Thinking Recursively

Part V

Friday Four Square!

Today at 4:15PM at
Gates Computer Science

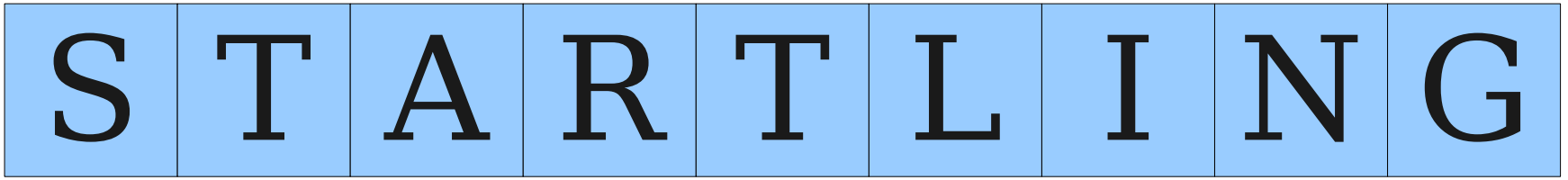
WiCS Hackathon

- Stanford Women in Computer Science are running a hackathon this **Sunday** from 10AM – 10PM in the Huang Engineering Center basement.
  - (That's right outside of this classroom!)
  - Free food!
  - RSVP at **http://hackoverflow.org**

A Little Word Puzzle

“What nine-letter word can be reduced to a single-letter word one letter at a time by removing letters, leaving it a legal word at each step?”

One Solution



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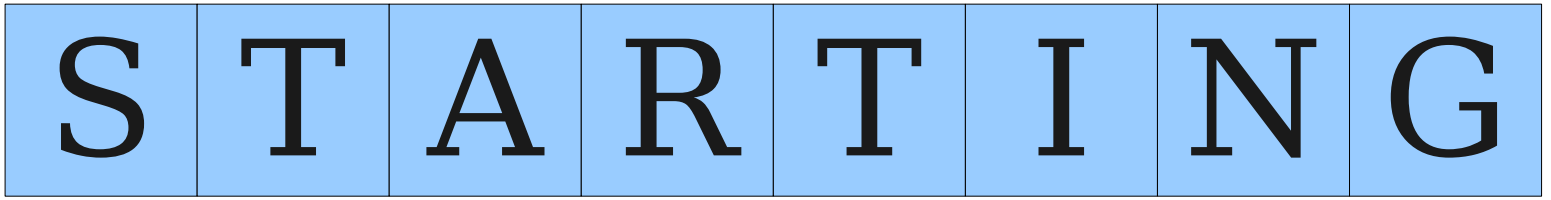

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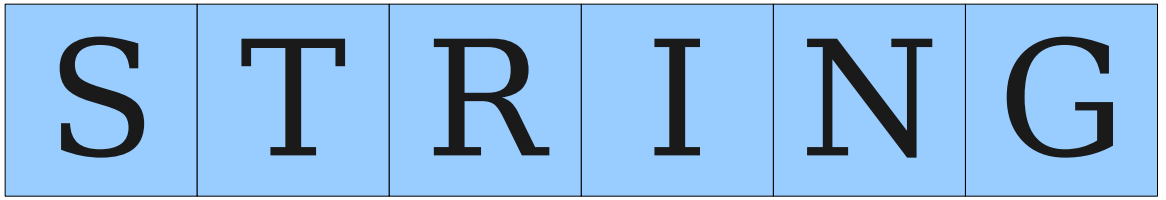

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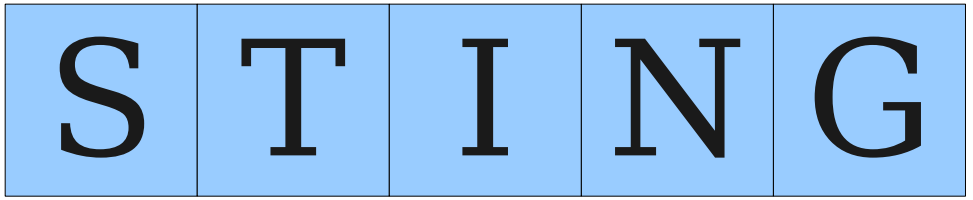

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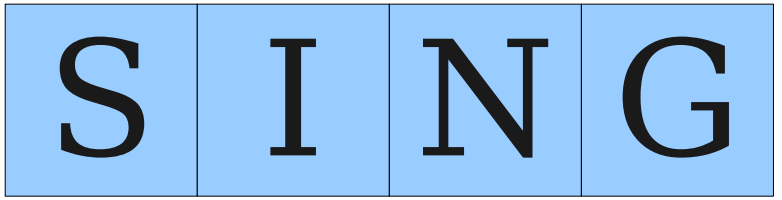

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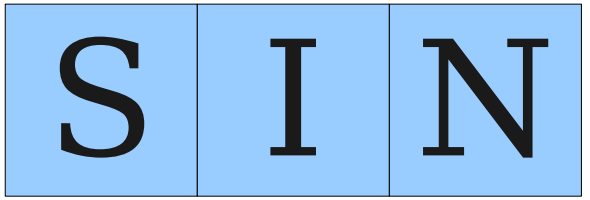

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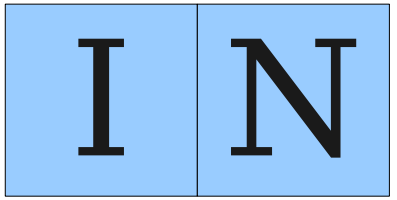

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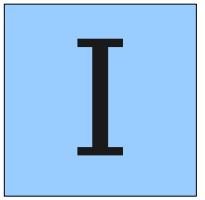
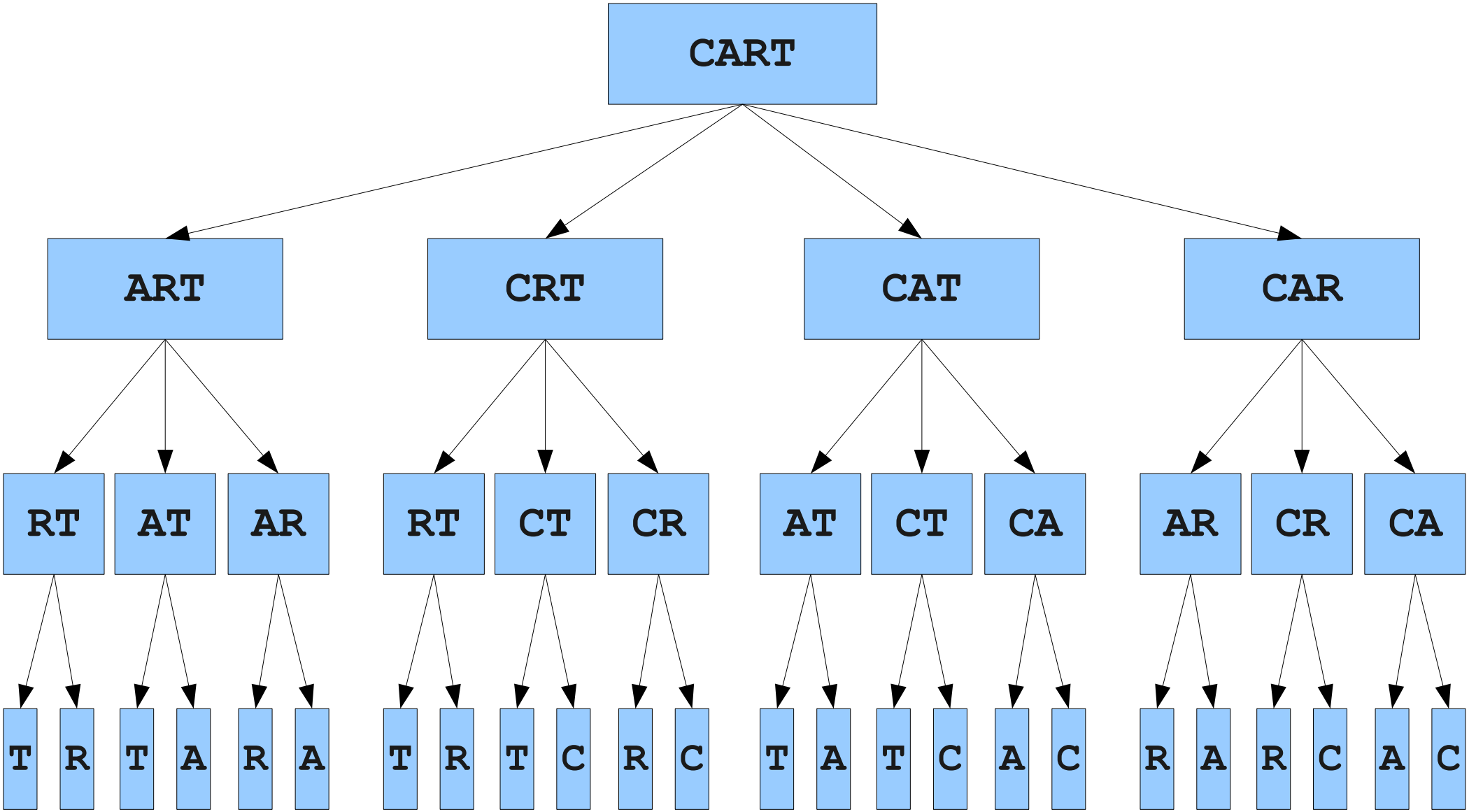


All Possible Paths



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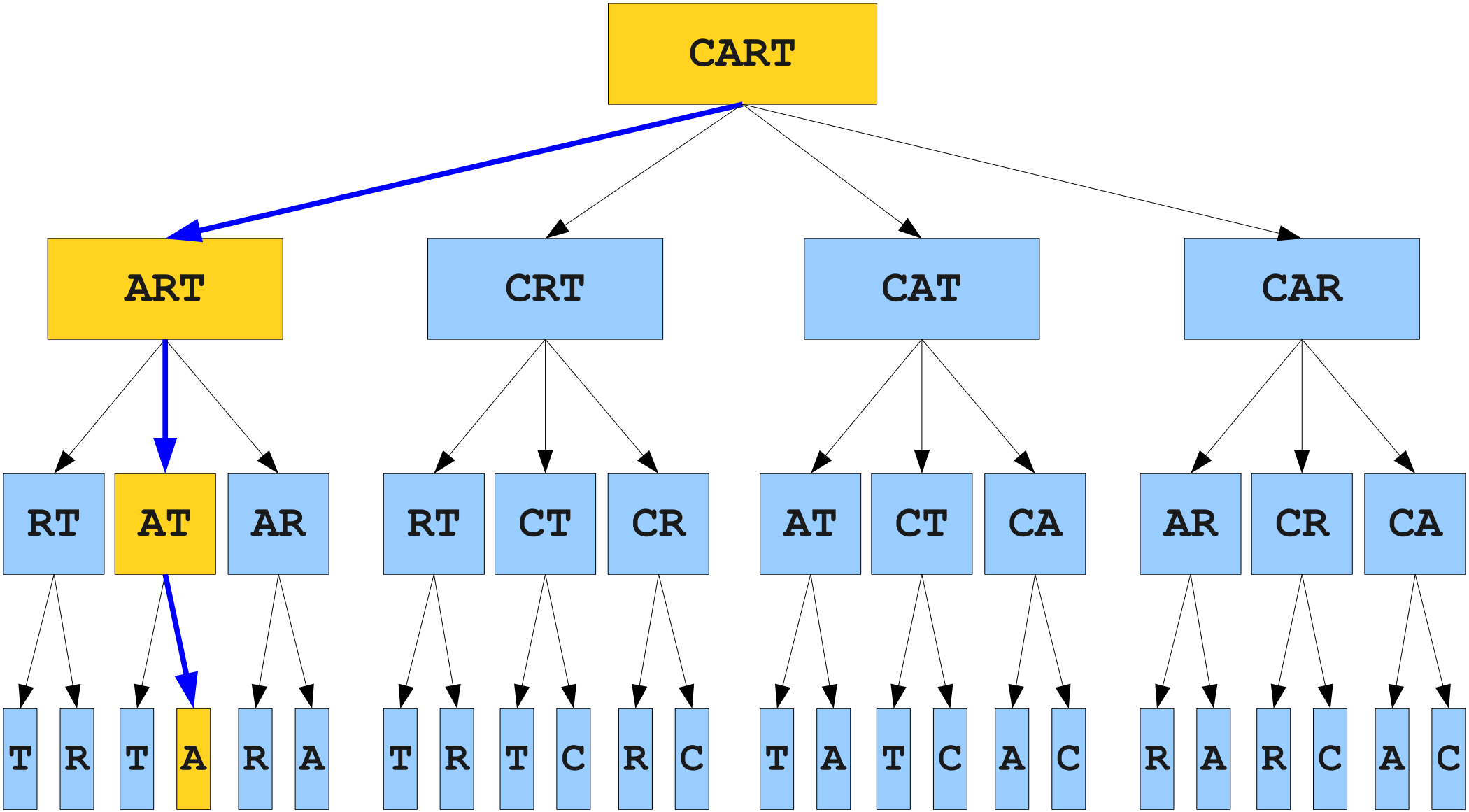
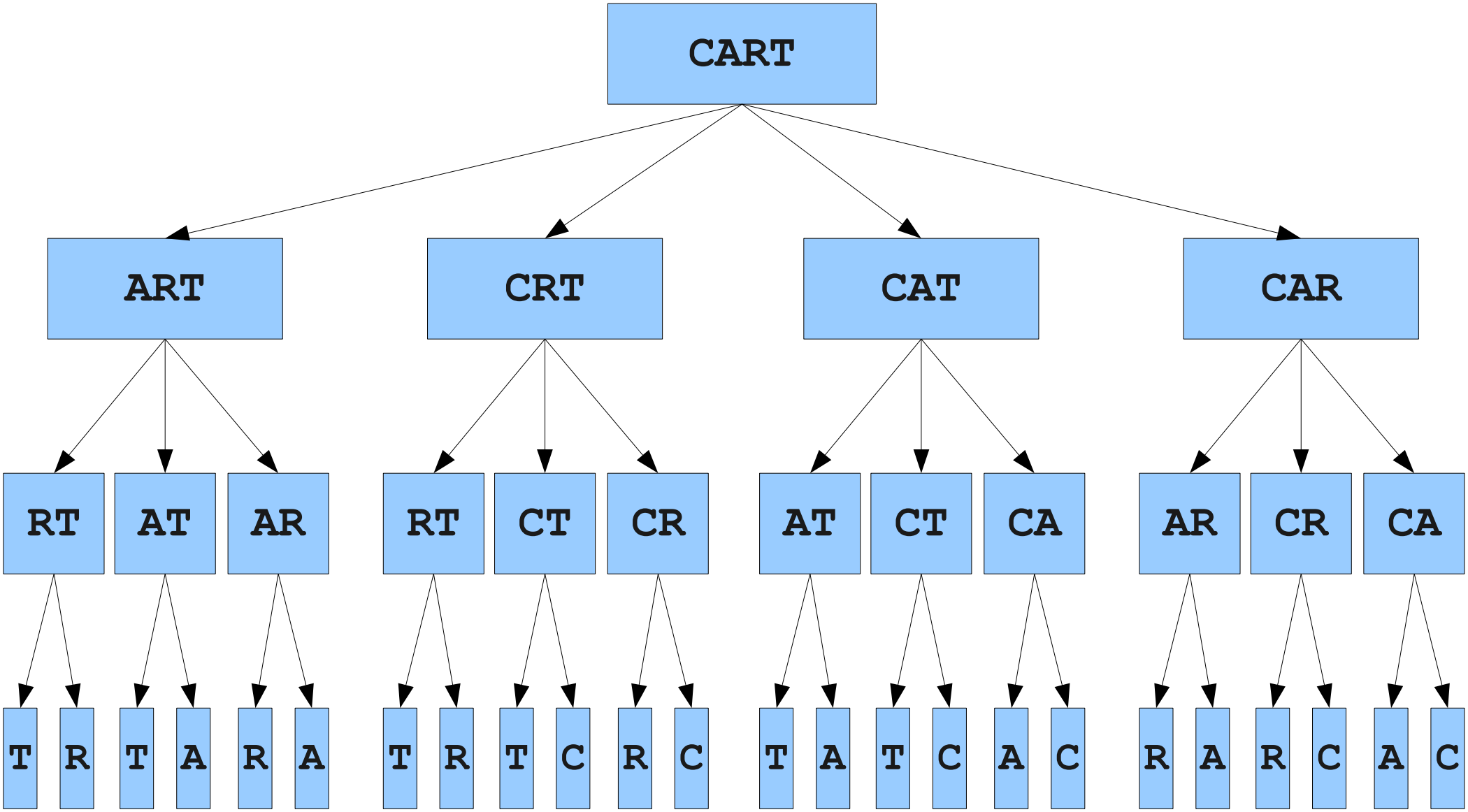


Shrinkable Words

- Let's define a **shrinkable word** as a word that can be reduced down to one letter by removing one character at a time, leaving a word at each step.
- **Base Cases:**
  - Any string that is not a word cannot be a shrinkable word.
  - Any single-letter word is shrinkable.
    - A, I, O
- **Recursive Step:**
  - Any multi-letter word is shrinkable if you can remove a letter to form a shrinkable word.

Recursive Backtracking



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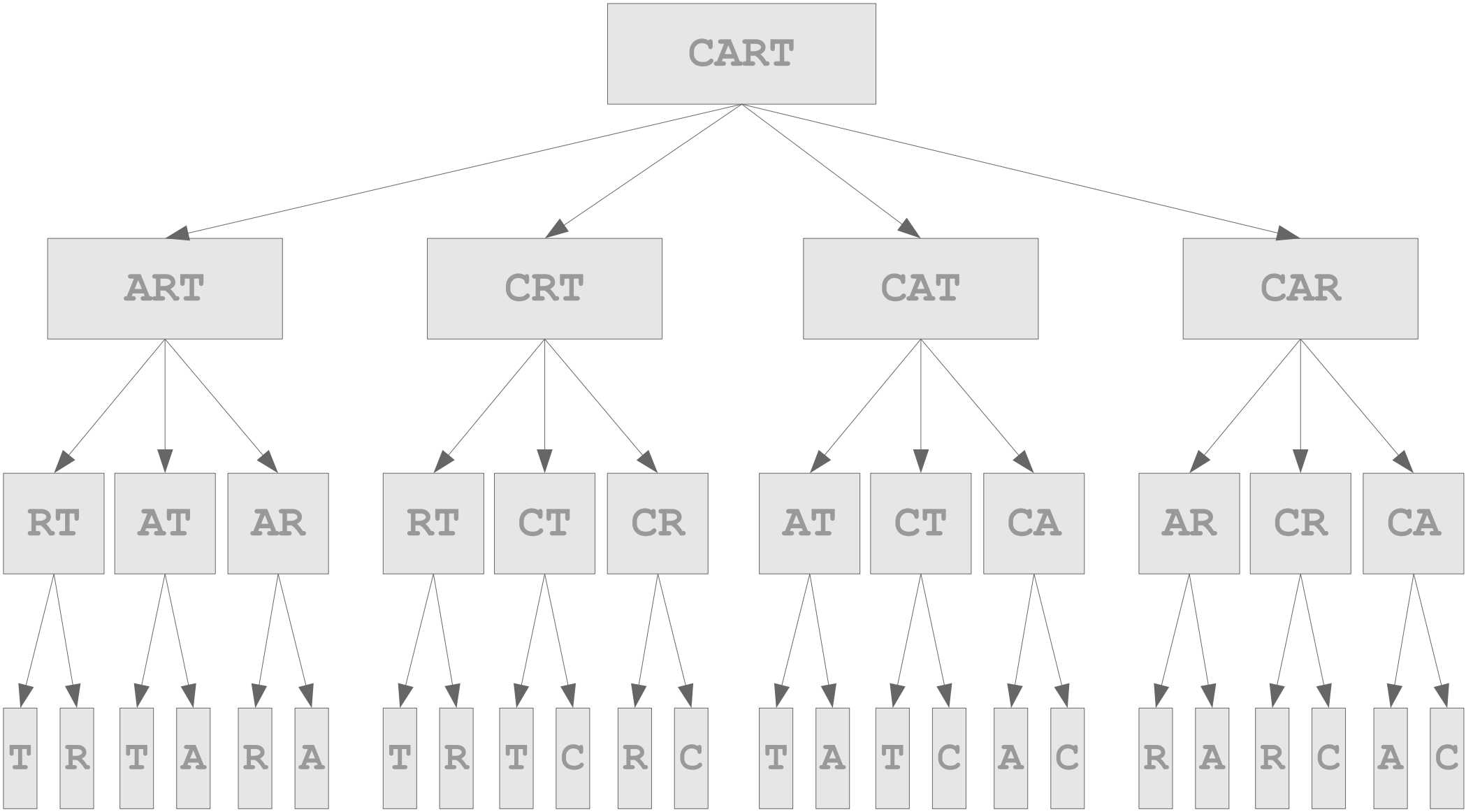

