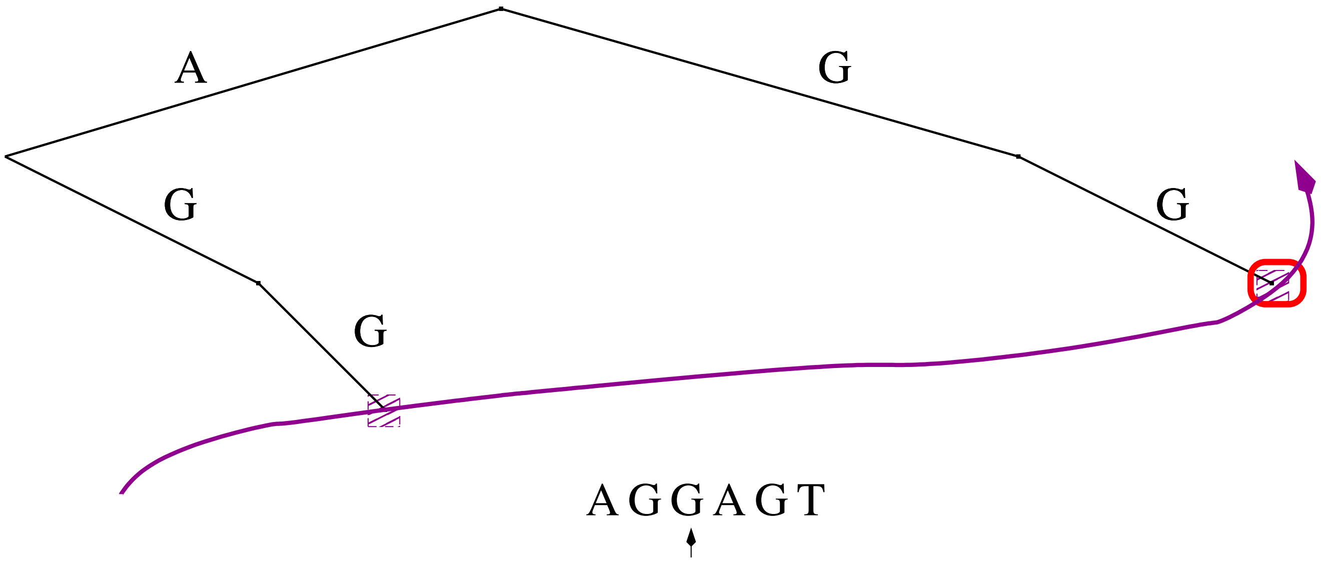


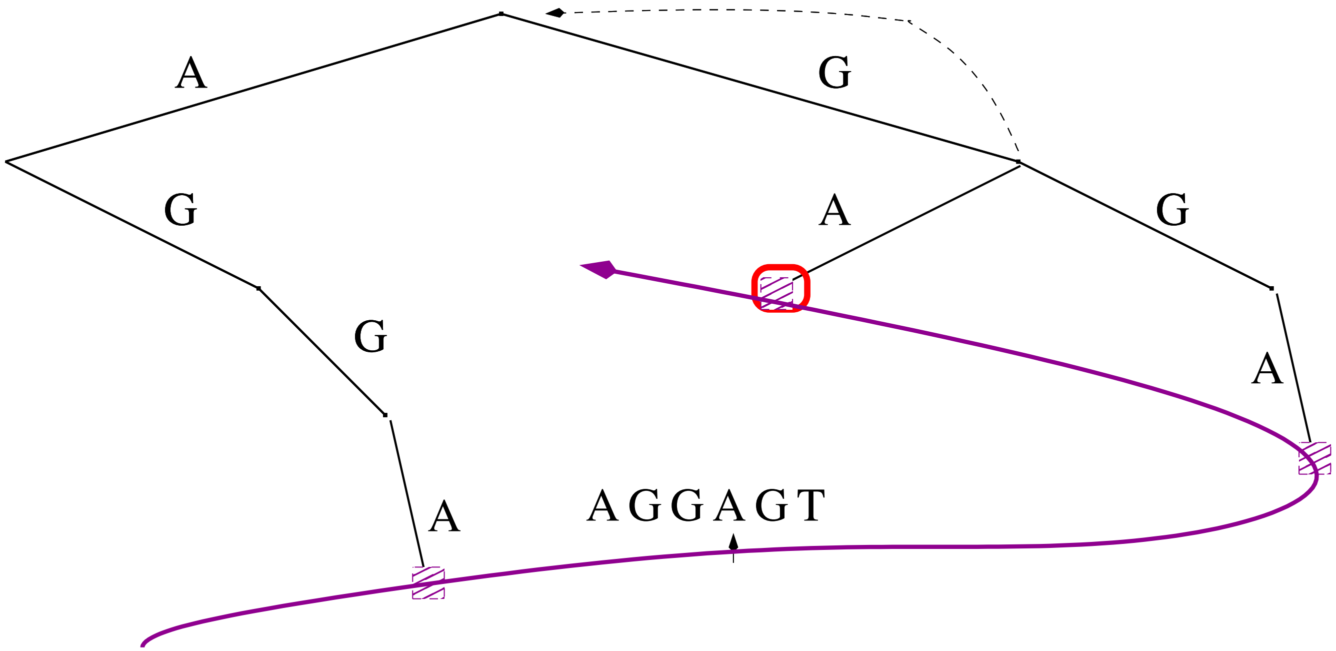
k-factor tree construction ($k = 4$)

$k - 1$ first phases : usual construction of a suffix tree, putting the leaves in a queue



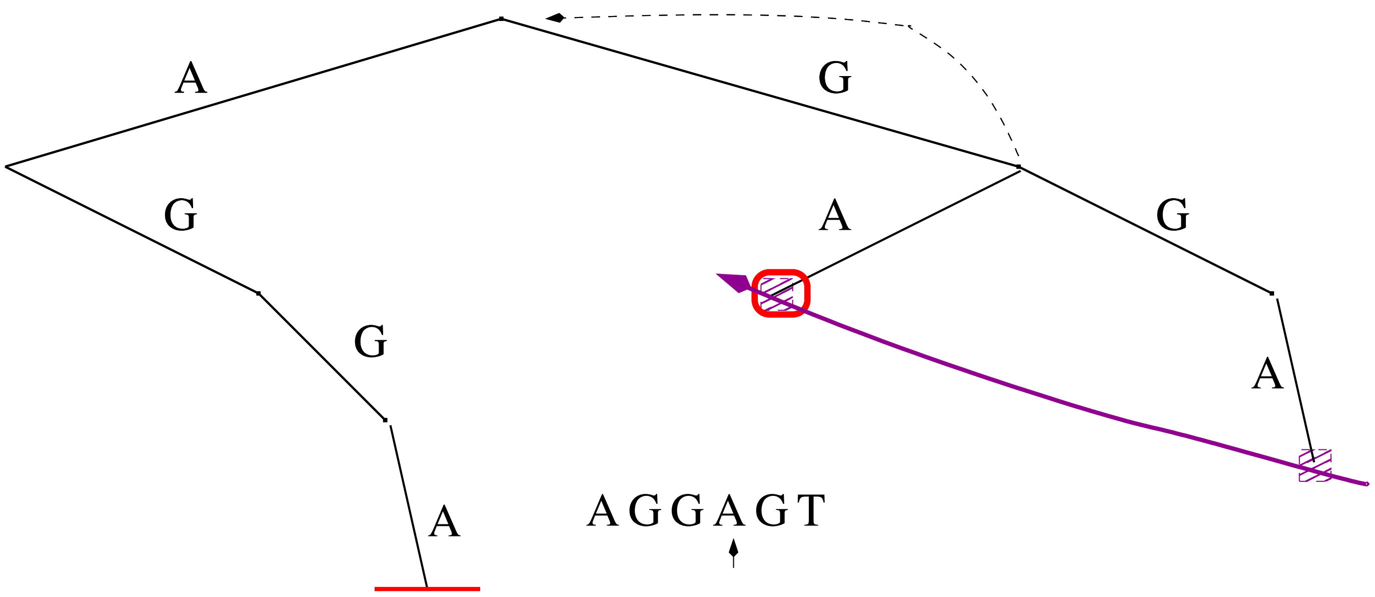
k-factor tree construction ($k = 4$)

After k^{th} phase, usual construction of a suffix tree, still putting the leaves in a queue, but...