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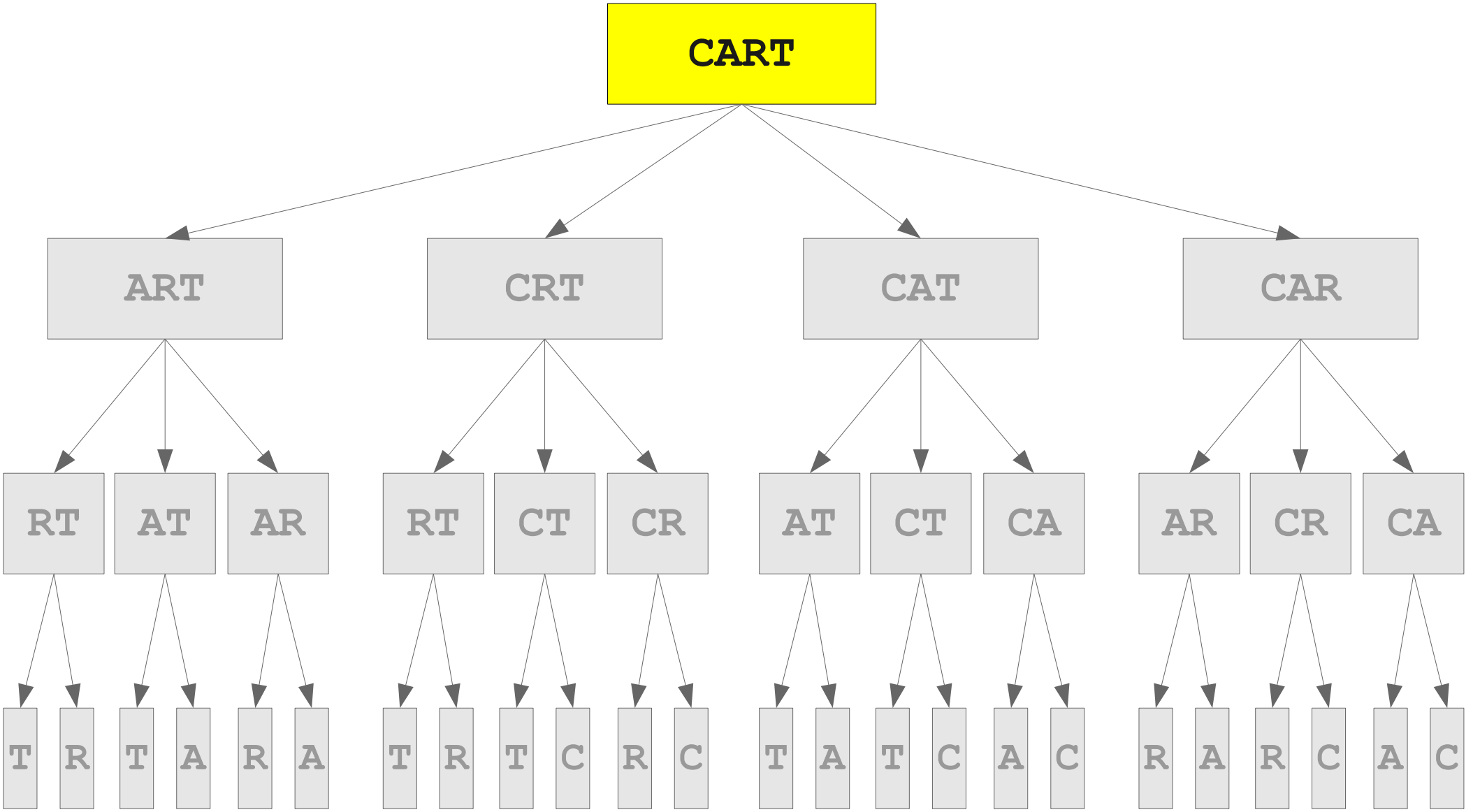

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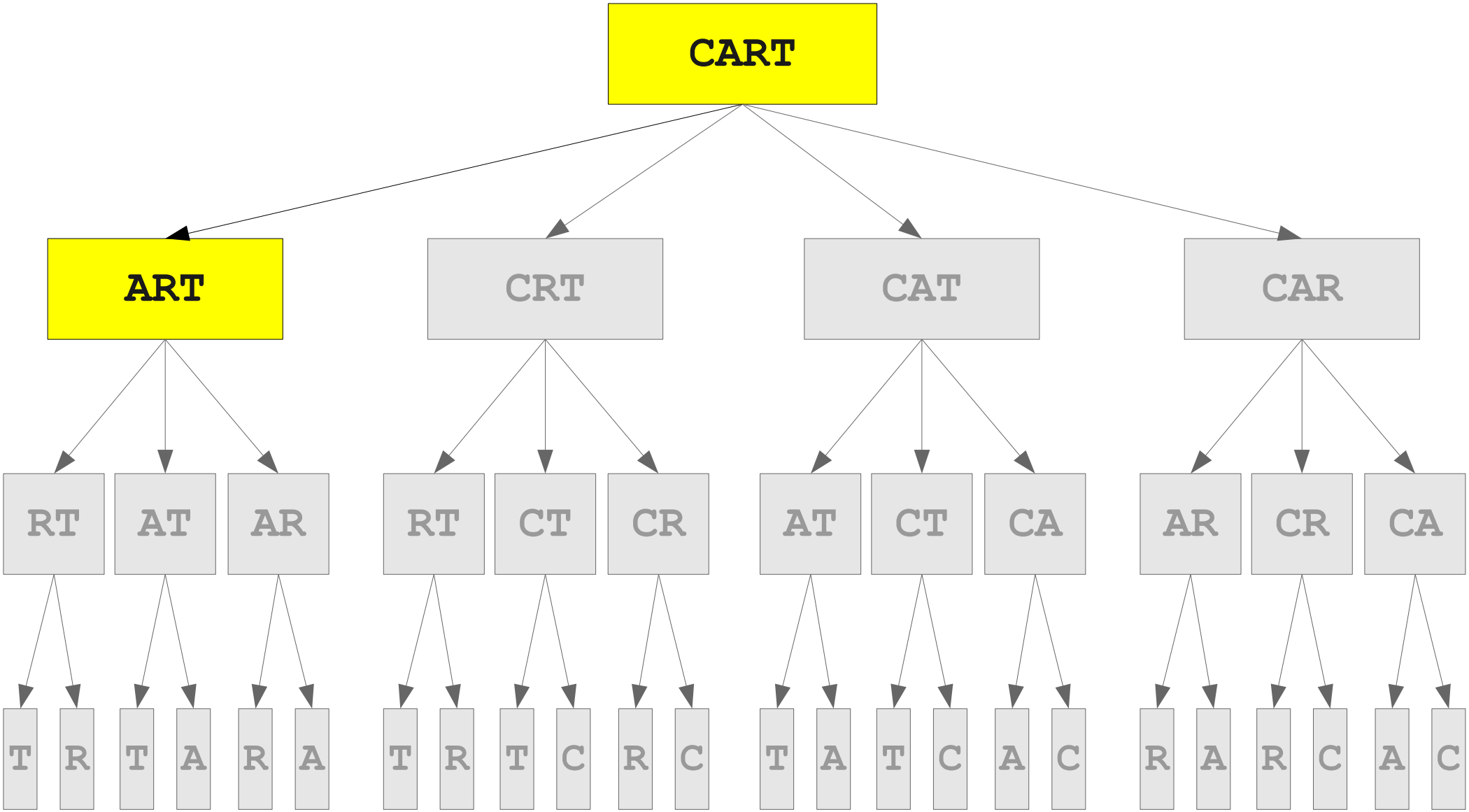

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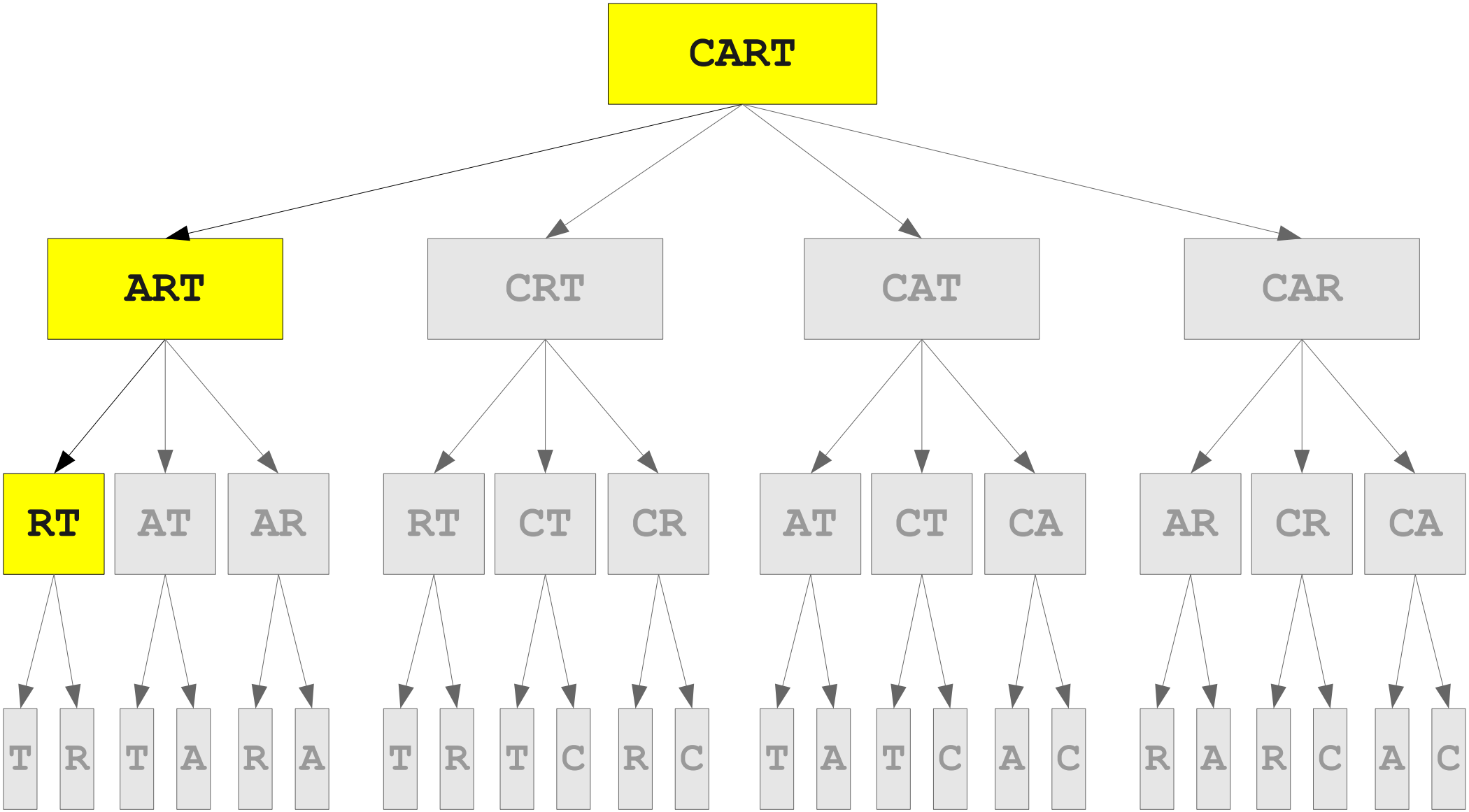

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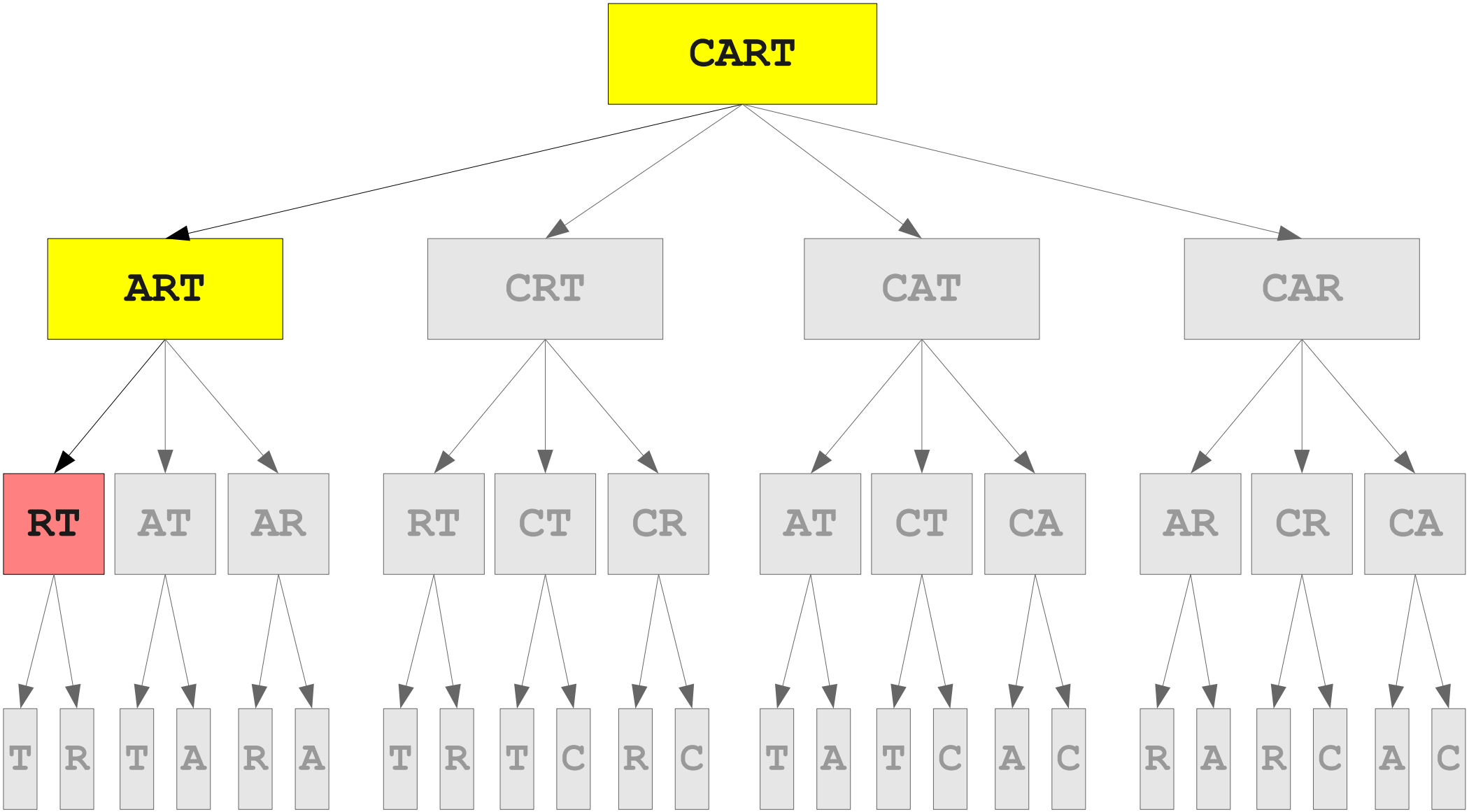

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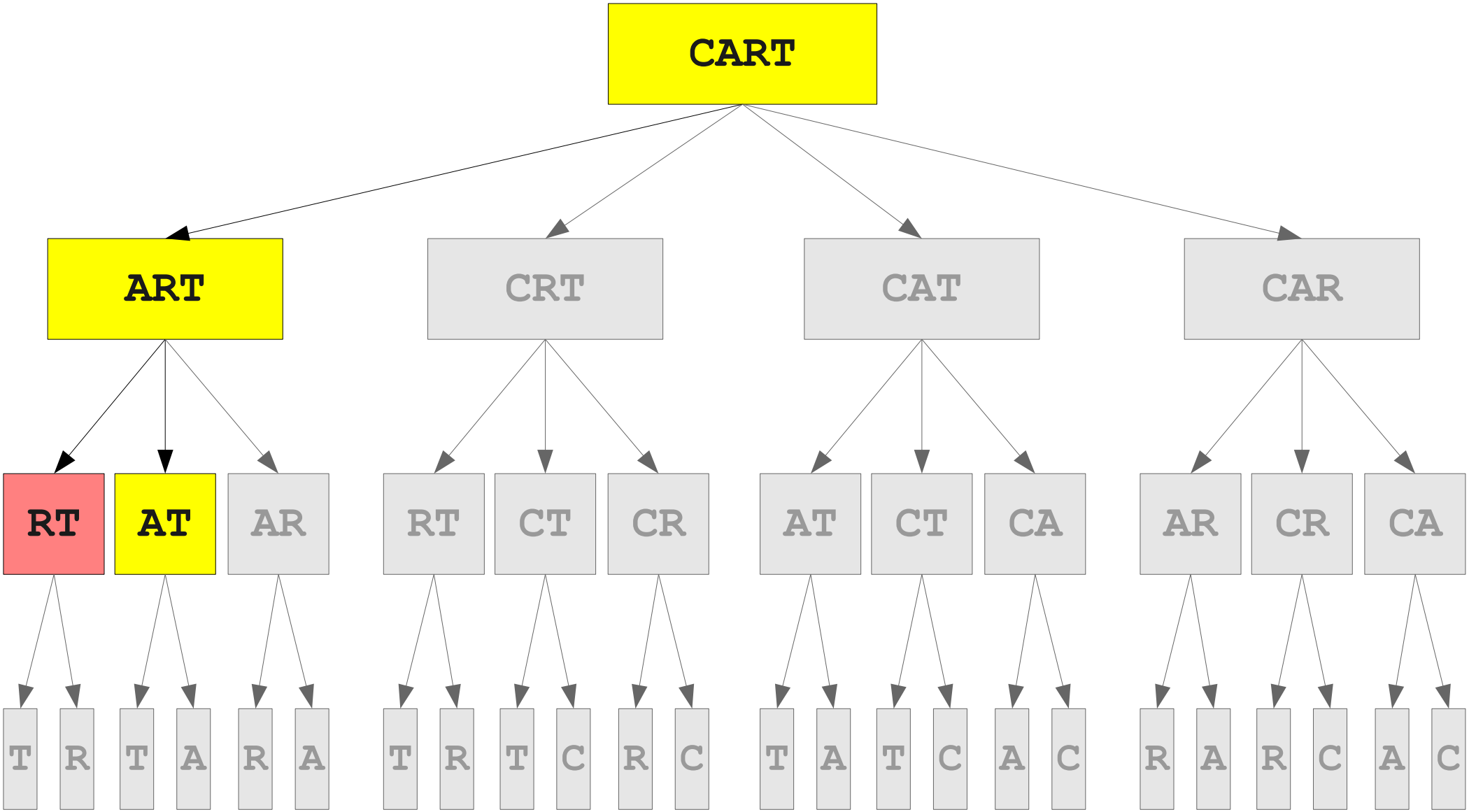

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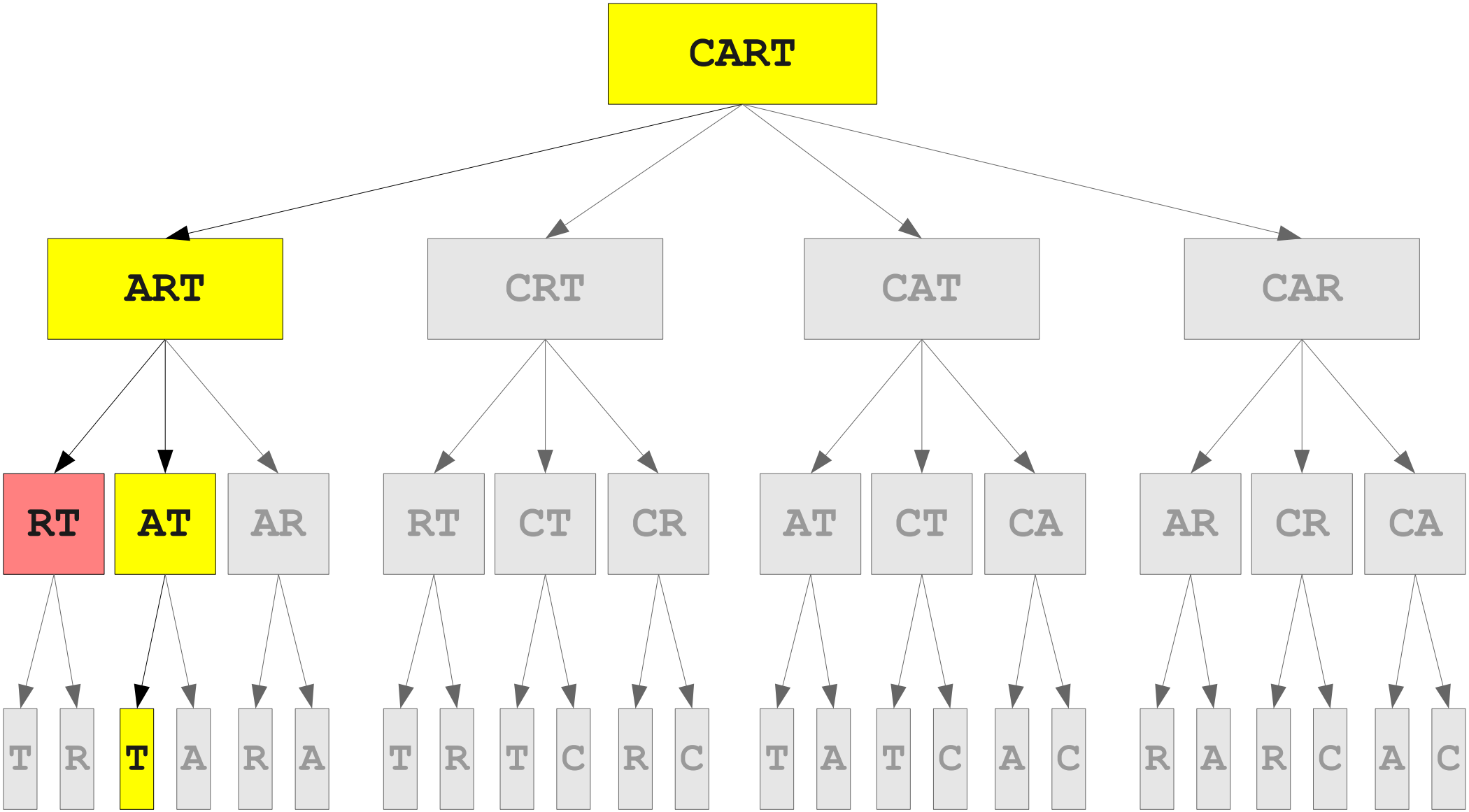

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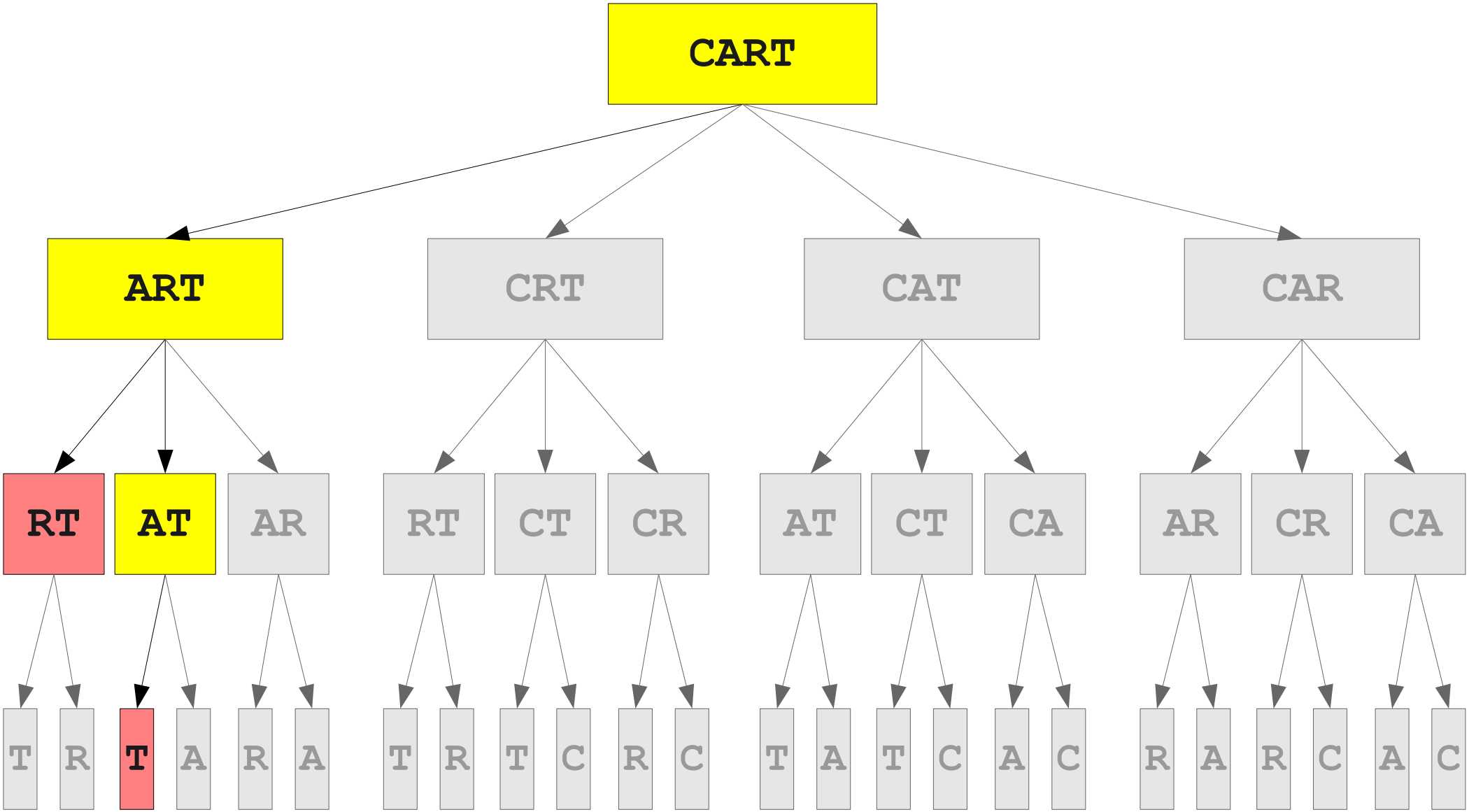

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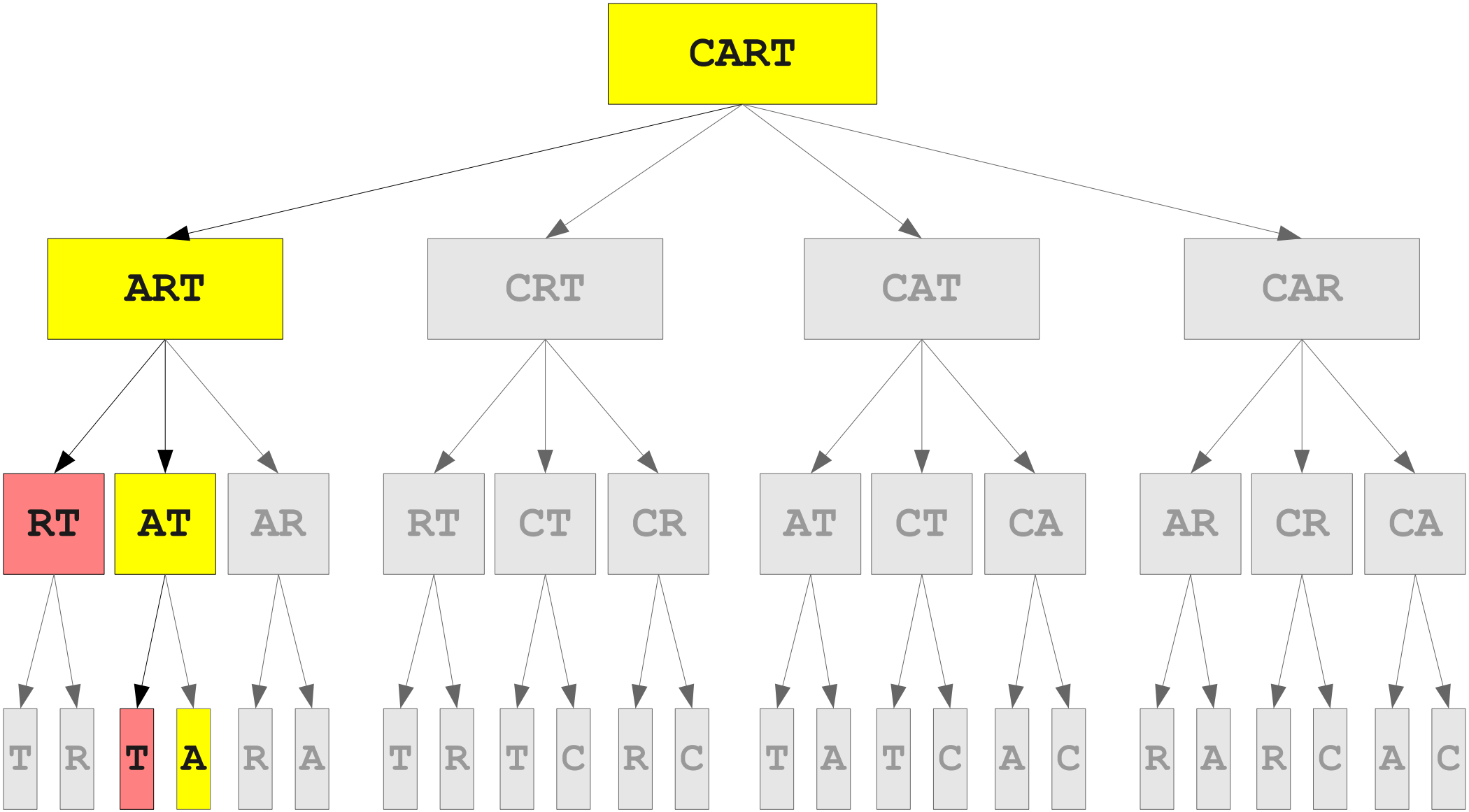

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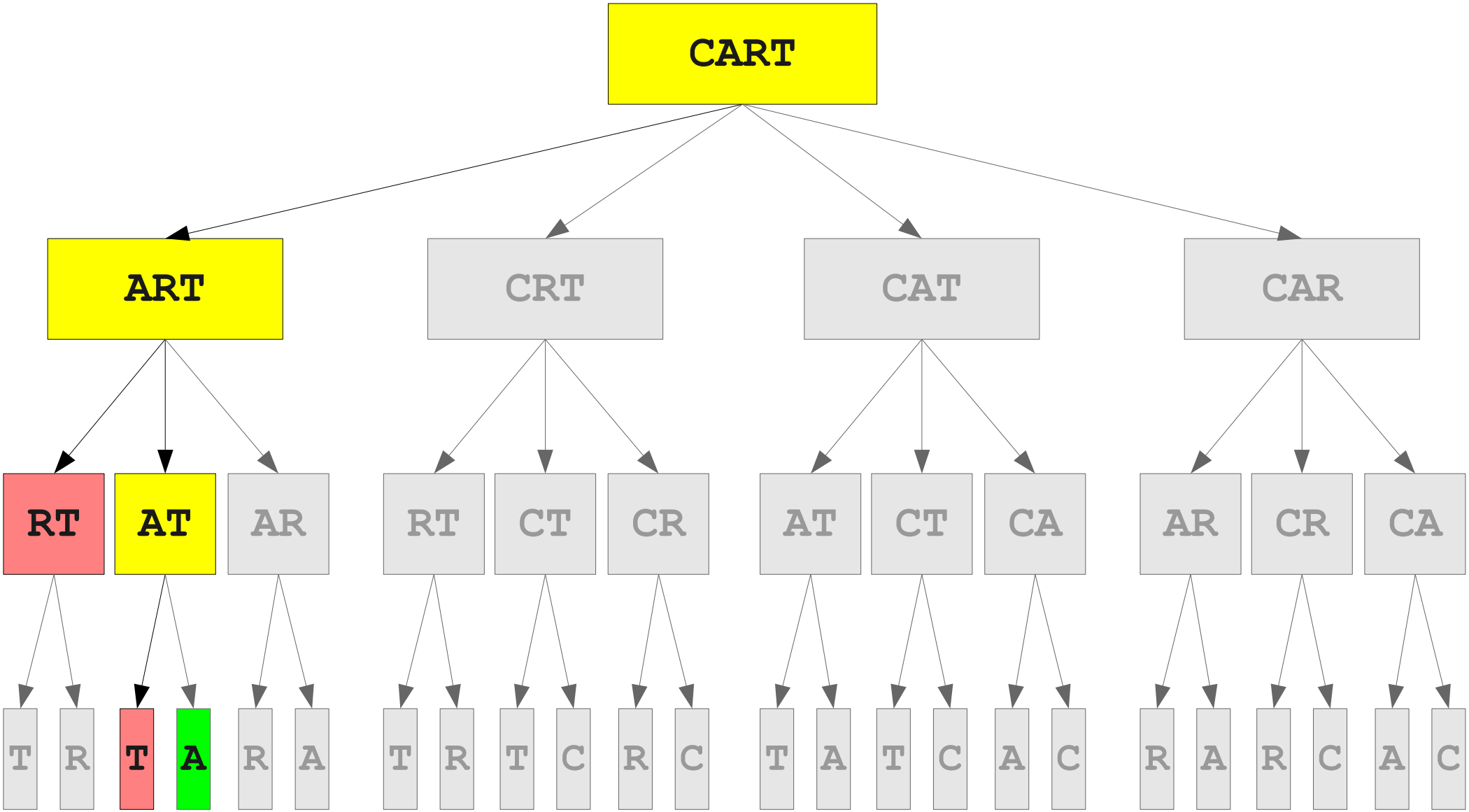

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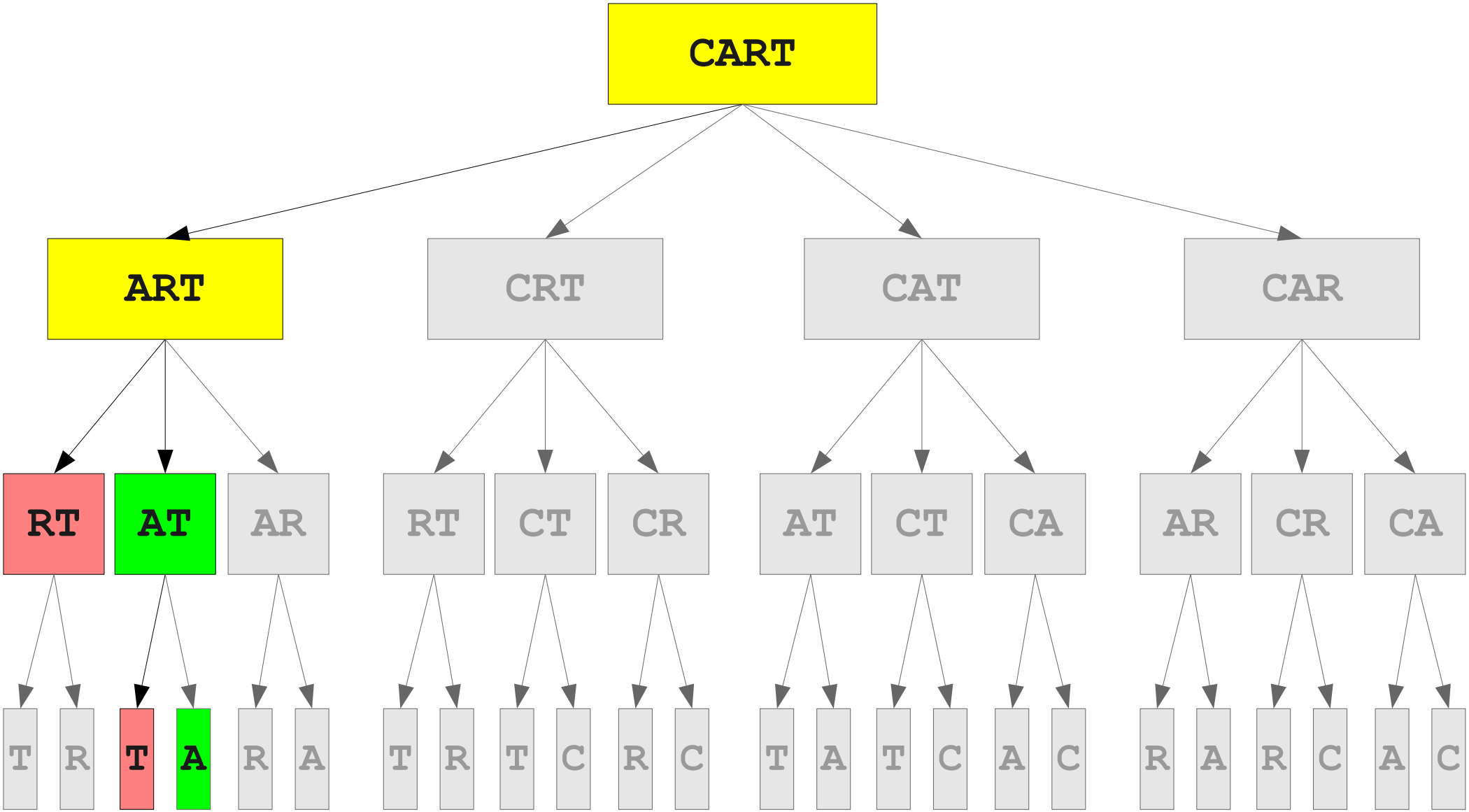

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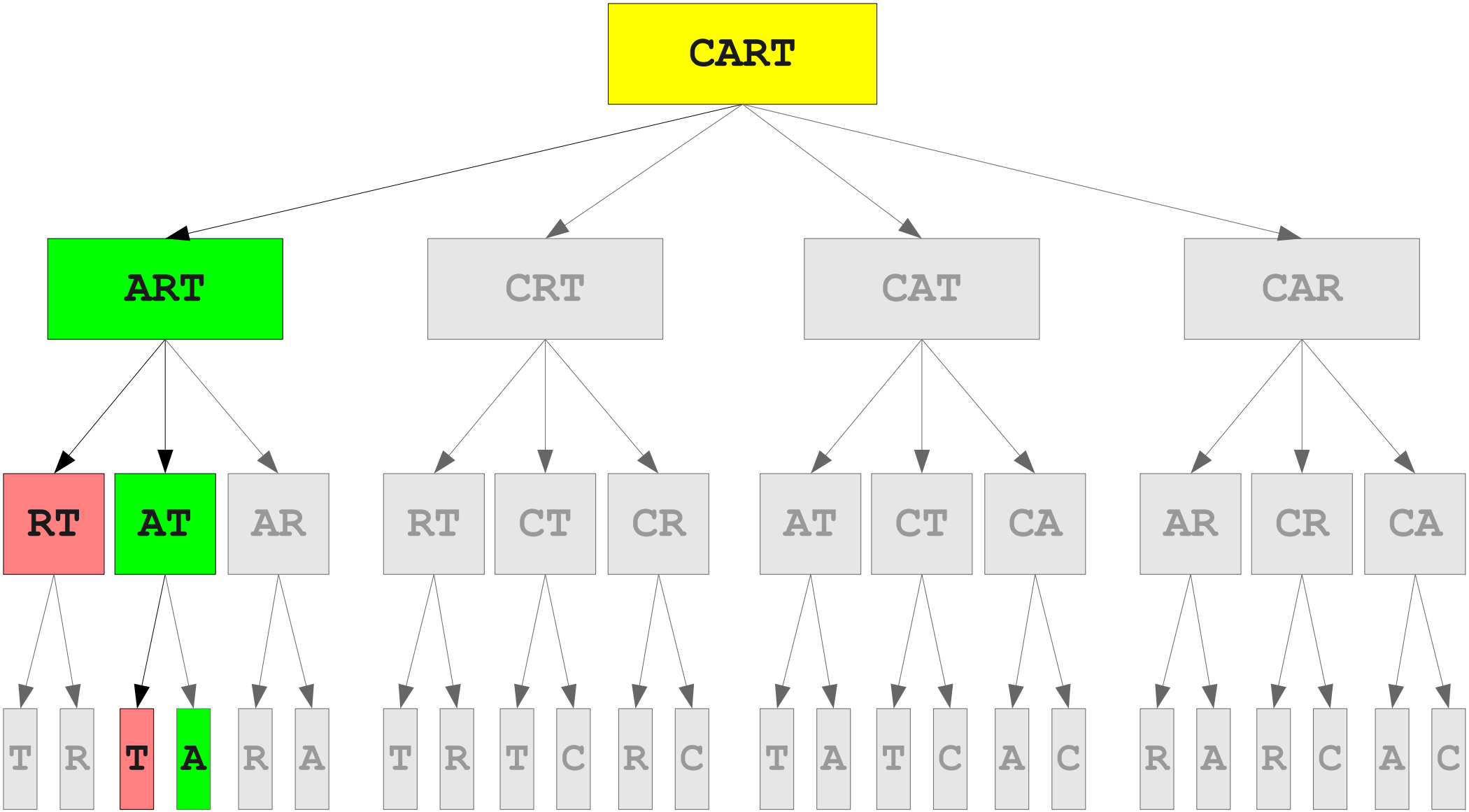