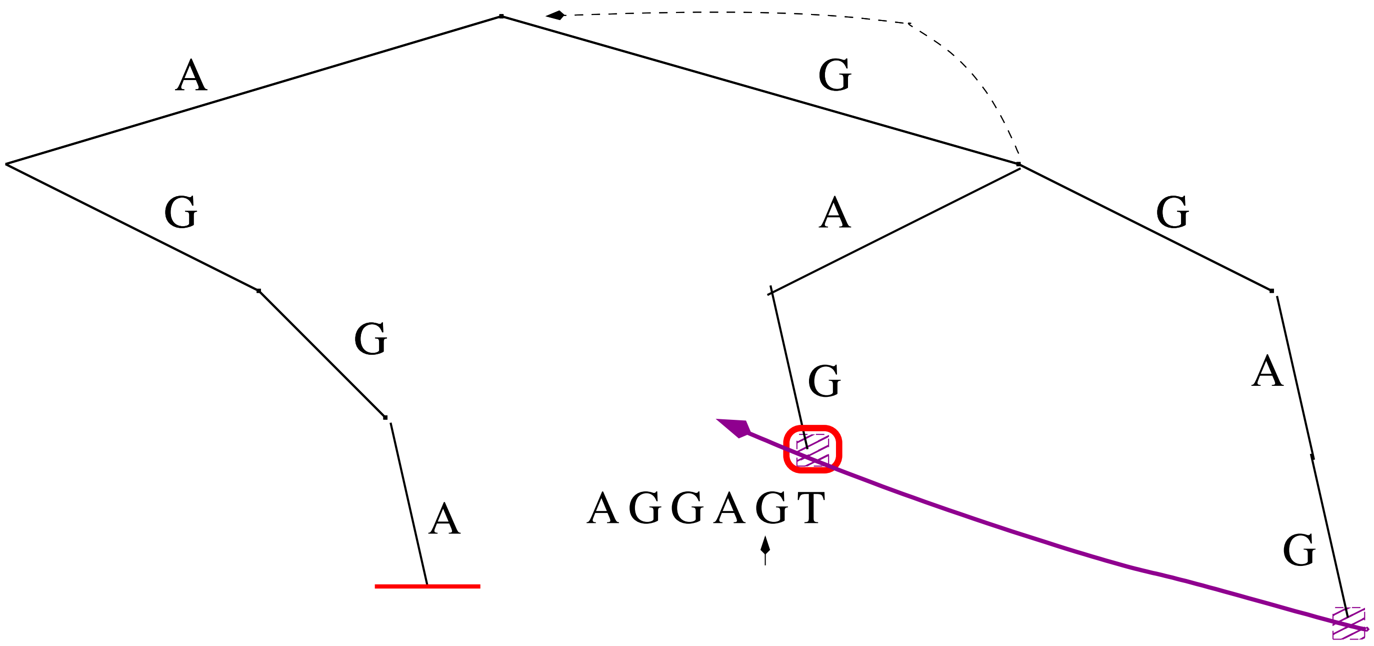
k-factor tree construction ($k = 4$)

...but removing the end of the queue at the end of the phase, stopping the automatic extension of the leaving leaf



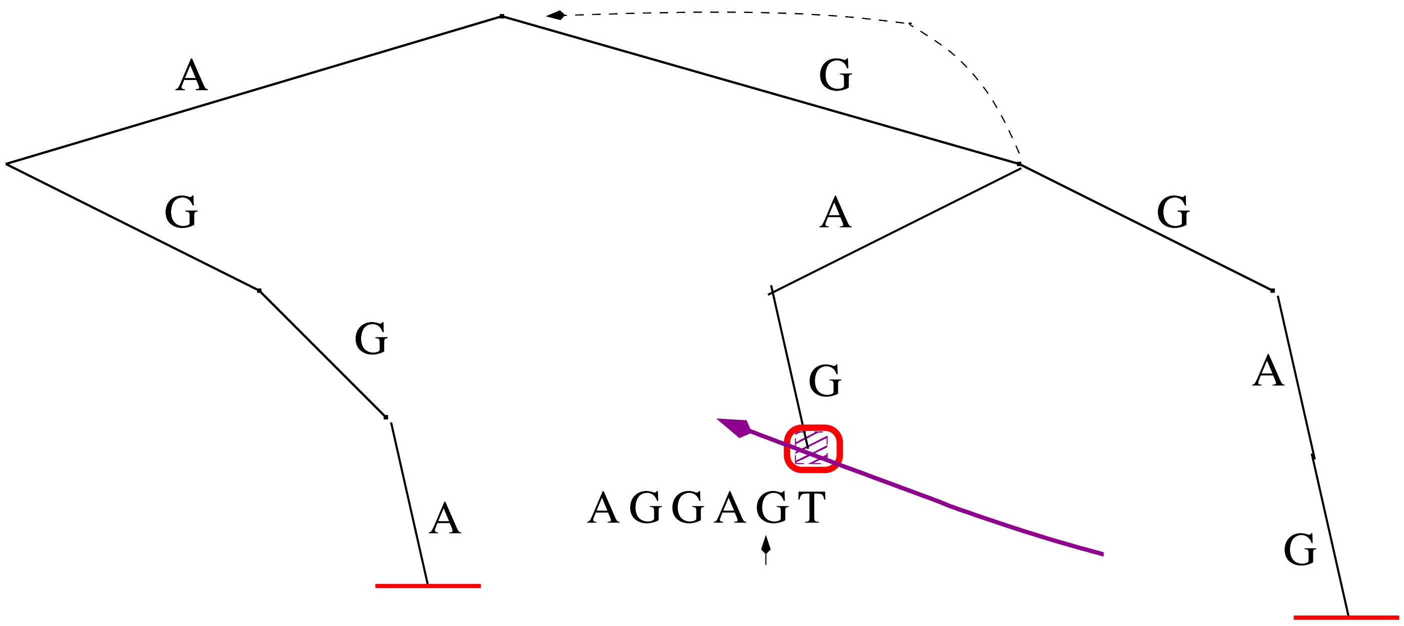
k-factor tree construction ($k = 4$)

Next step,



k-factor tree construction ($k = 4$)