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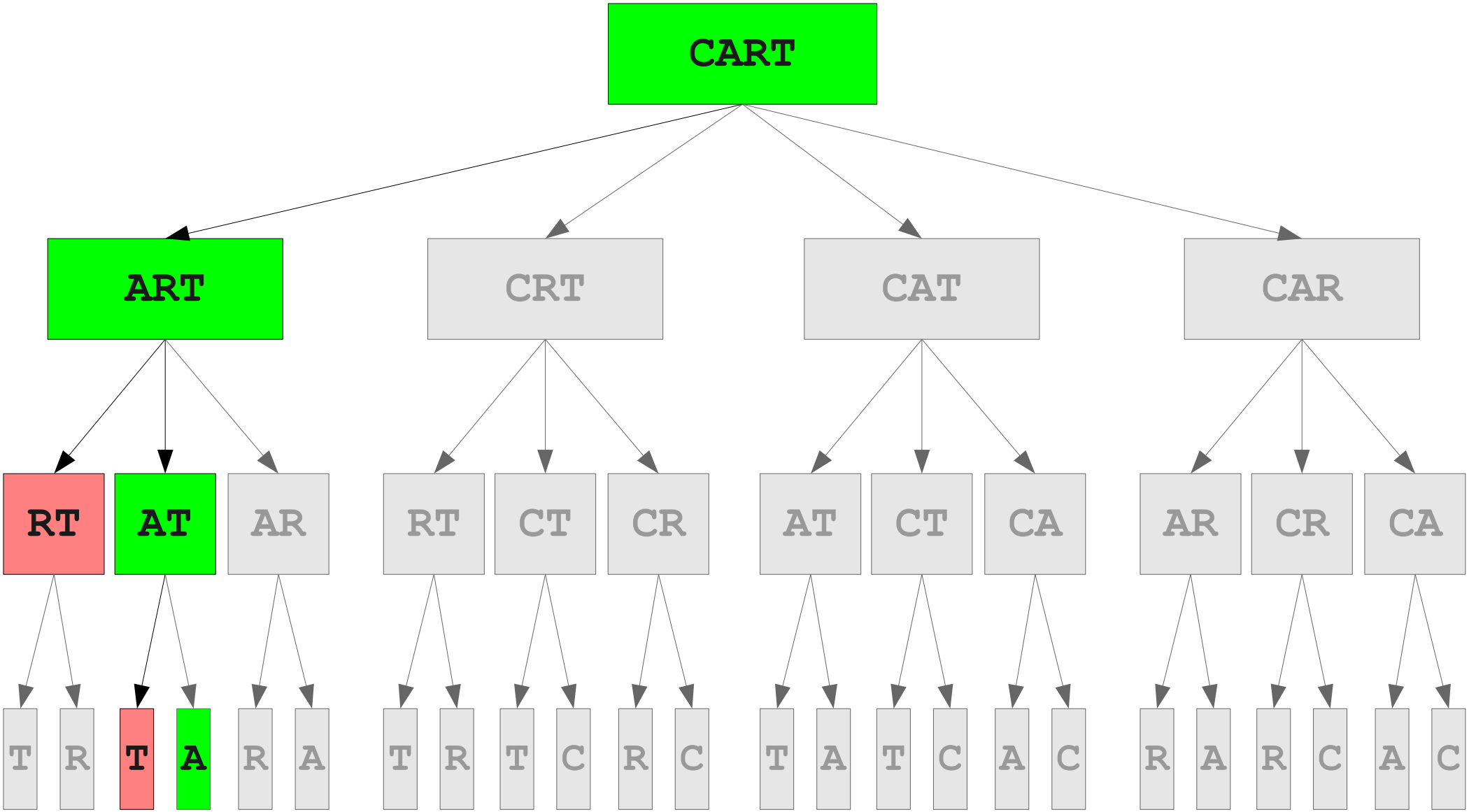
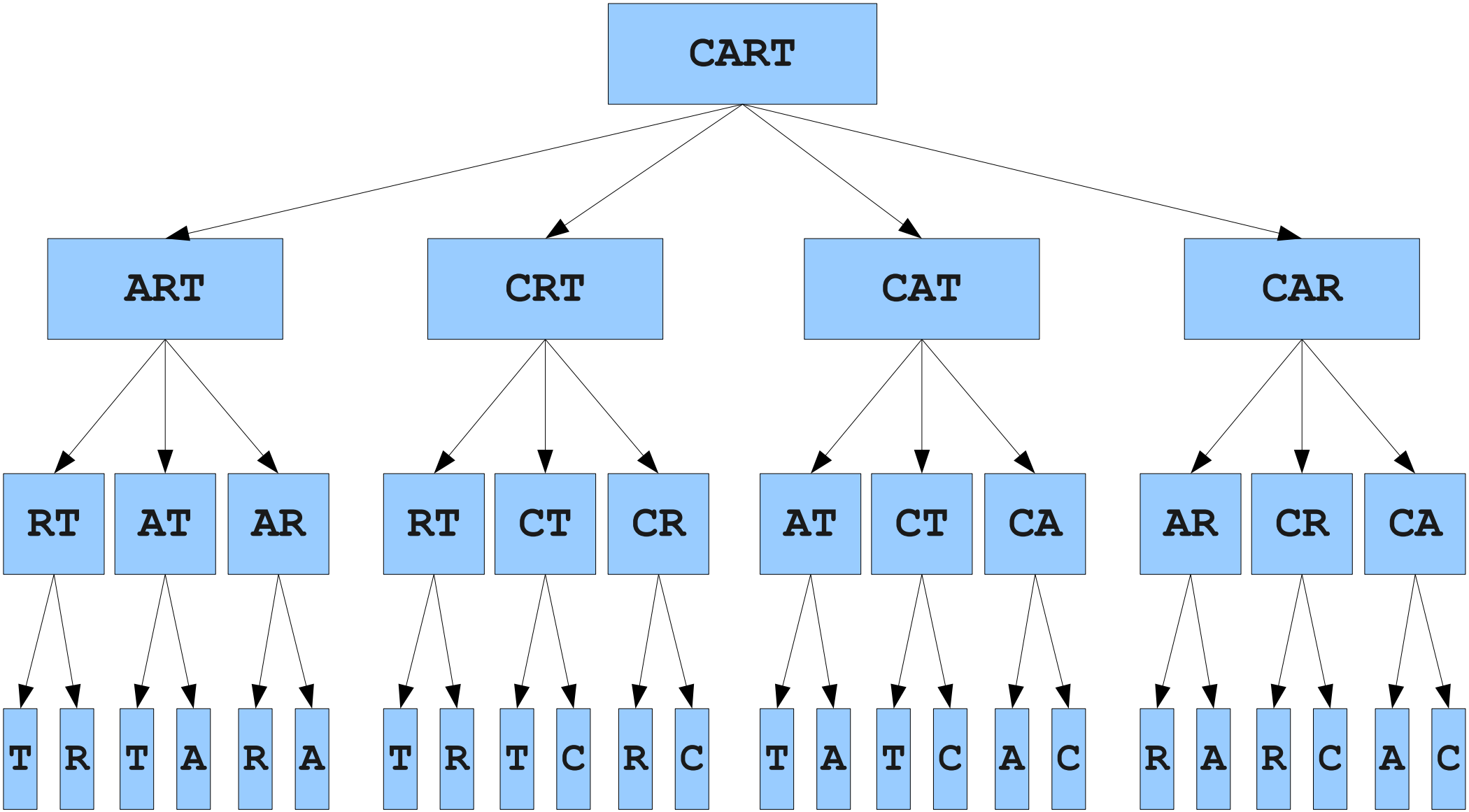


Recursive Backtracking

```
if (problem is sufficiently simple) {
   return whether or not the problem is solvable
} else {
   for (each choice) {
      try out that choice.
      if (that choice leads to success) {
         return success
      }
   }
   return failure
}
```

Returning Early



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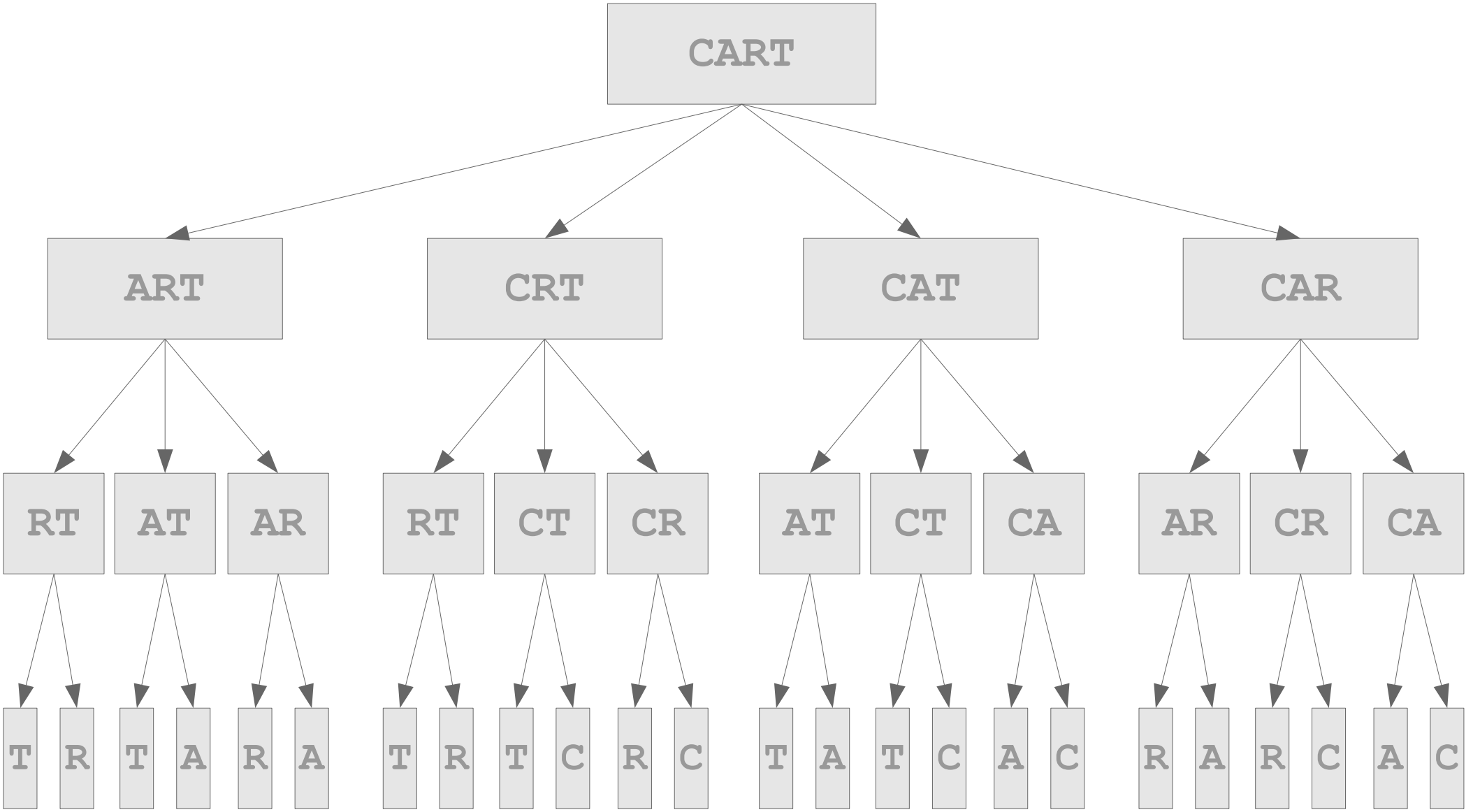

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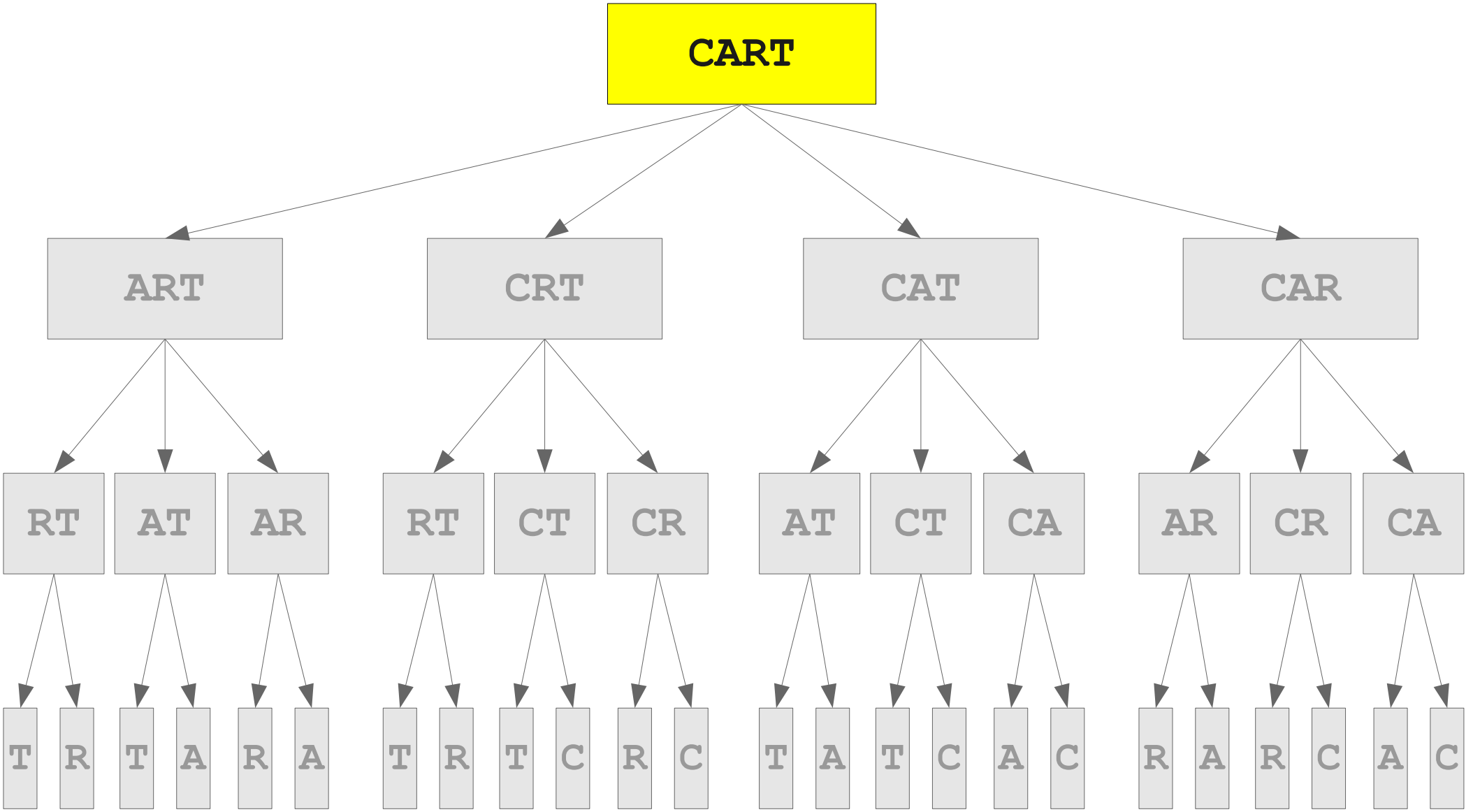

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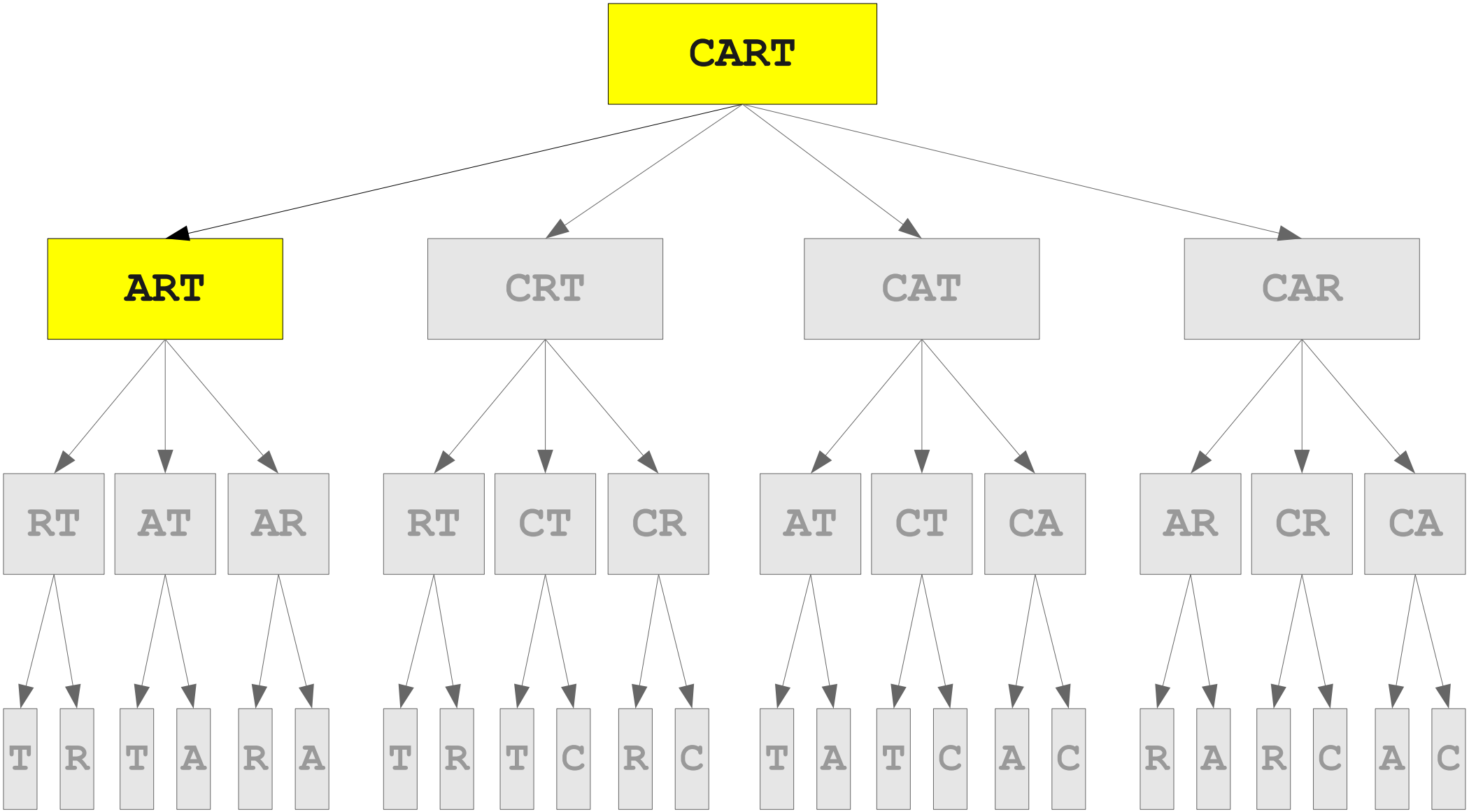

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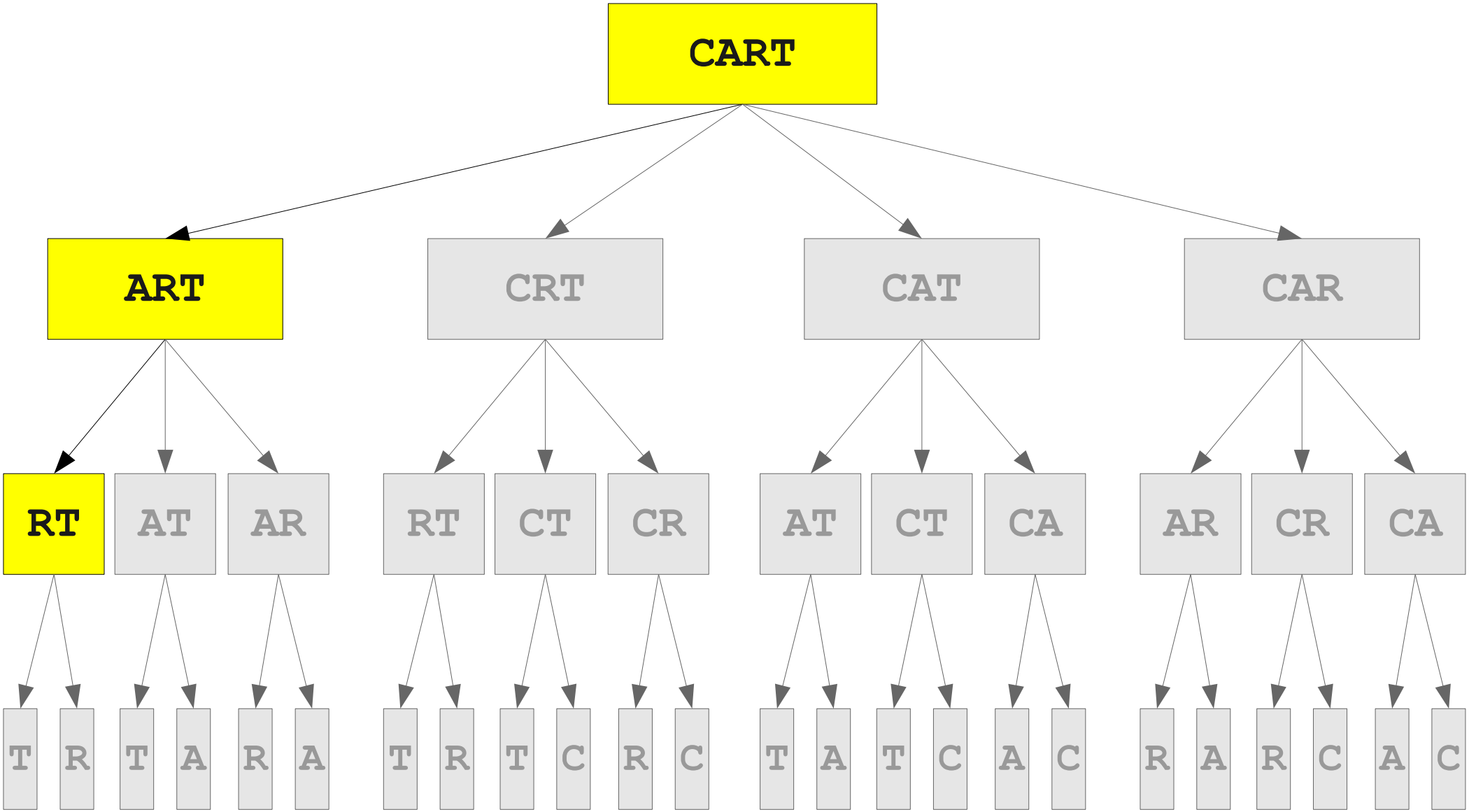

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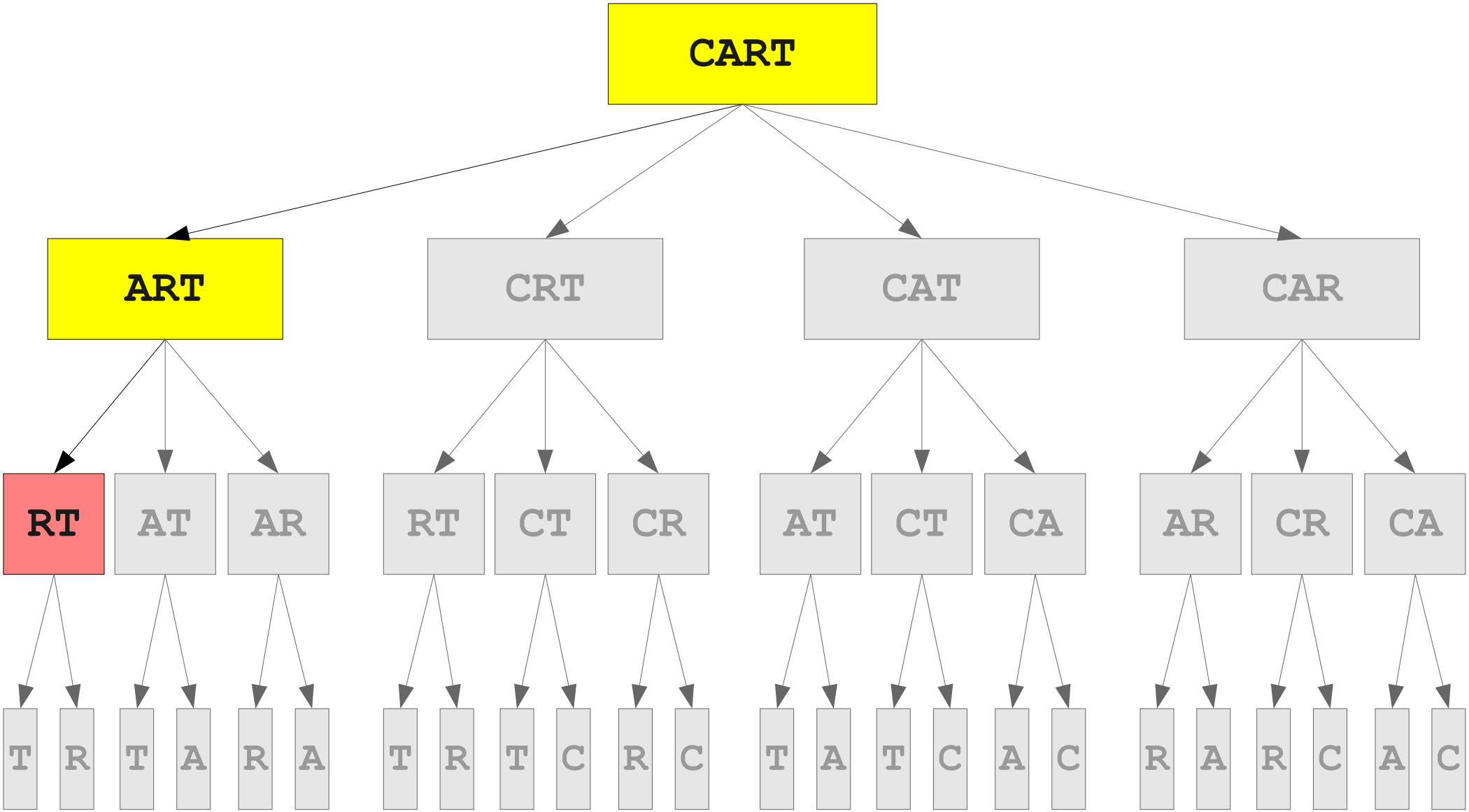

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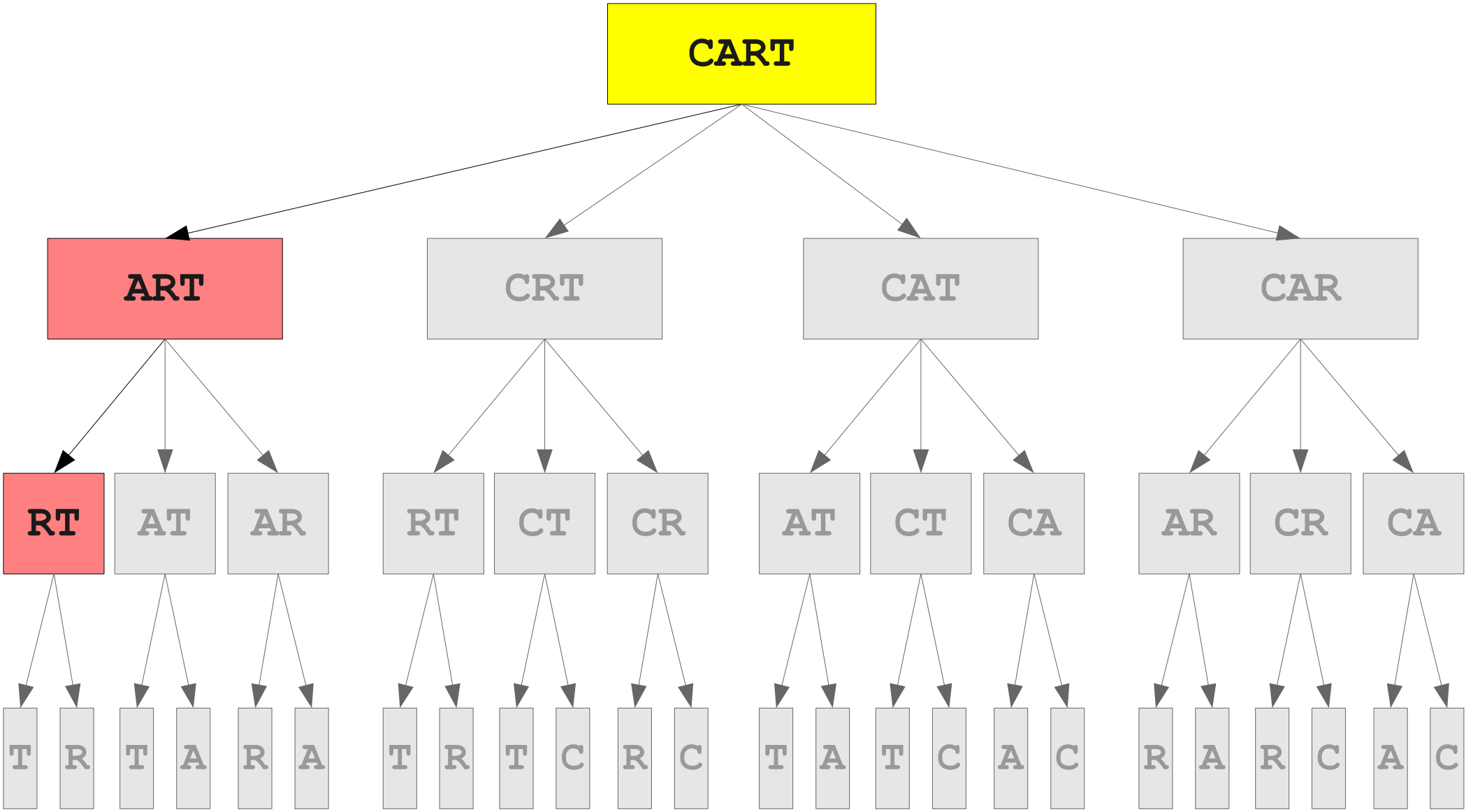

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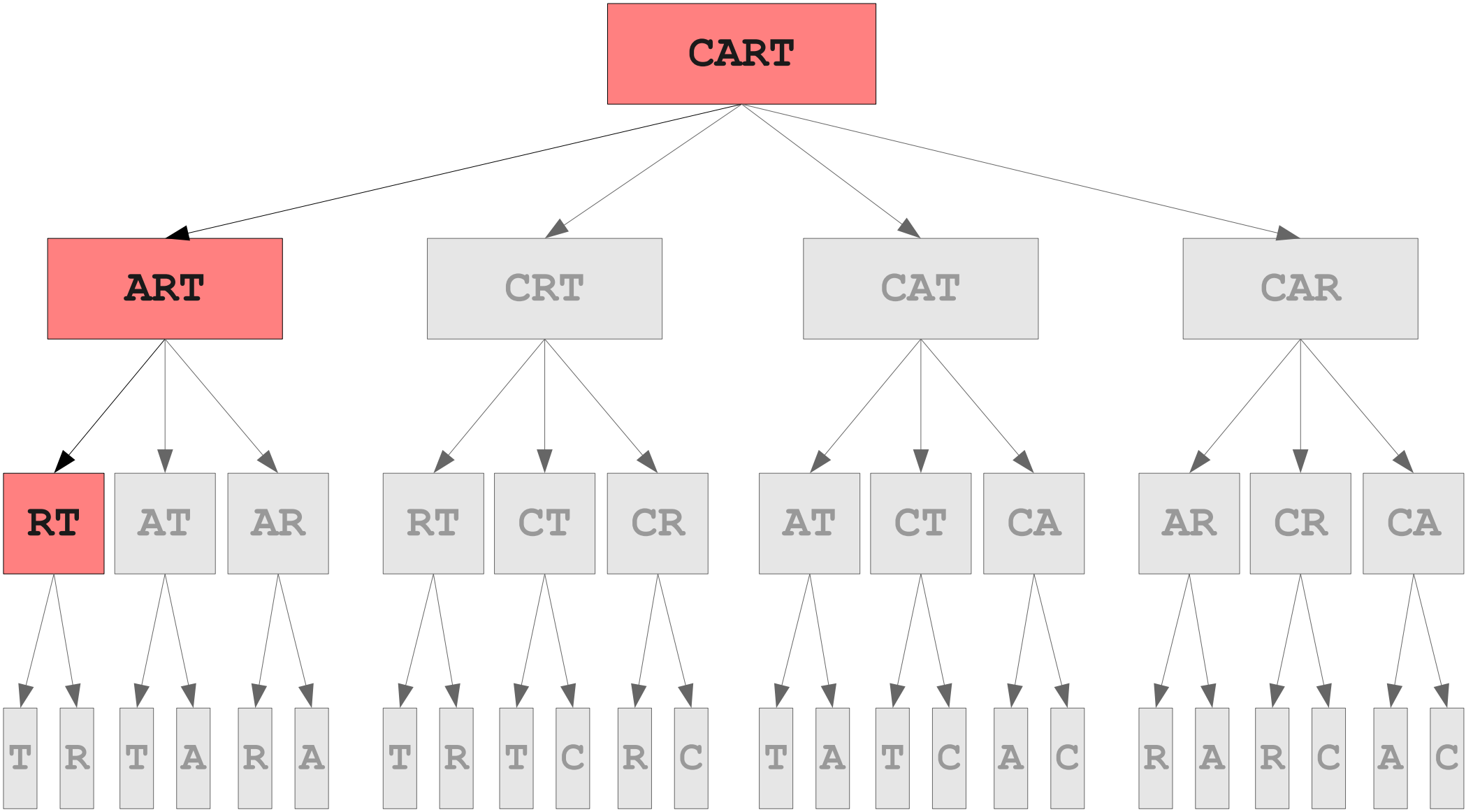


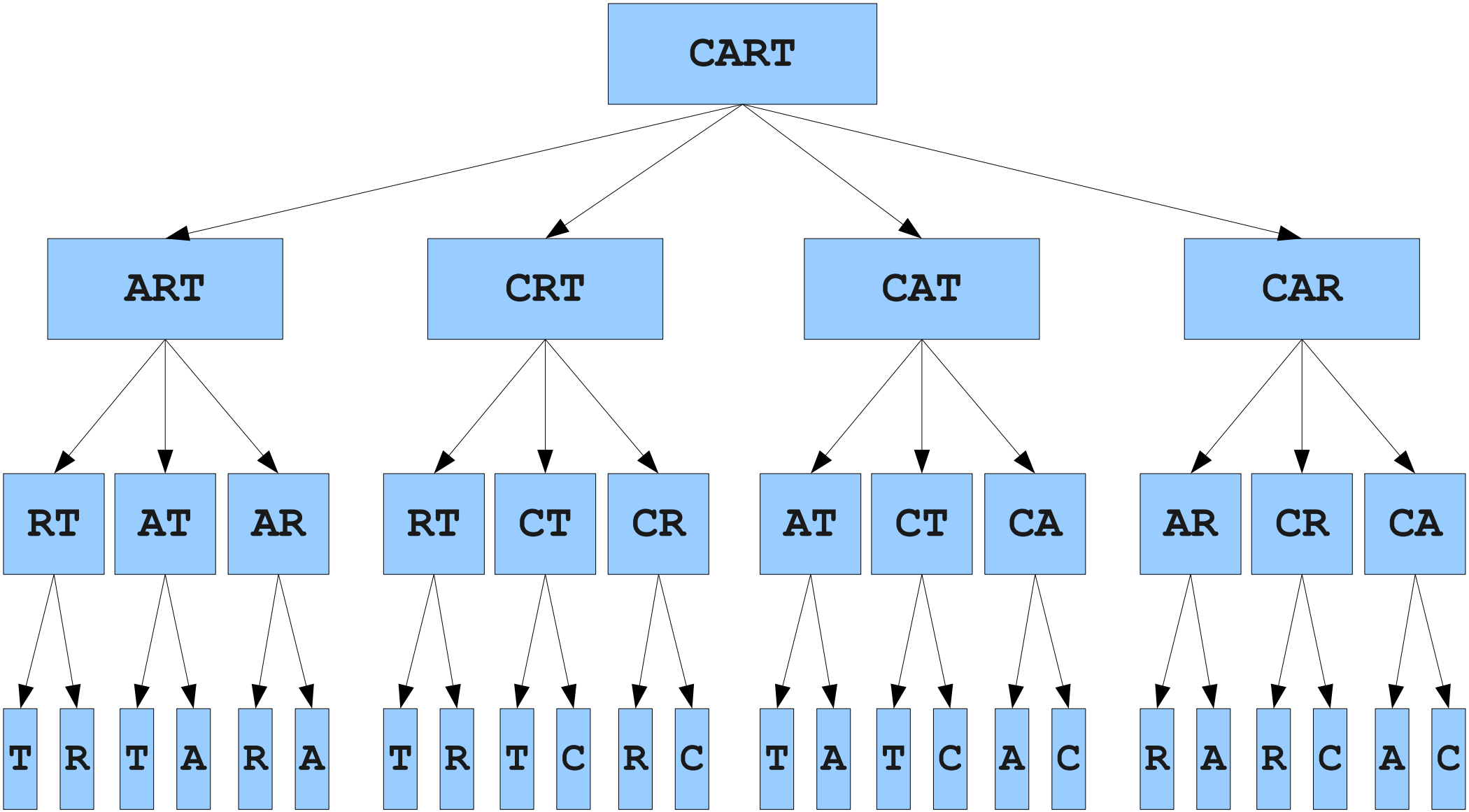
Extracting a Solution

- We now have a list of words that allegedly are shrinkable, but we don't actually know how to shrink them!
- Can the function tell us *how* to shrink the word?

Output Parameters

- An **output parameter** (or **outparam**) is a parameter to a function that stores the result of that function.
- Caller passes the parameter by reference, function overwrites the value.
- Useful if you need to return multiple values.

Generating the Answer



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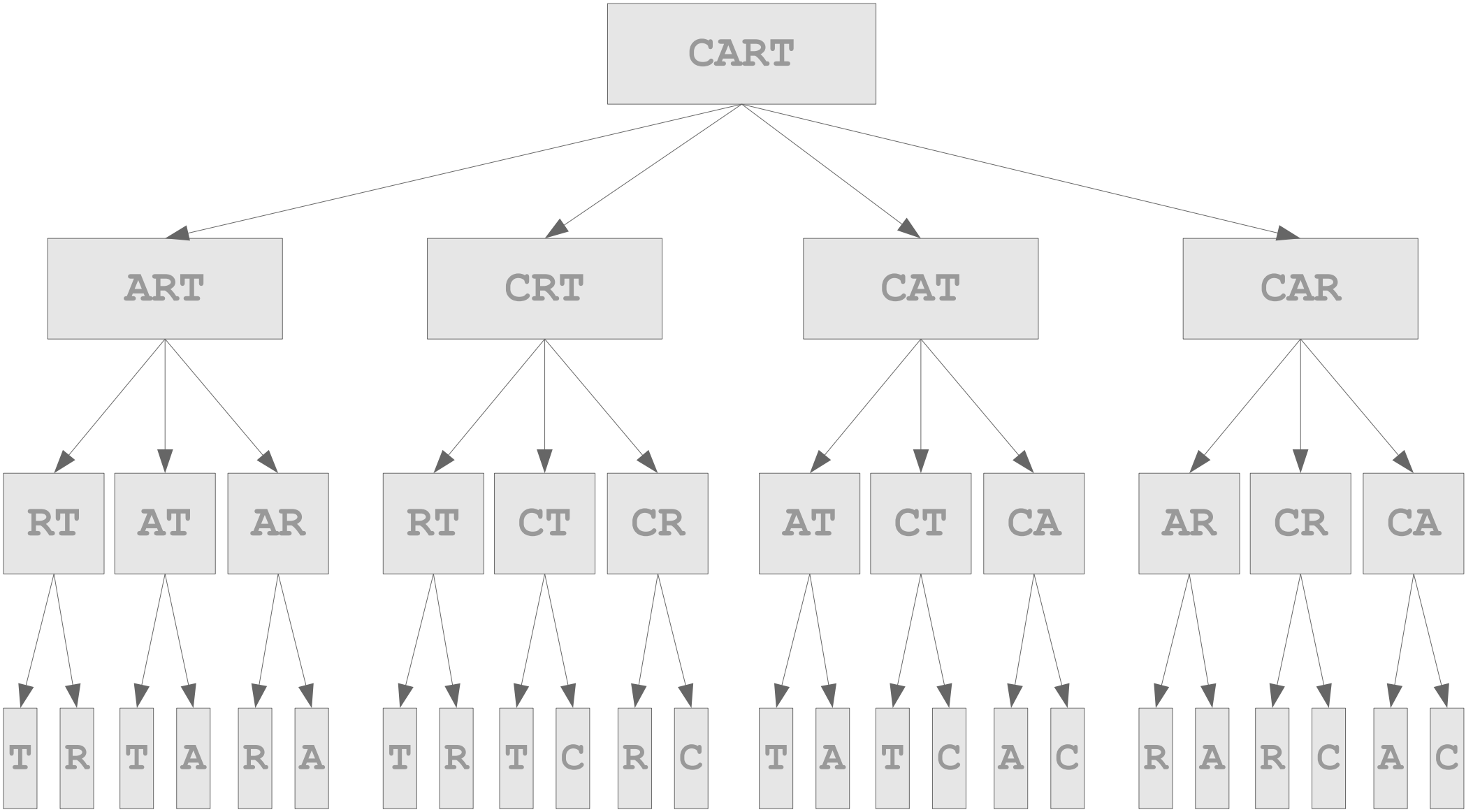