Next step, remove head



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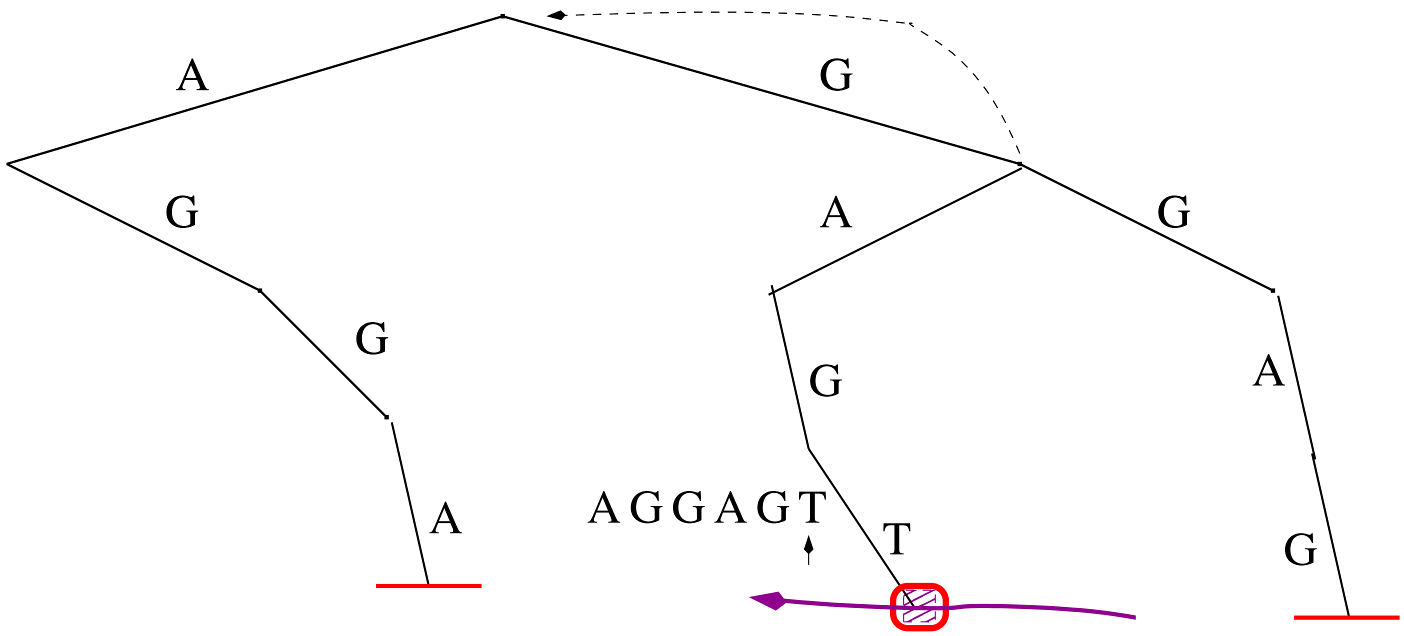

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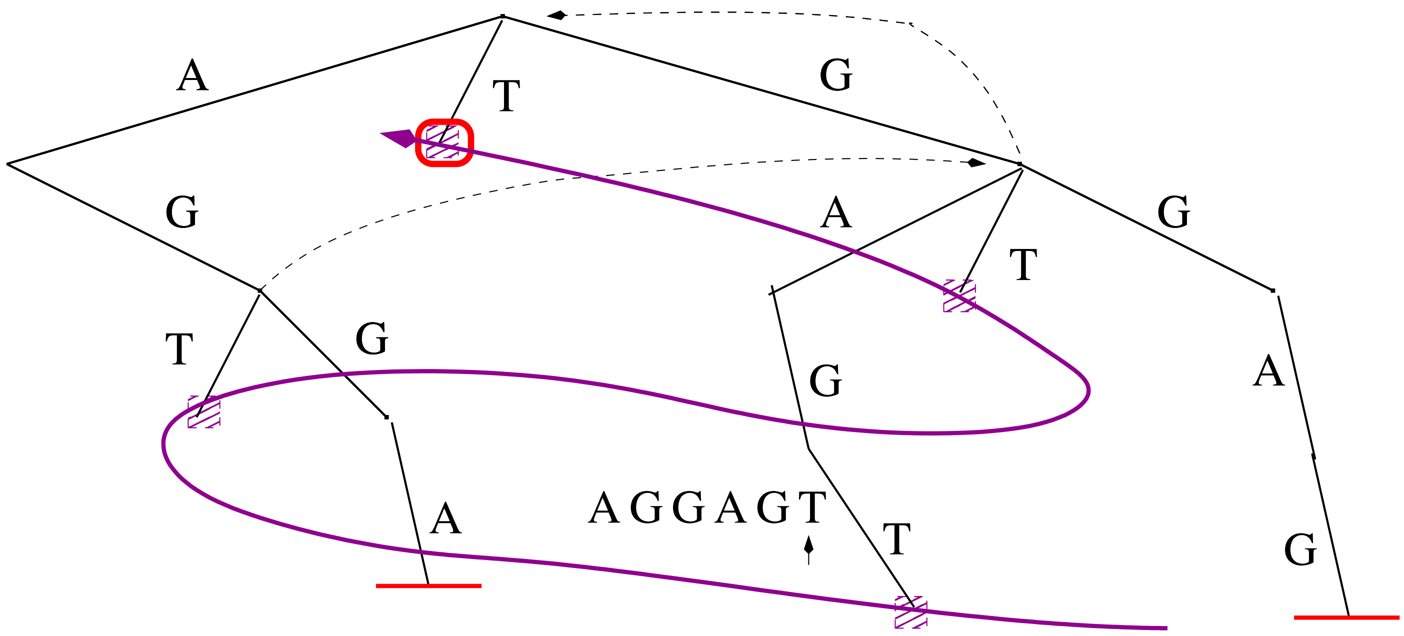

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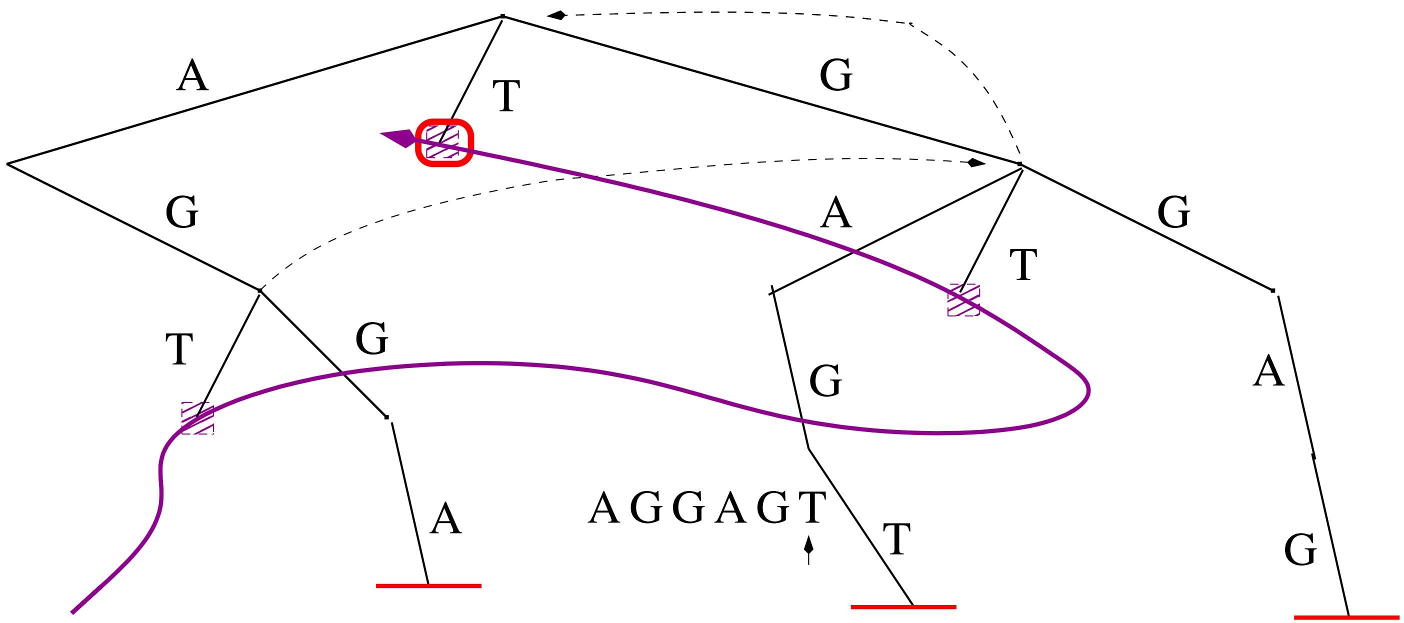