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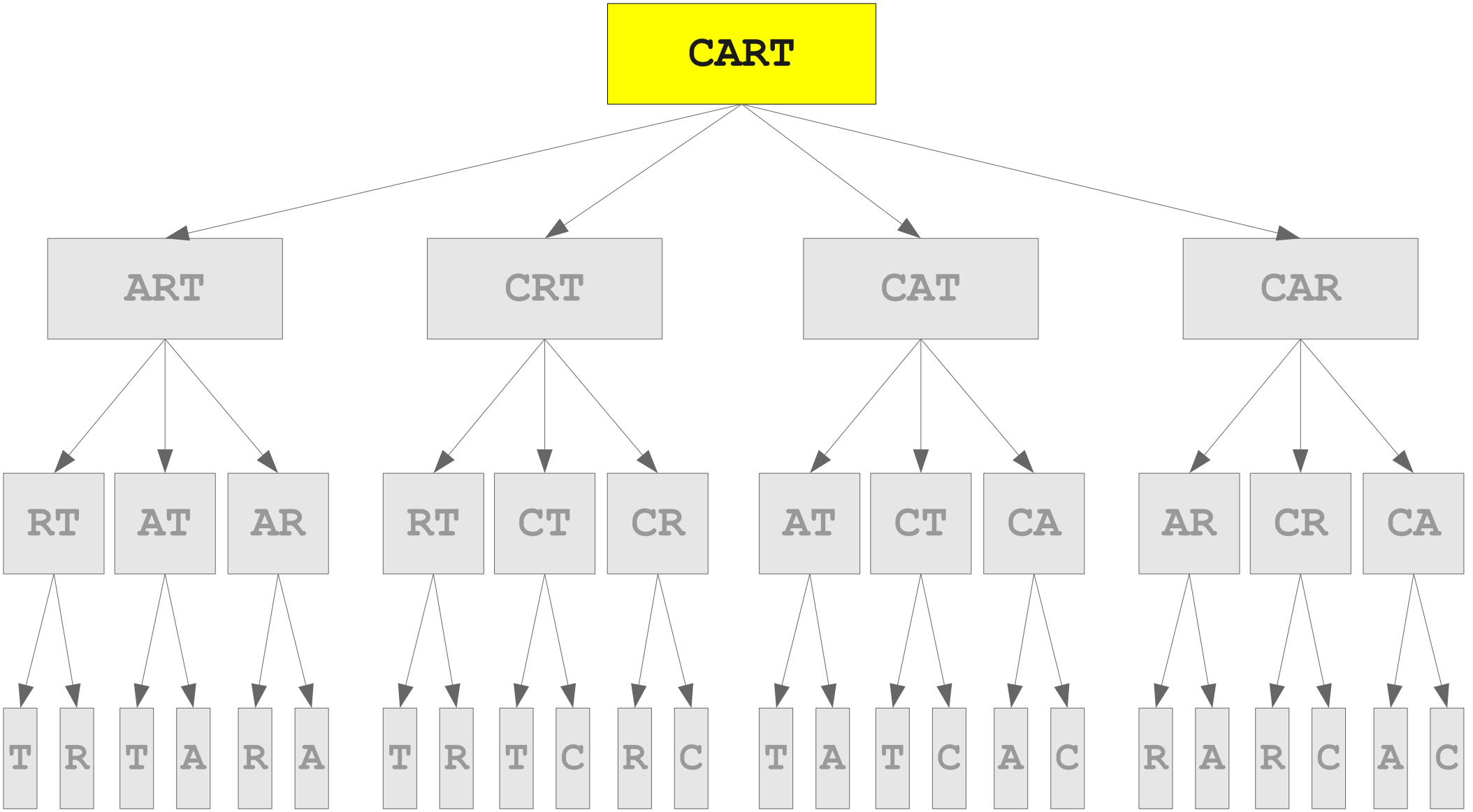

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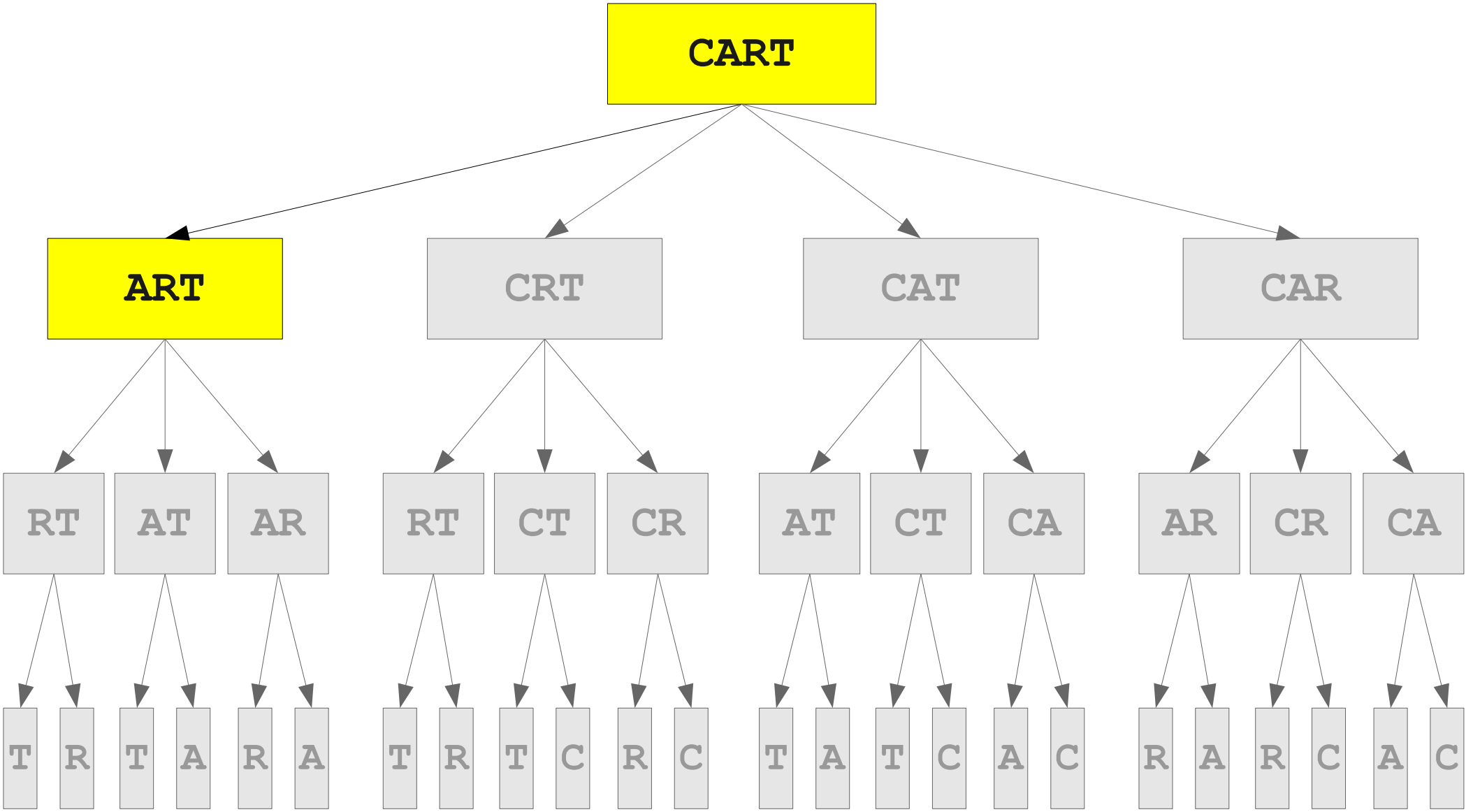

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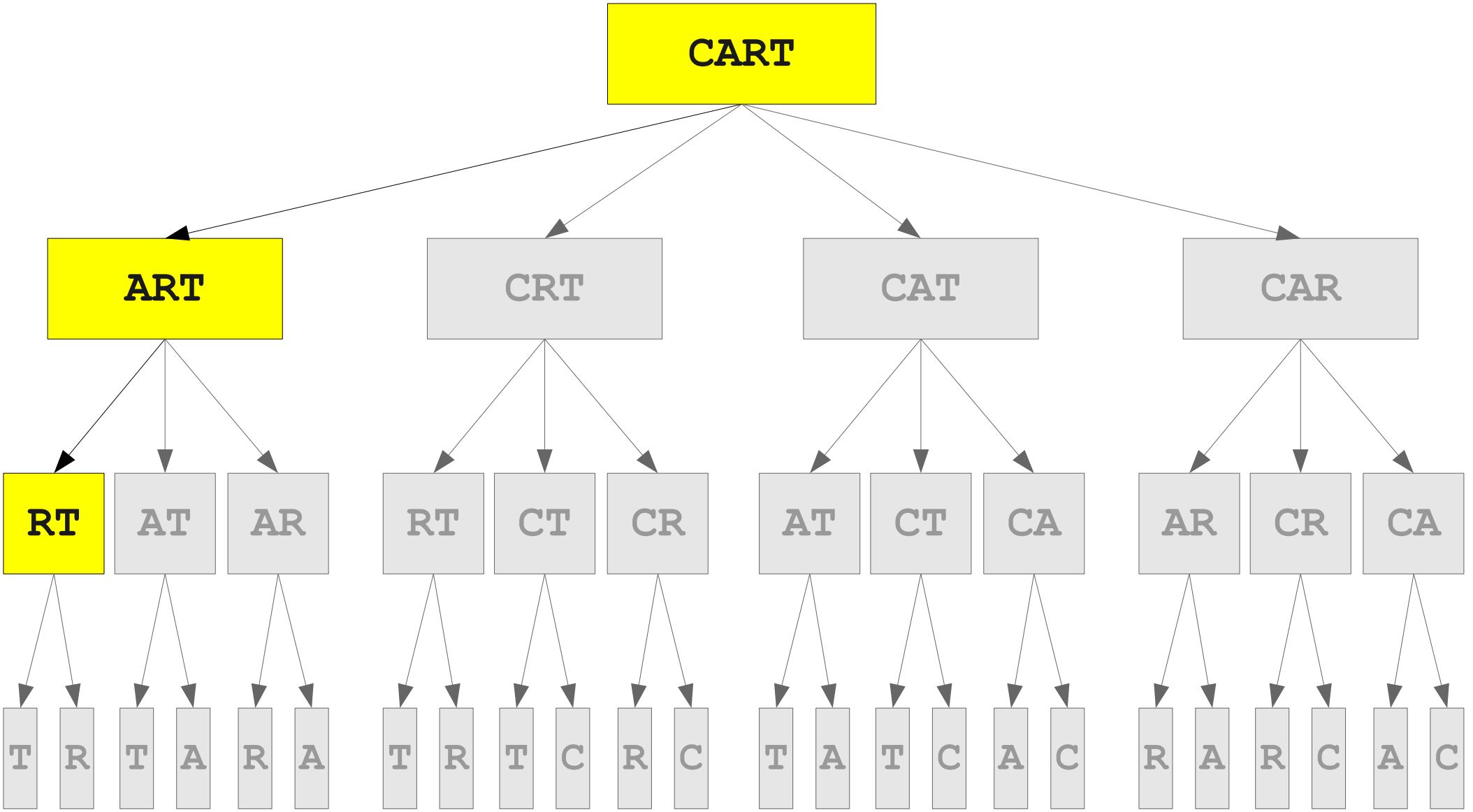

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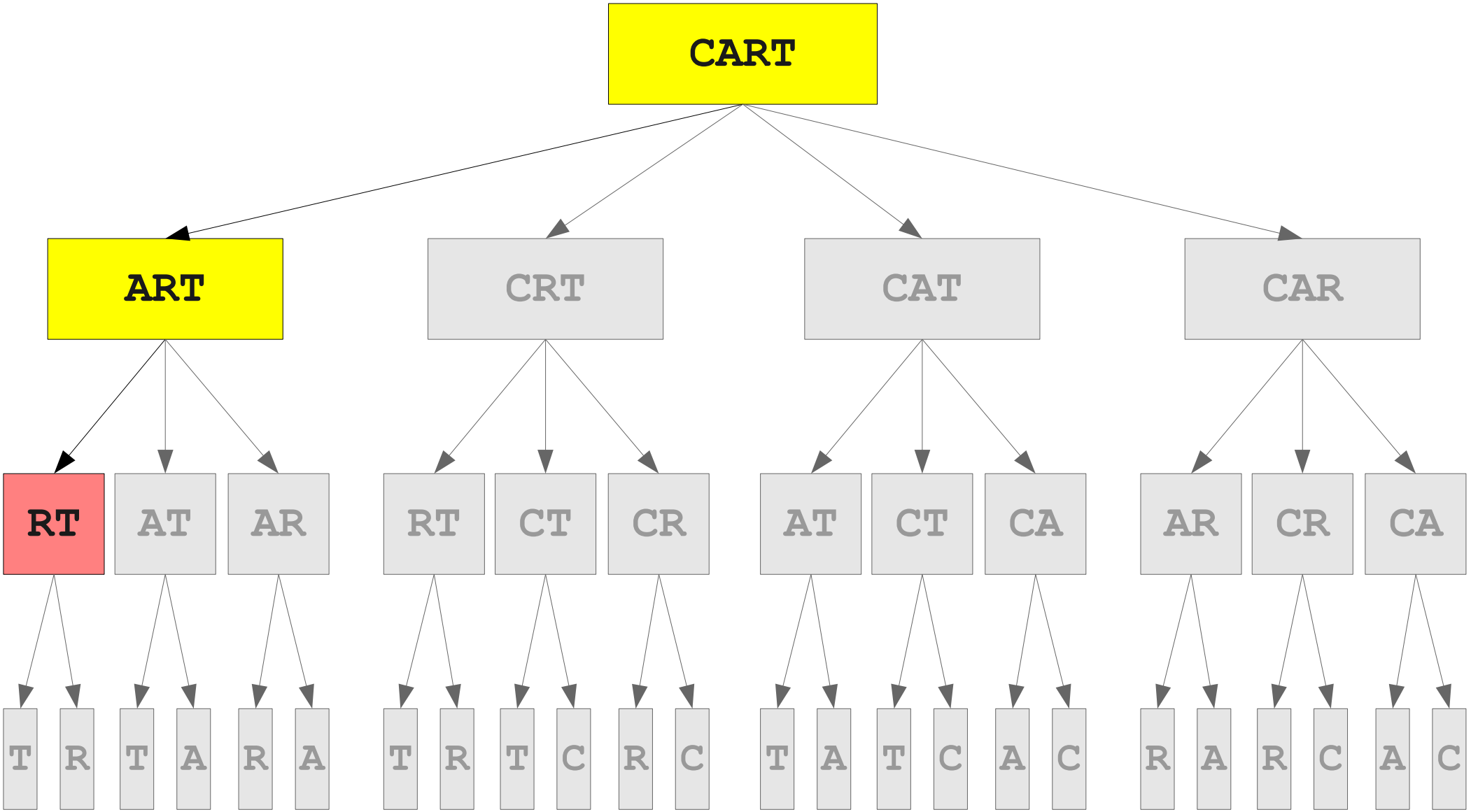

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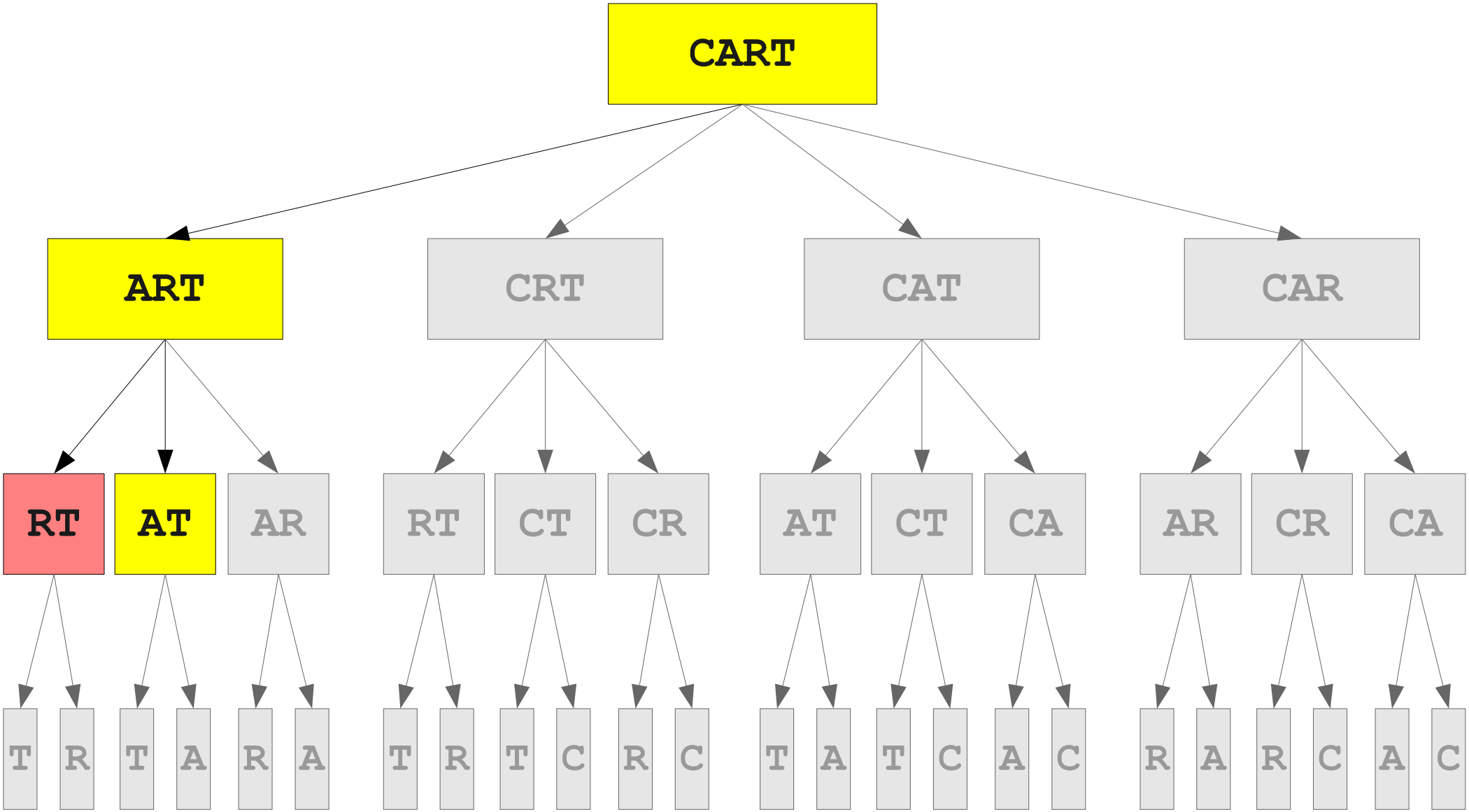

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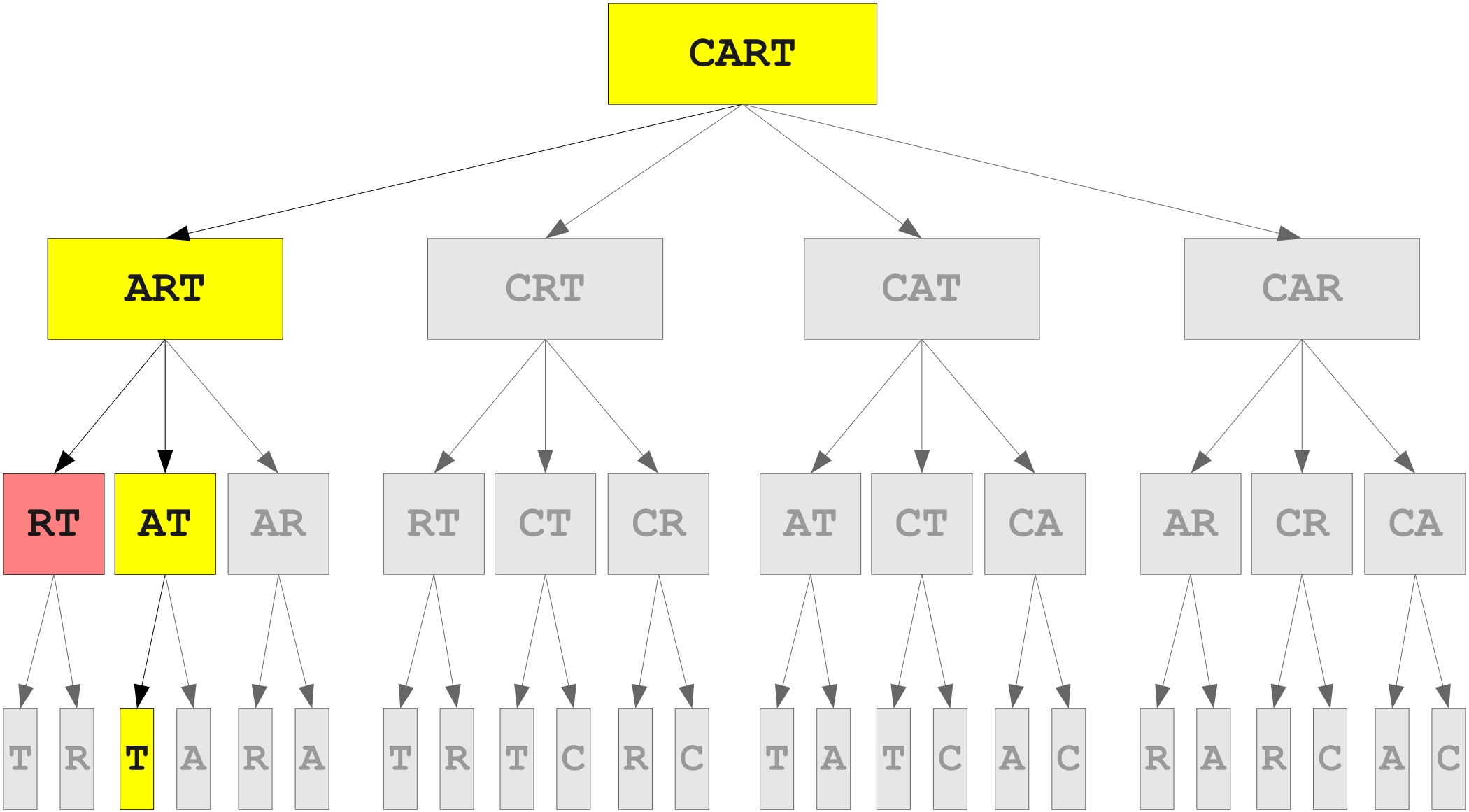