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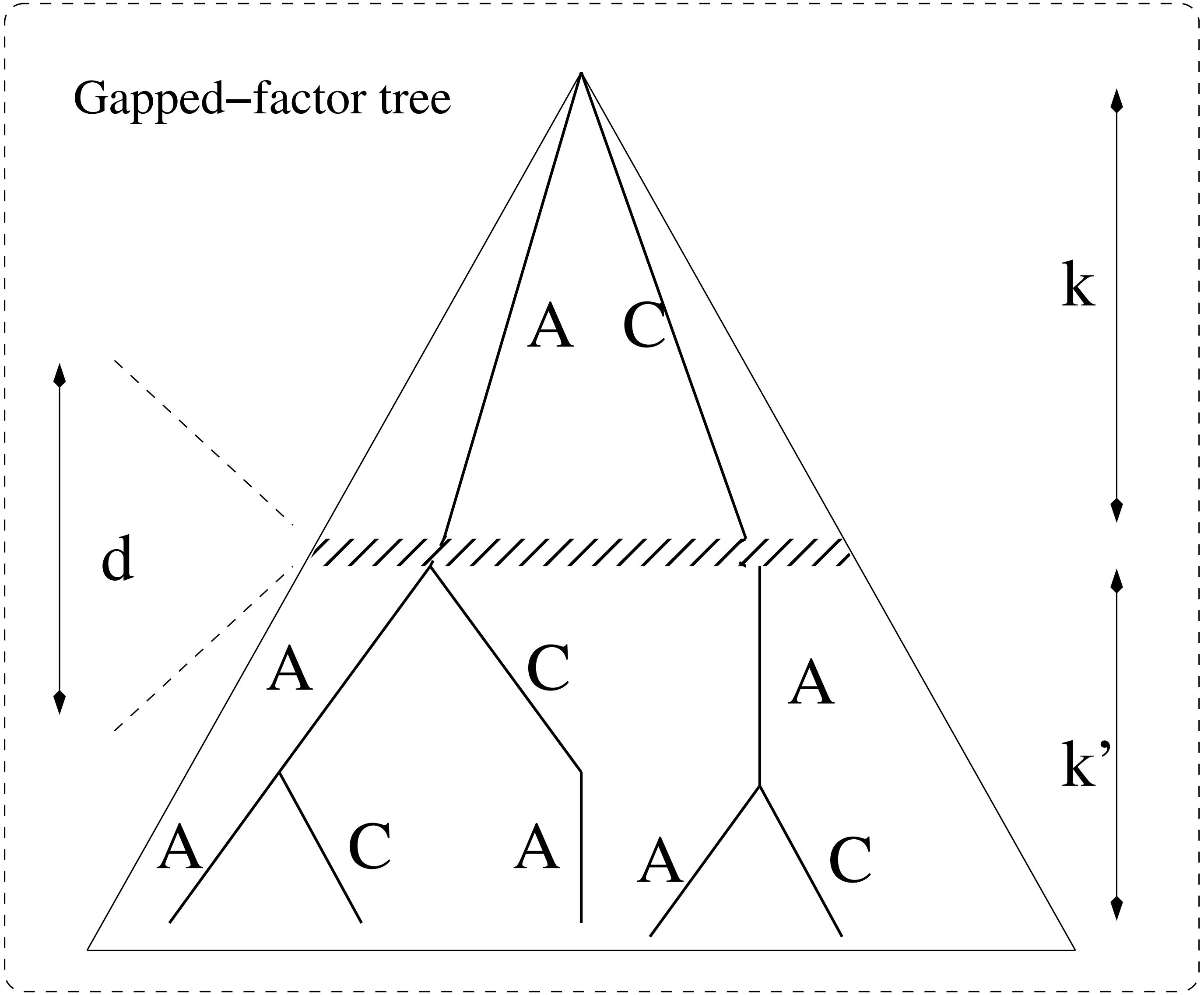
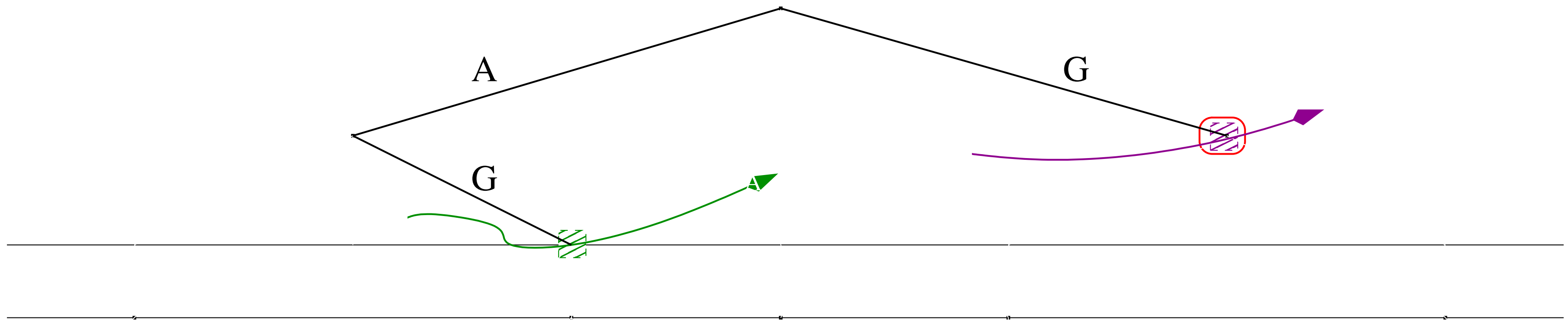


Gapped-factor tree construction ($k = 2$, $d = 1$, $k' = 3$)

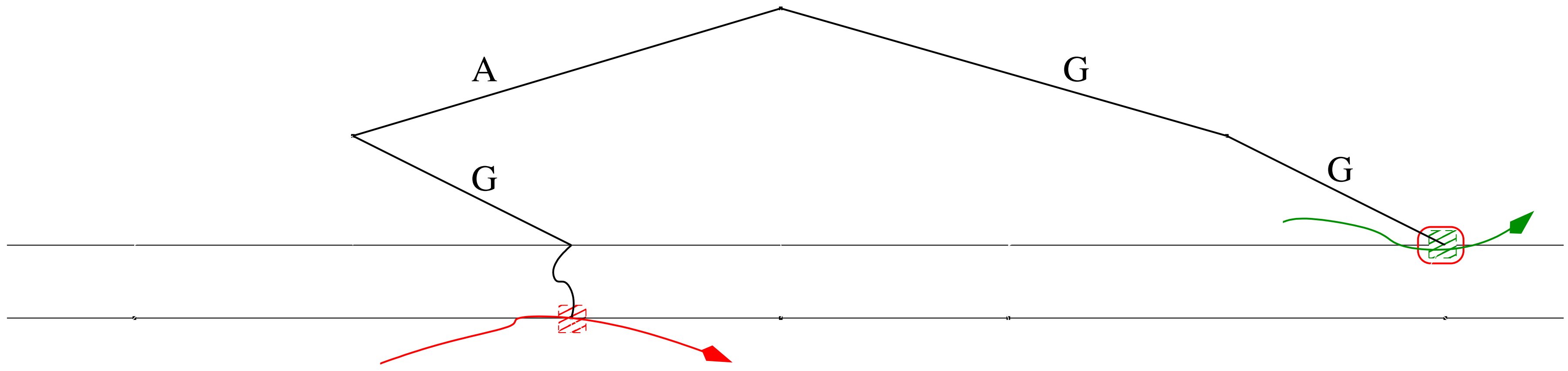
Three queues : upper extension leaves →, hidden extension leaves →,



AGGAGAACAA

Gapped-factor tree construction ($k = 2$, $d = 1$, $k' = 3$)

Three queues : upper extension leaves ⟶, hidden extension leaves ⟶, lower extension leaves ⟶

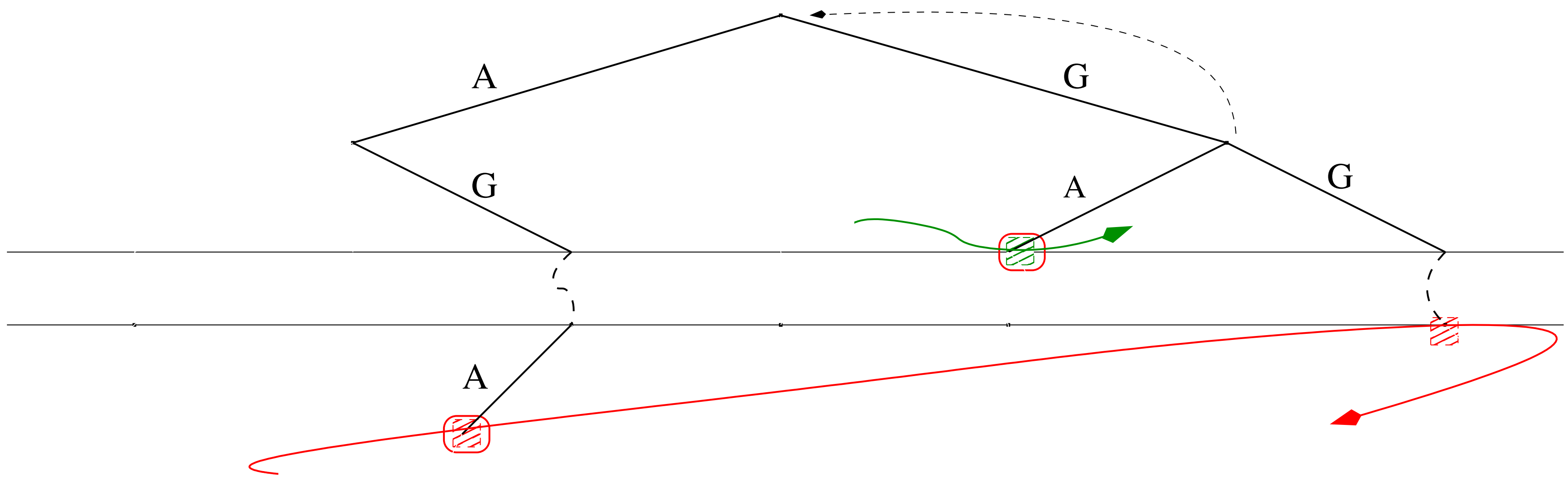


AGGAGAACAA

↑

Gapped-factor tree construction ($k = 2$, $d = 1$, $k' = 3$)

Lower part of the tree : same principles as for the upper part



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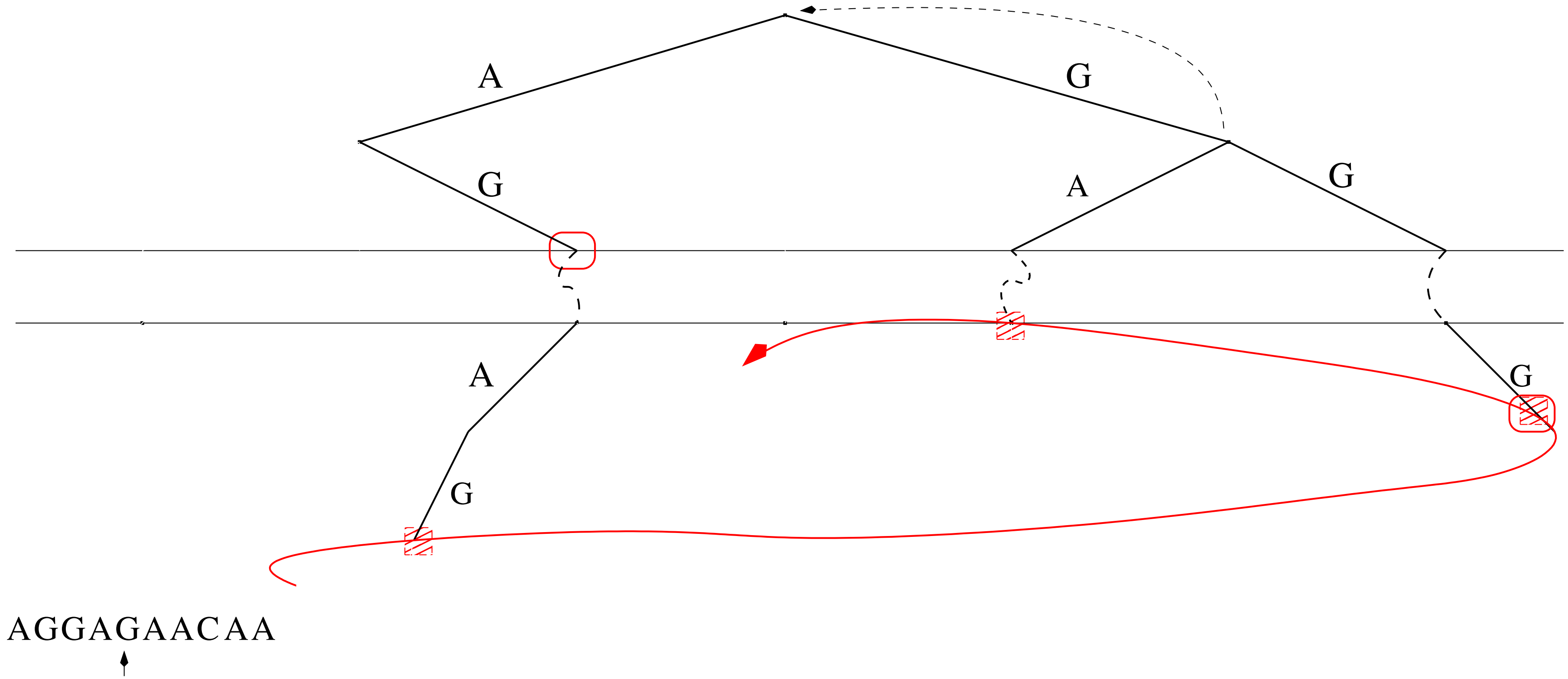