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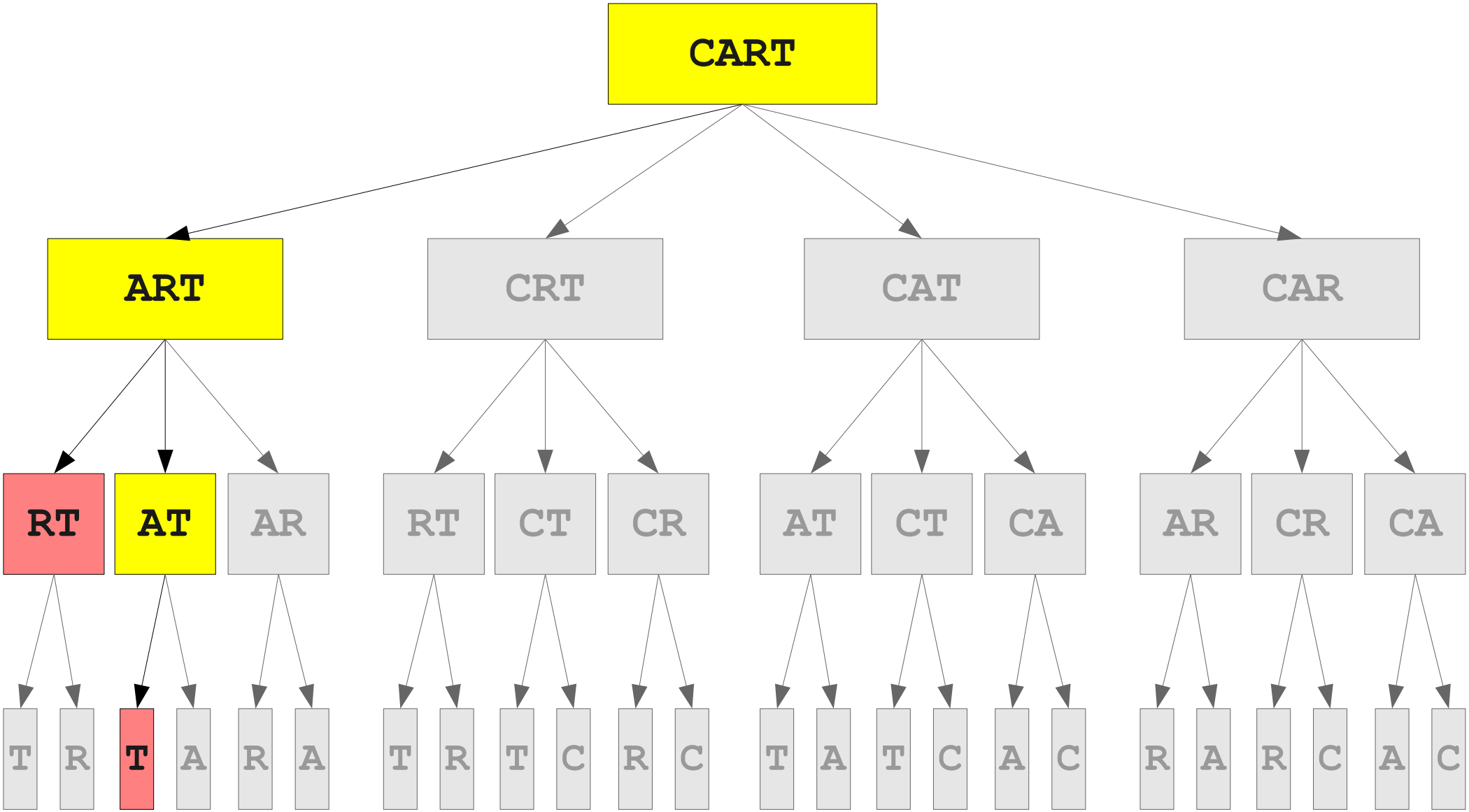

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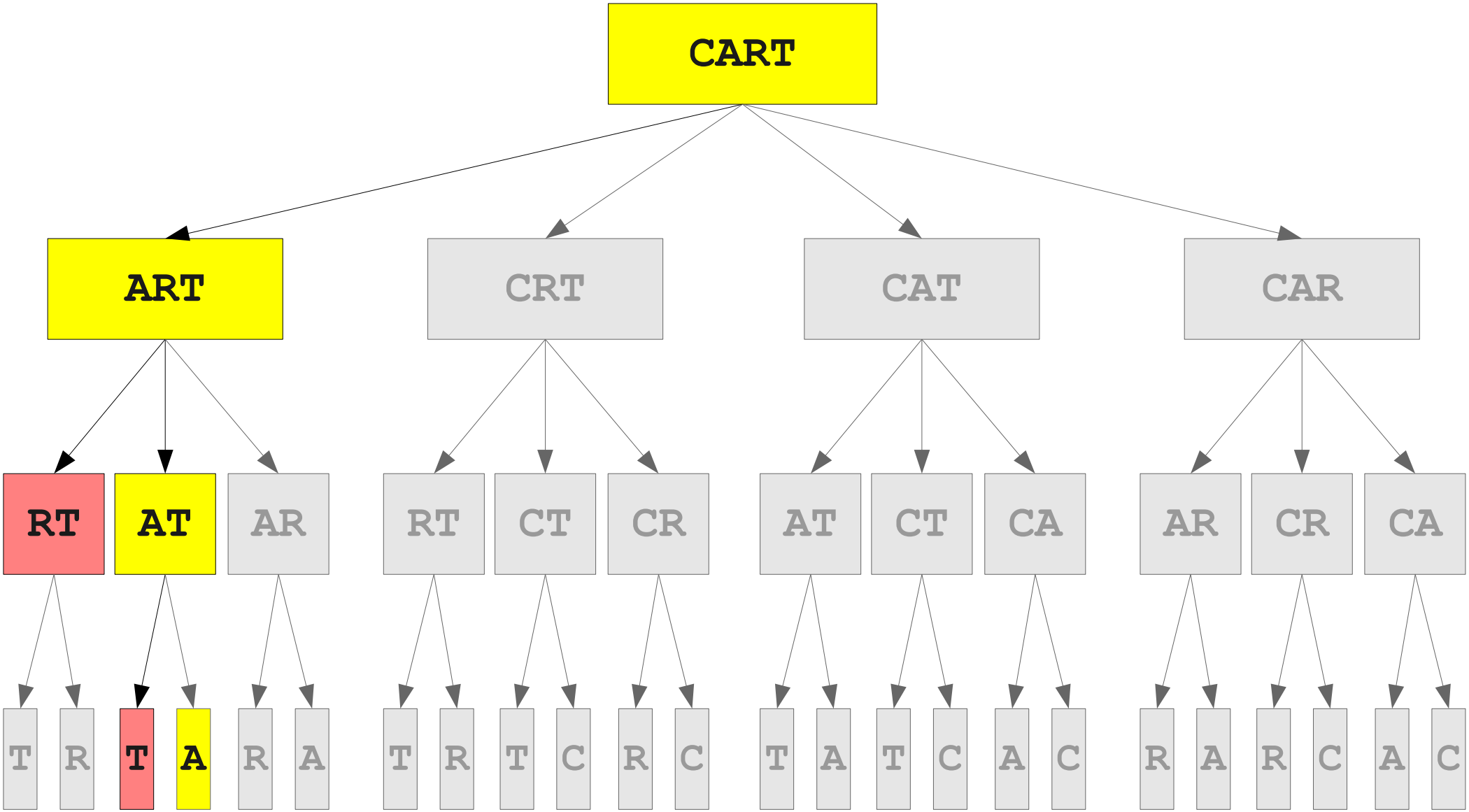

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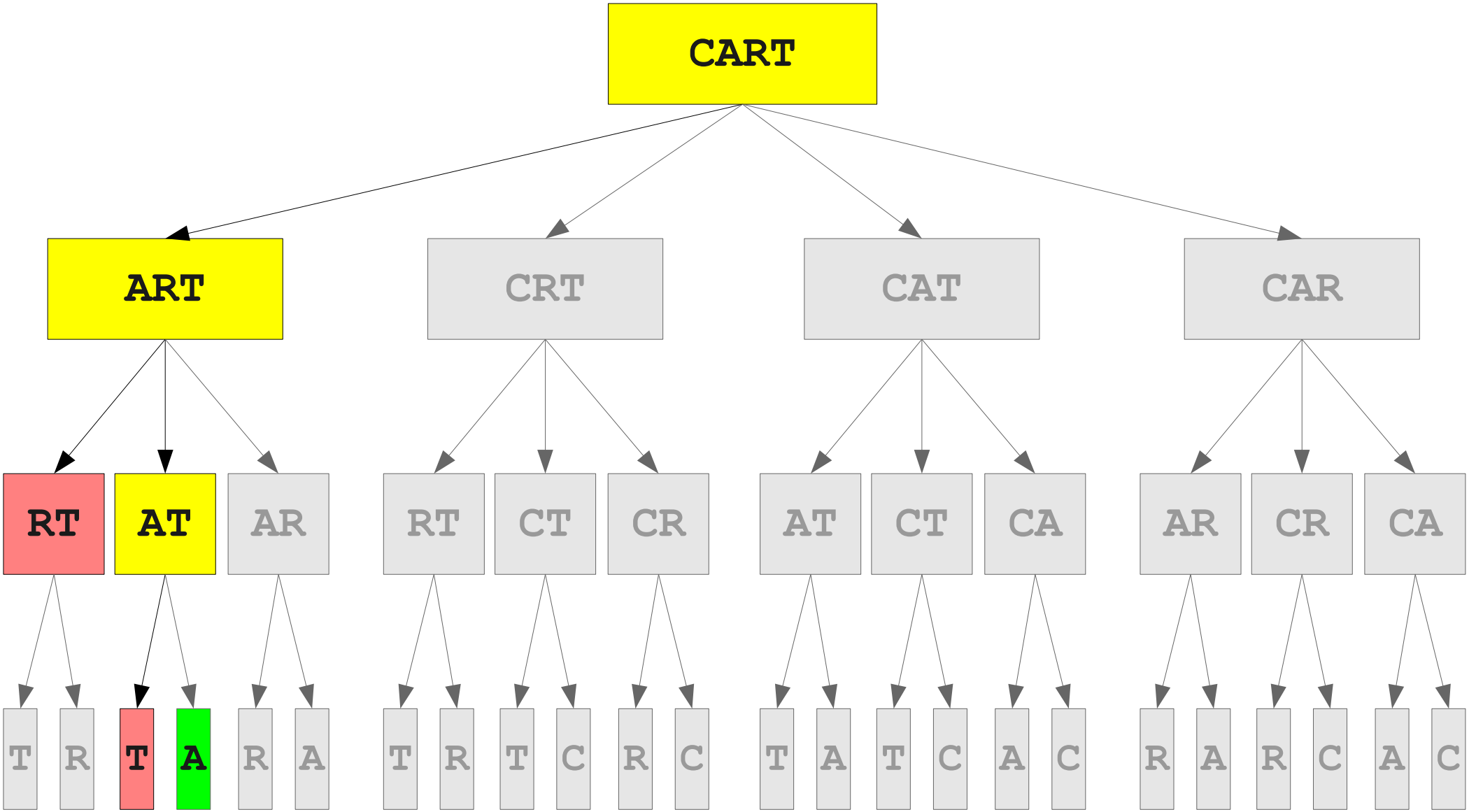

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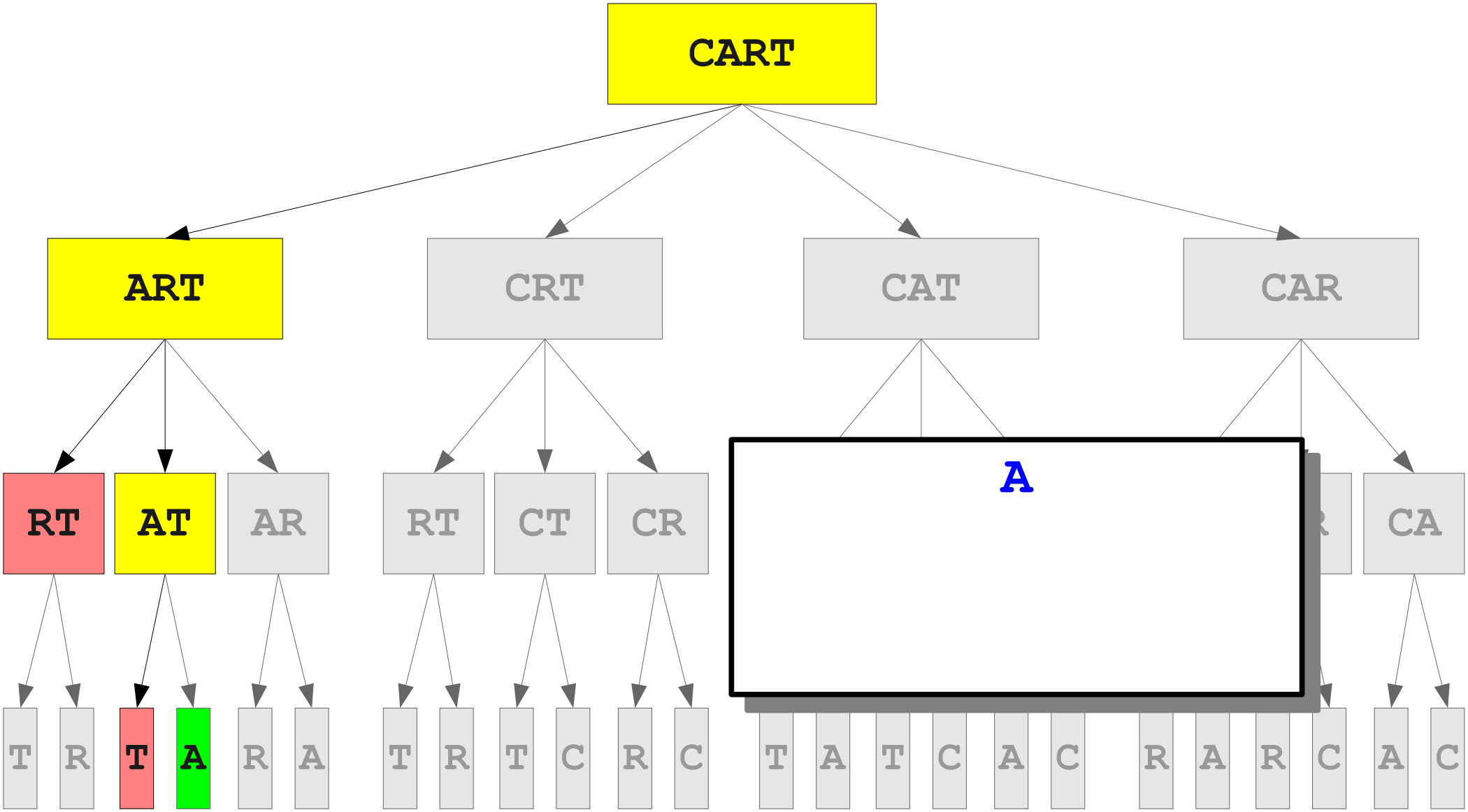

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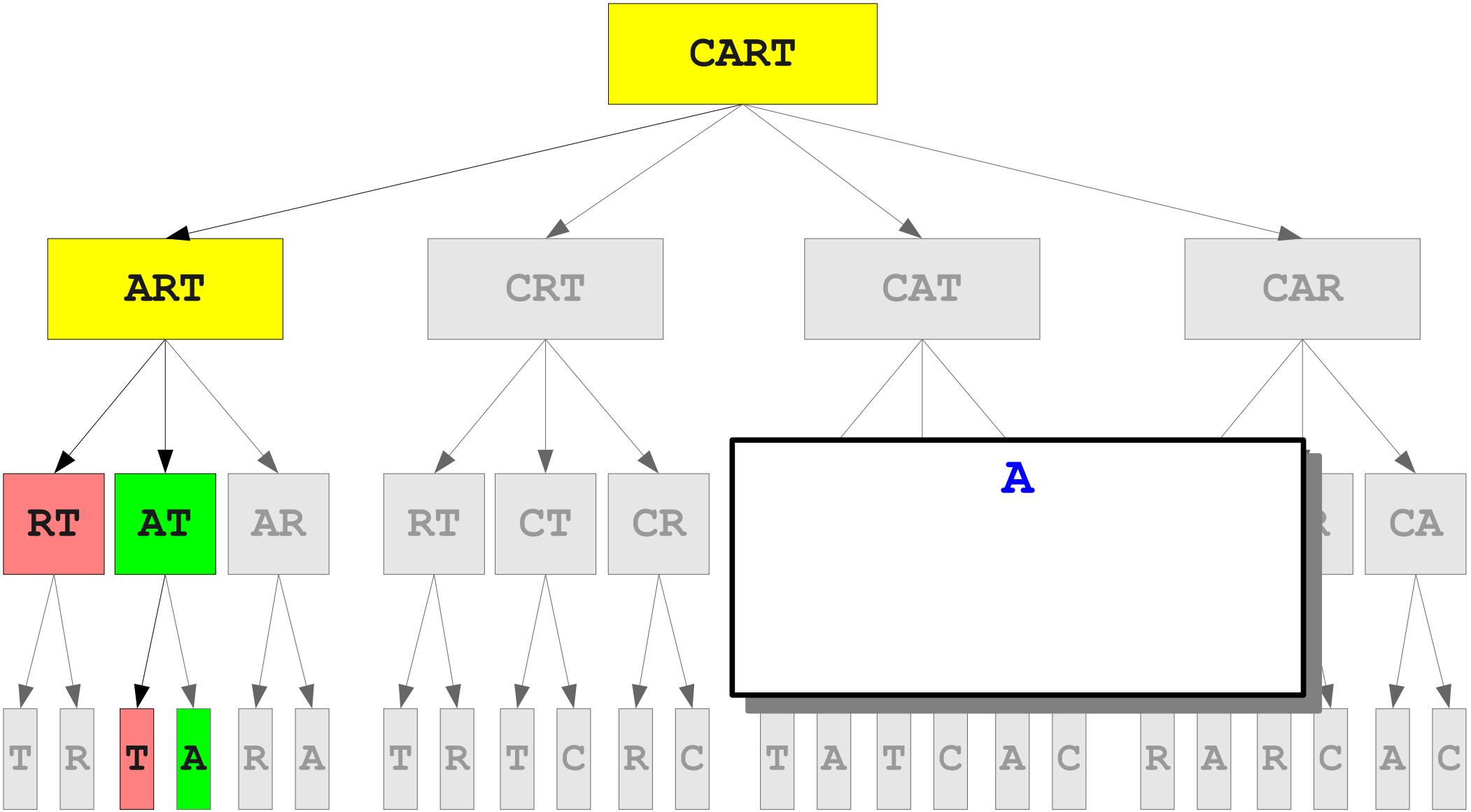