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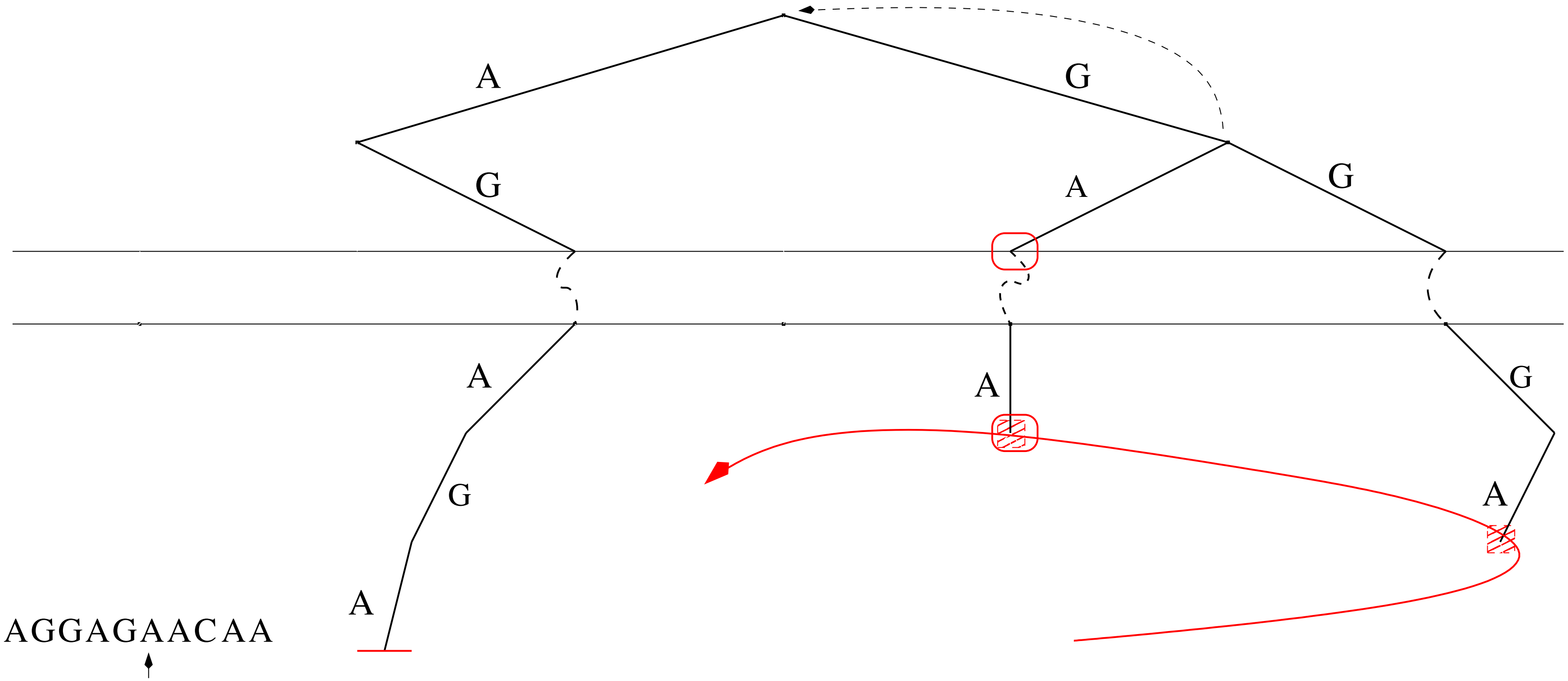

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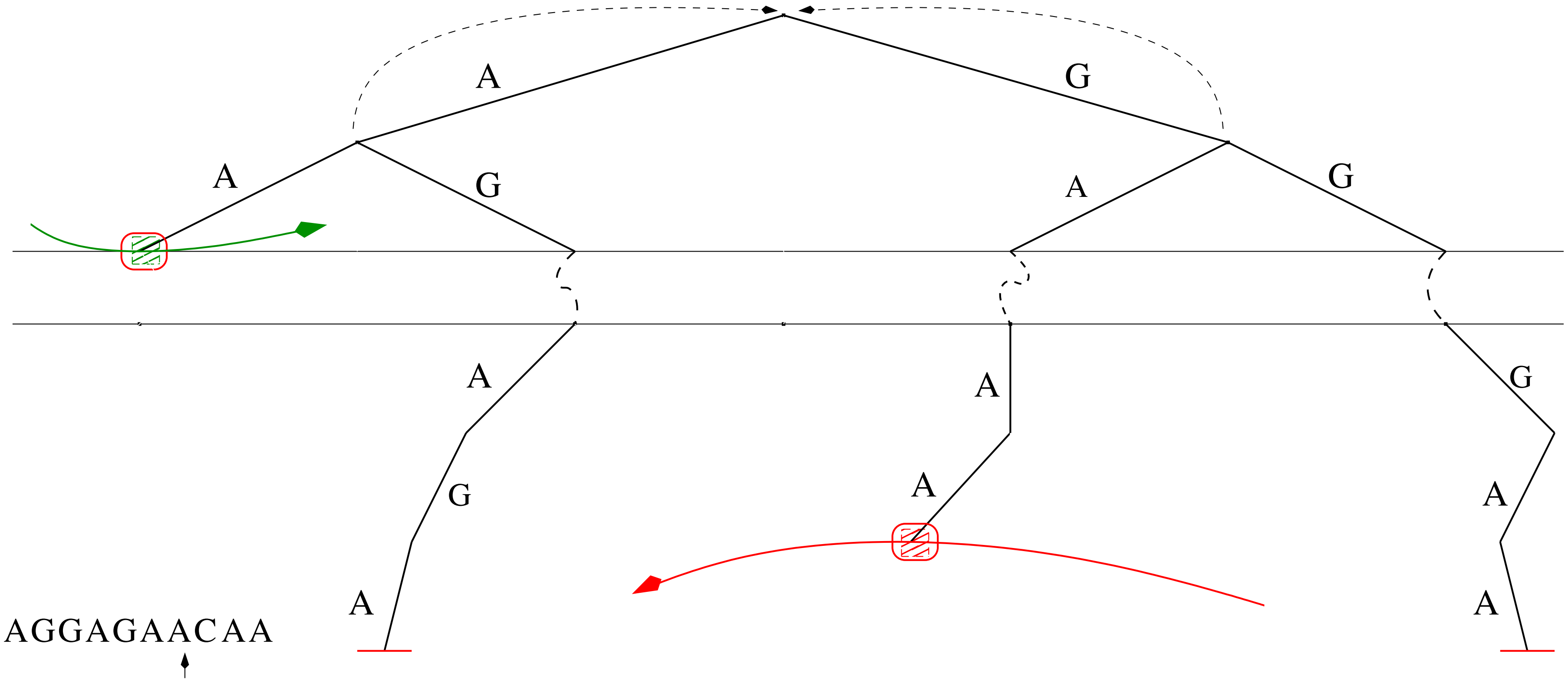
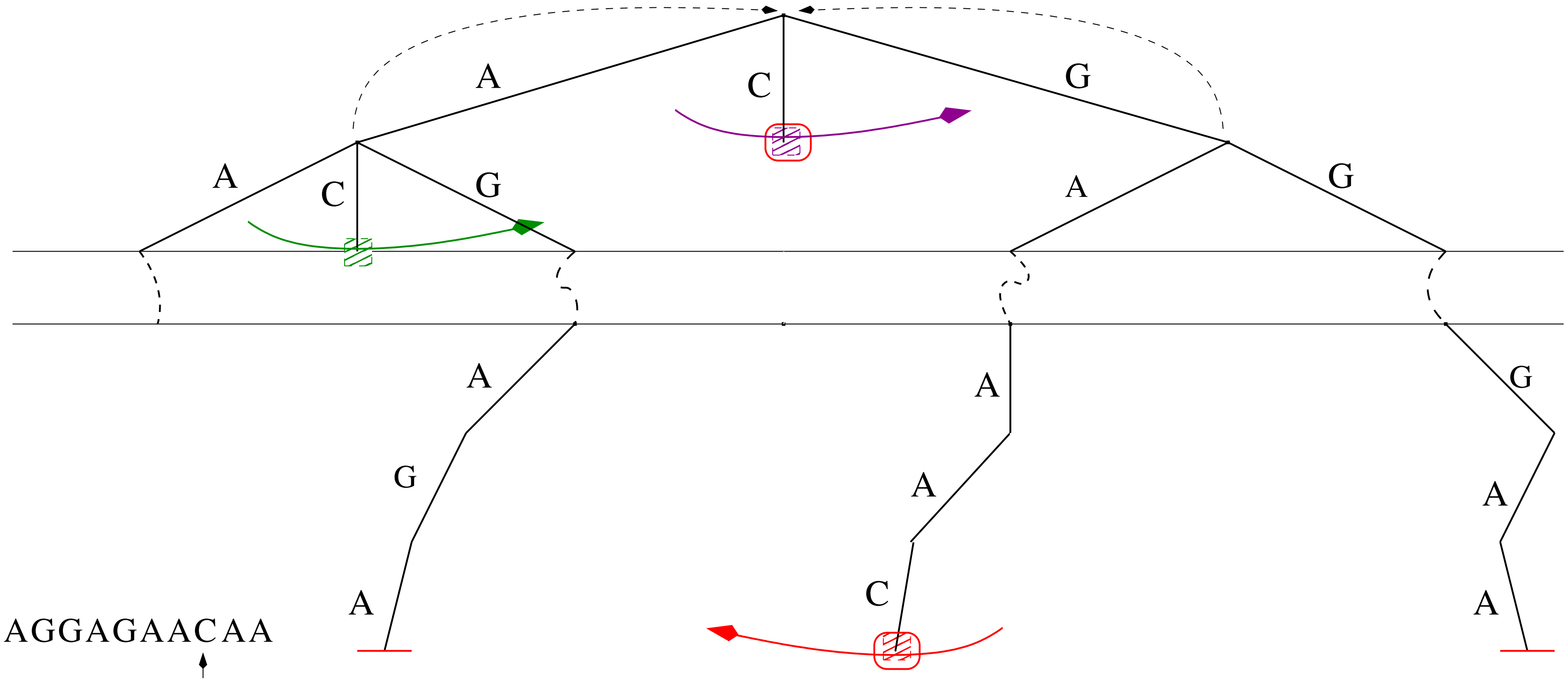
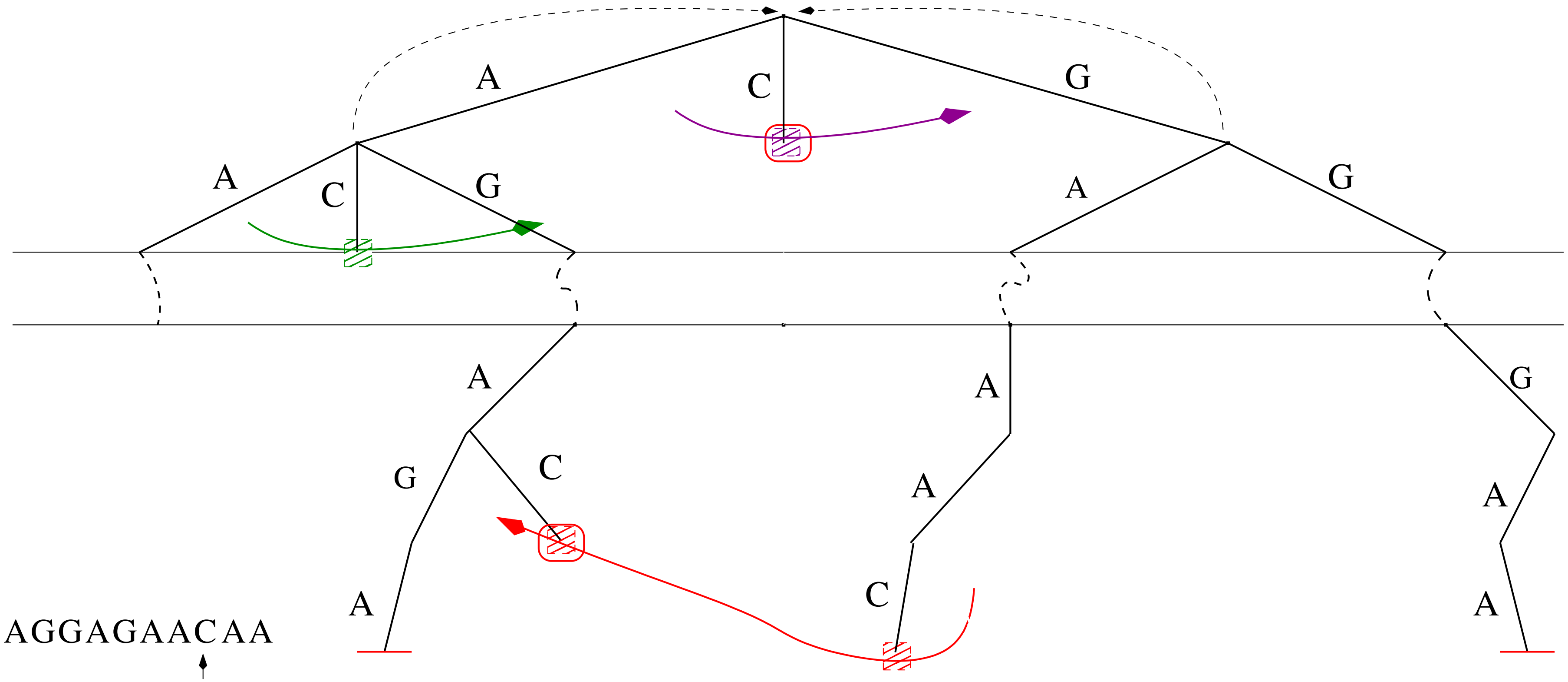


Gapped-factor tree construction ($k = 2$, $d = 1$, $k' = 3$)

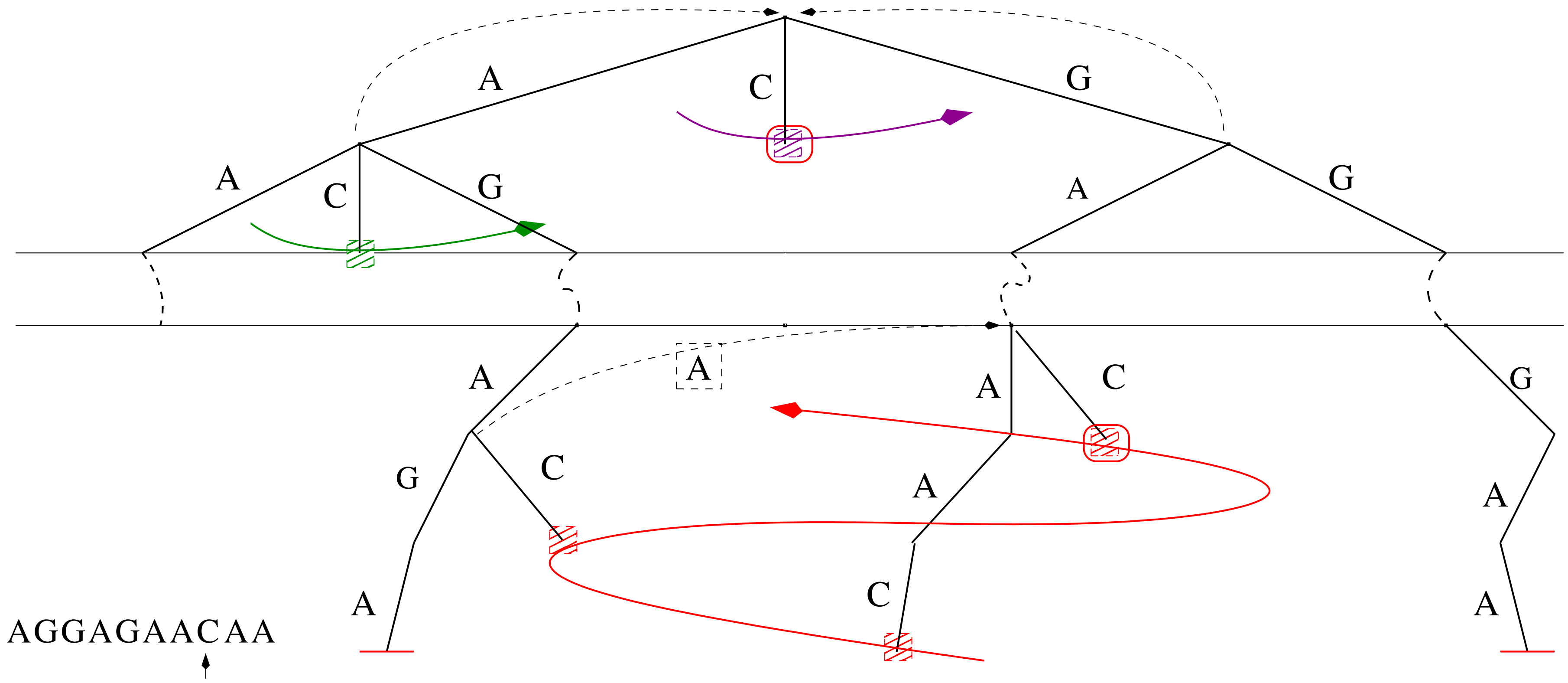
Multiple suffix link



Gapped-factor tree construction ($k = 2$, $d = 1$, $k' = 3$)



Gapped-factor tree construction ($k = 2$, $d = 1$, $k' = 3$)



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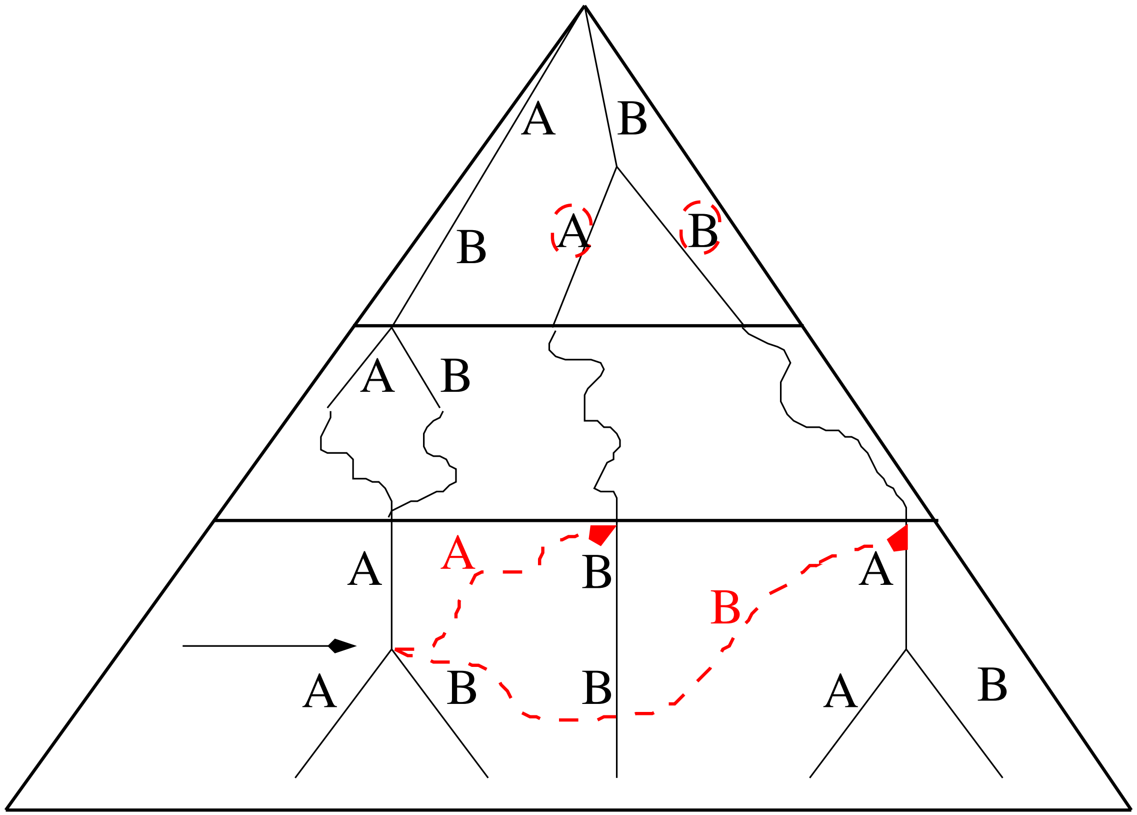

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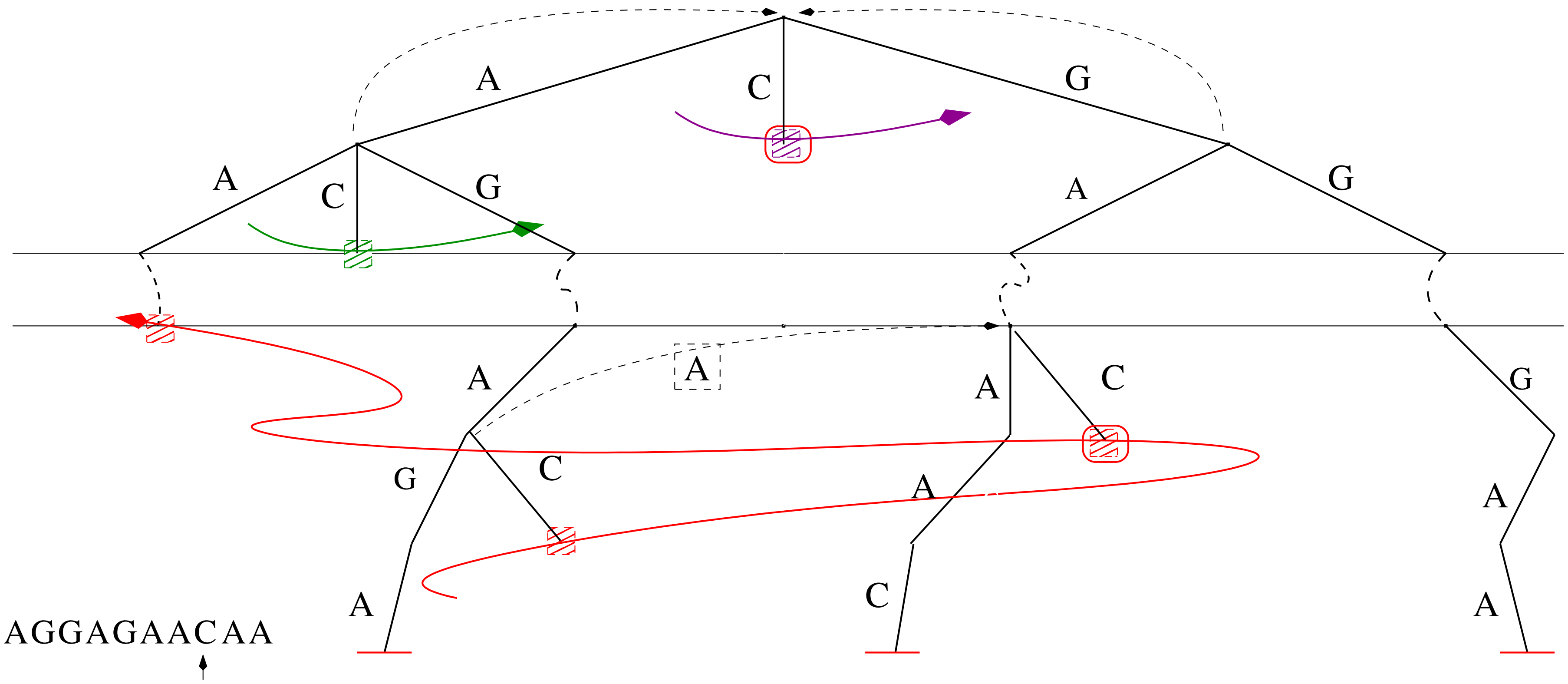

Complexity analysis

Time and memory

- During the construction : $O(n \times |\Sigma|)$
- Using the index : $O(n)$

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- Use and development of Ukkonen’s method
- Indexing structure useful for various stringology problems

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- Gapped suffix **array** $O(n)$