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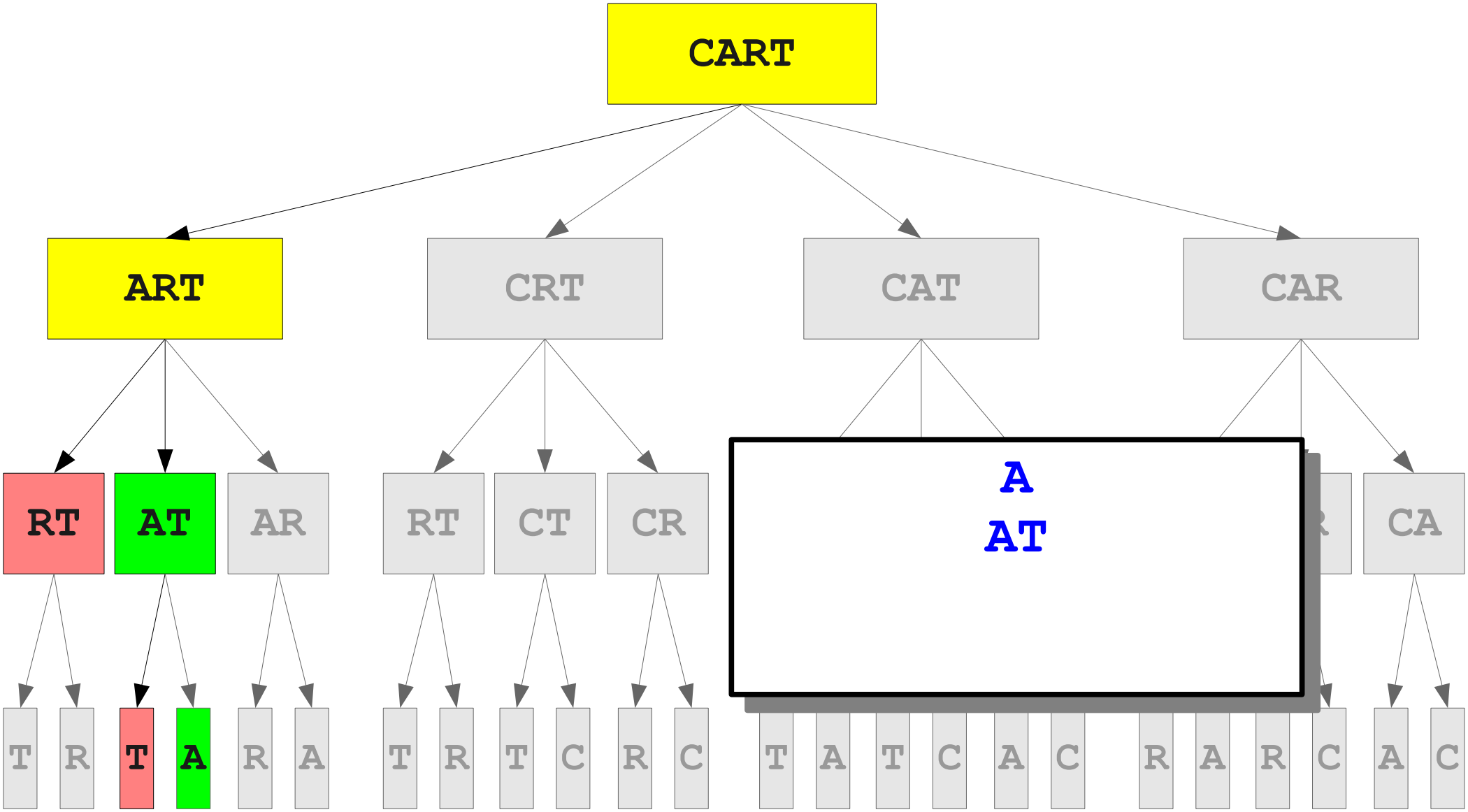

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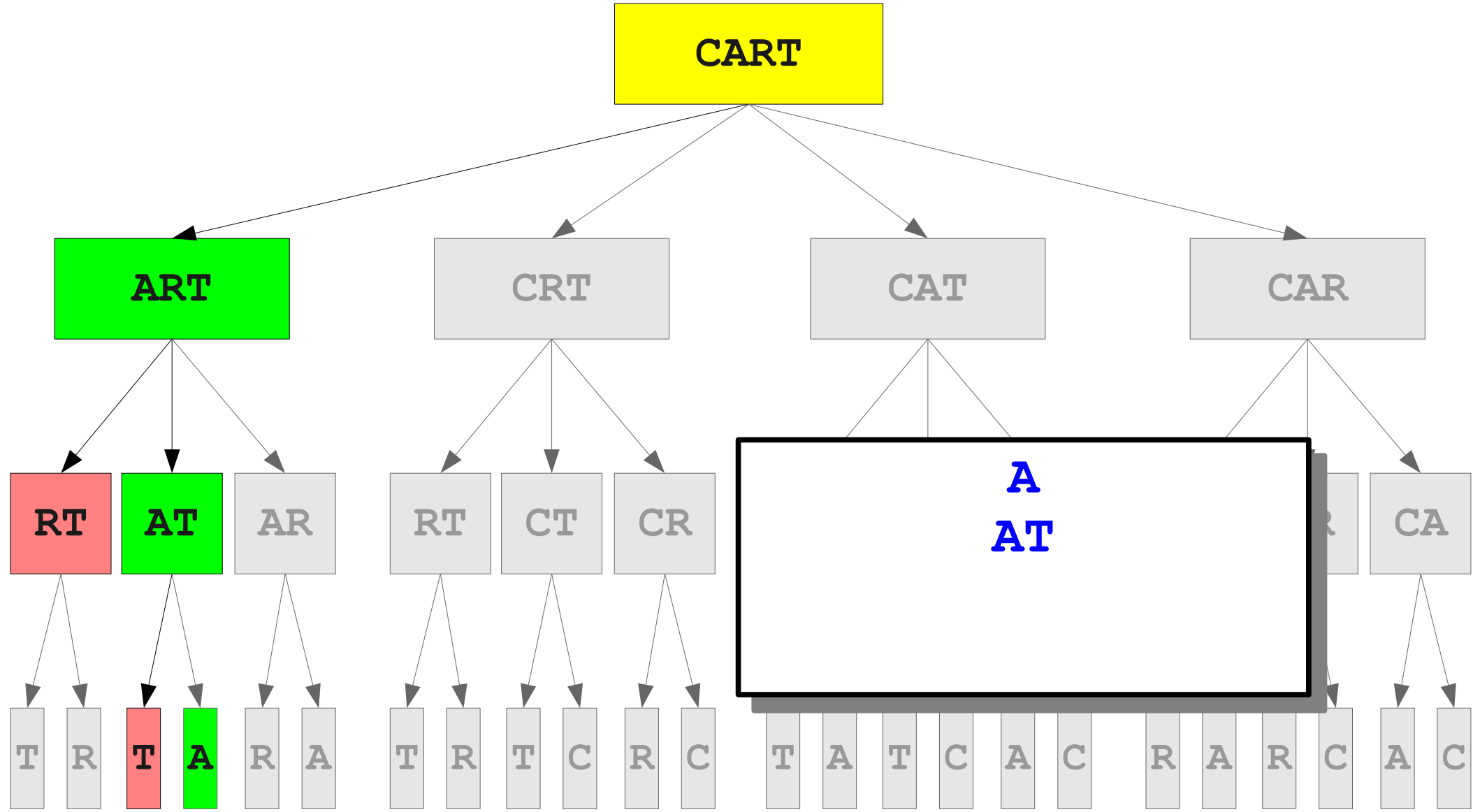

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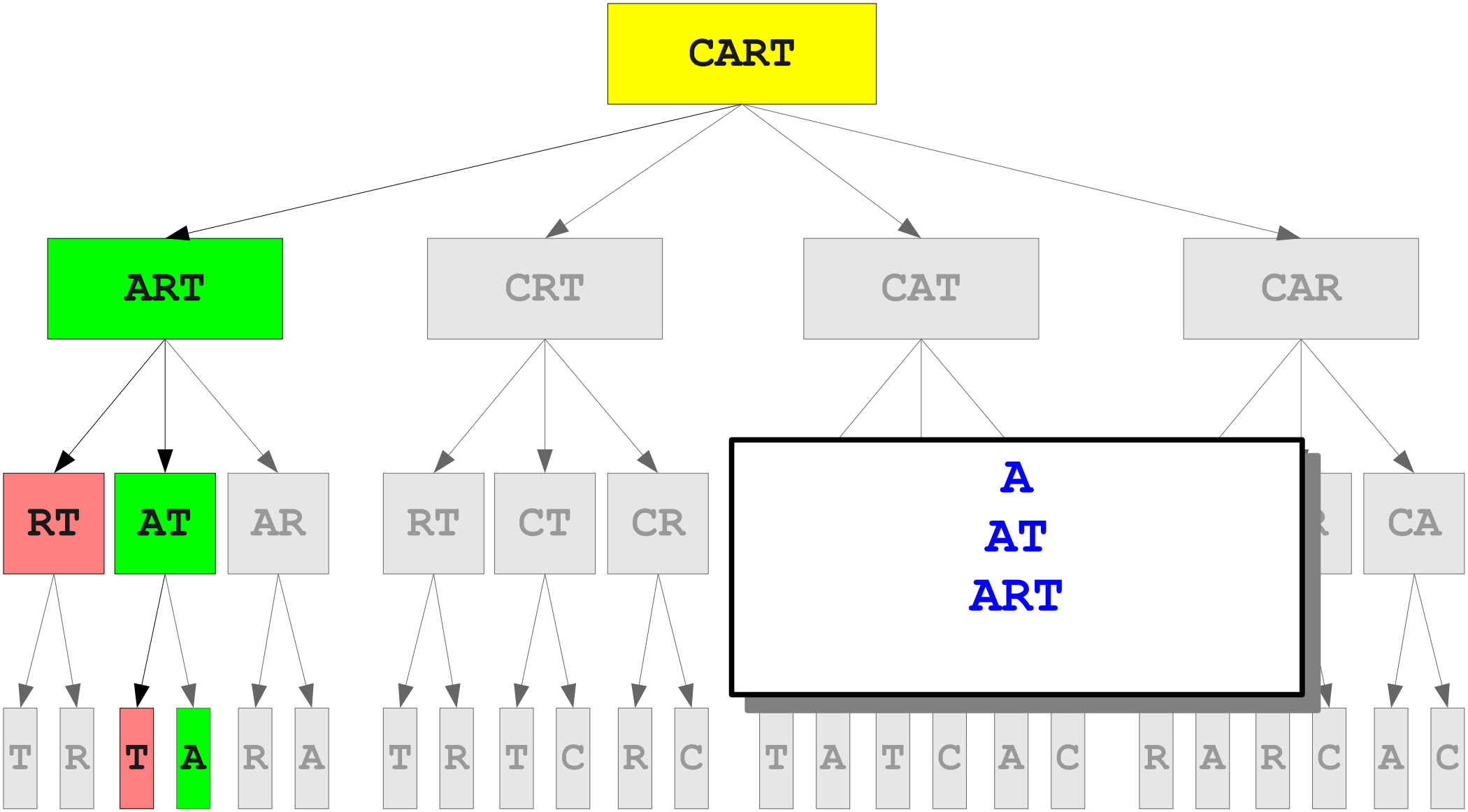

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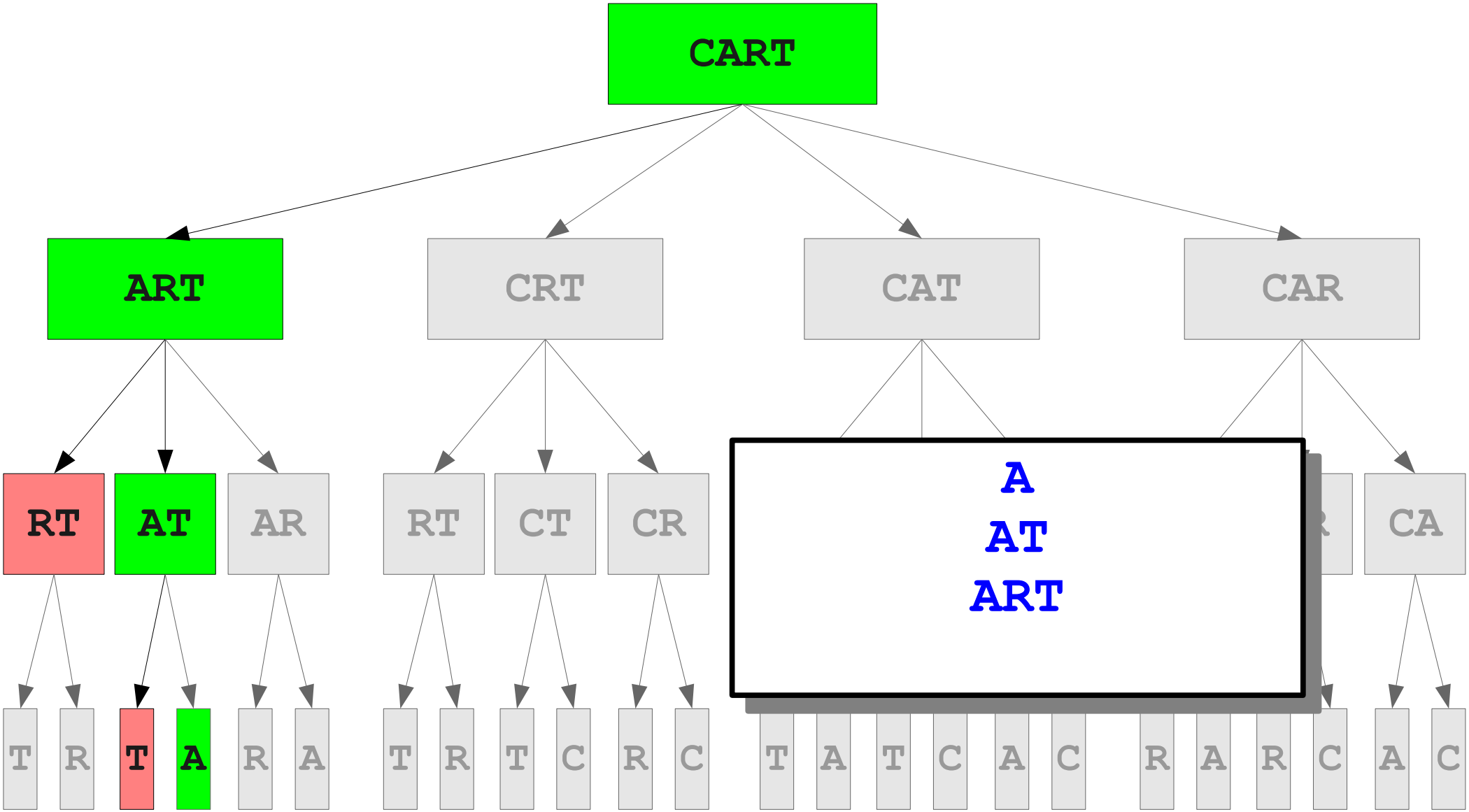

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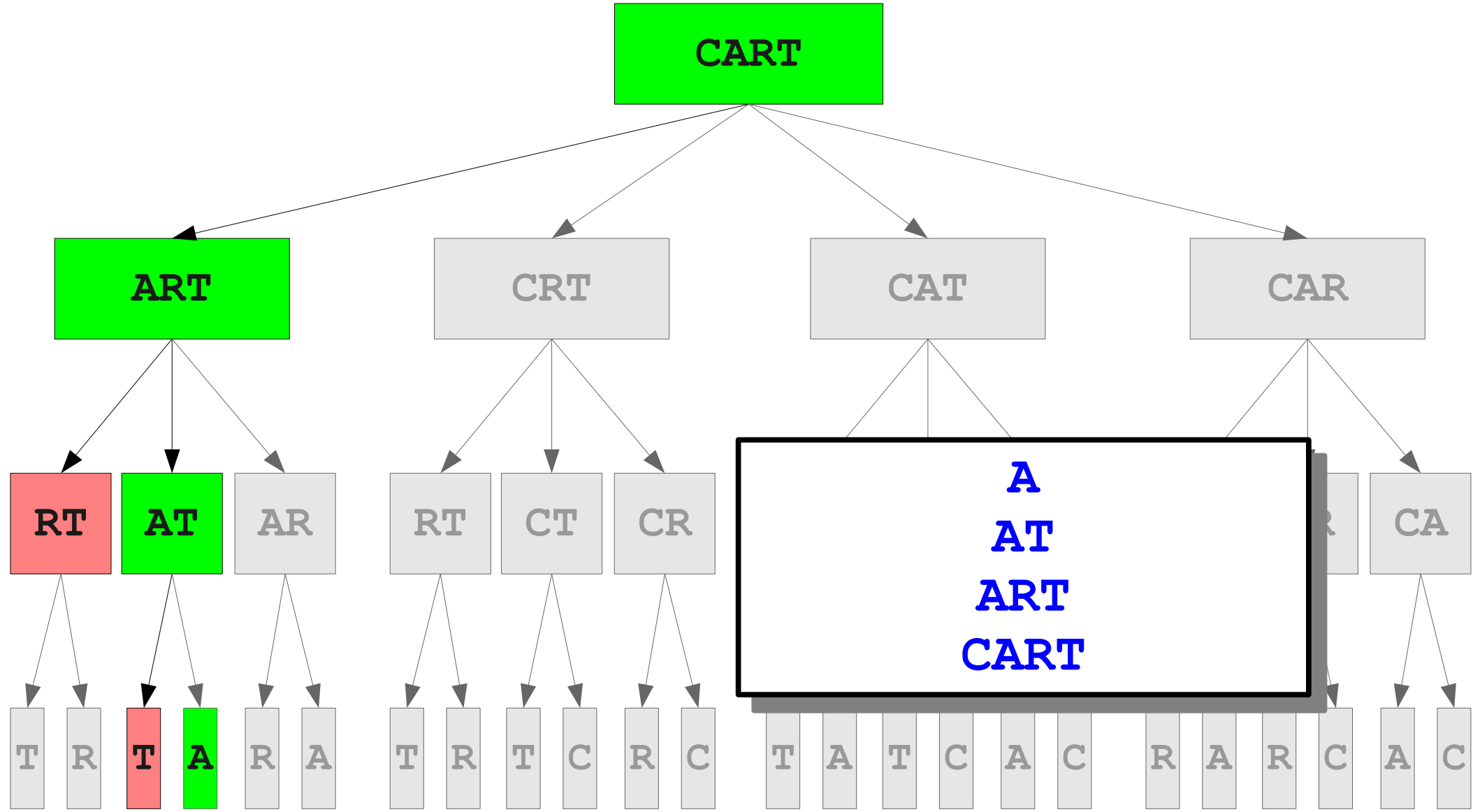
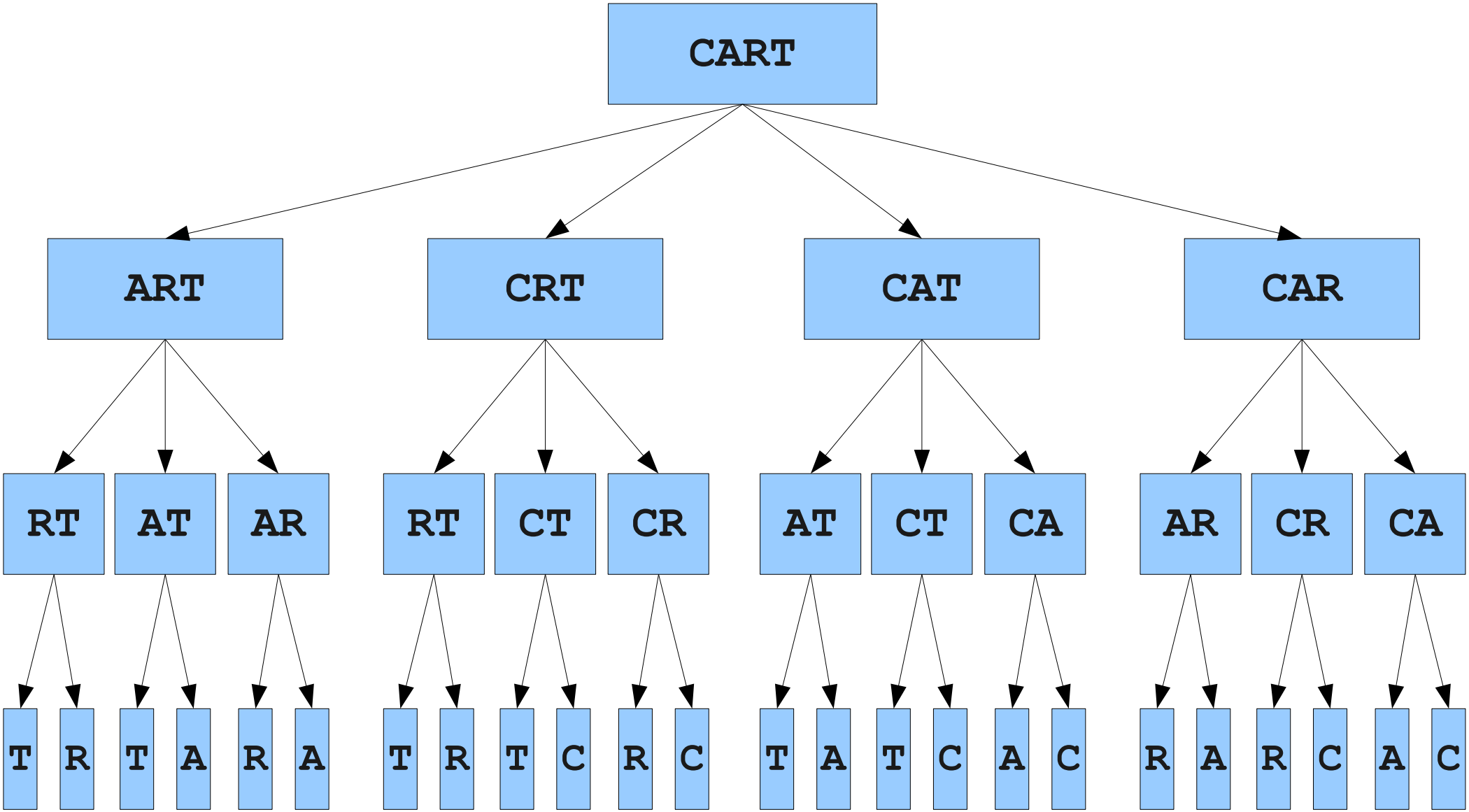


A Better Idea



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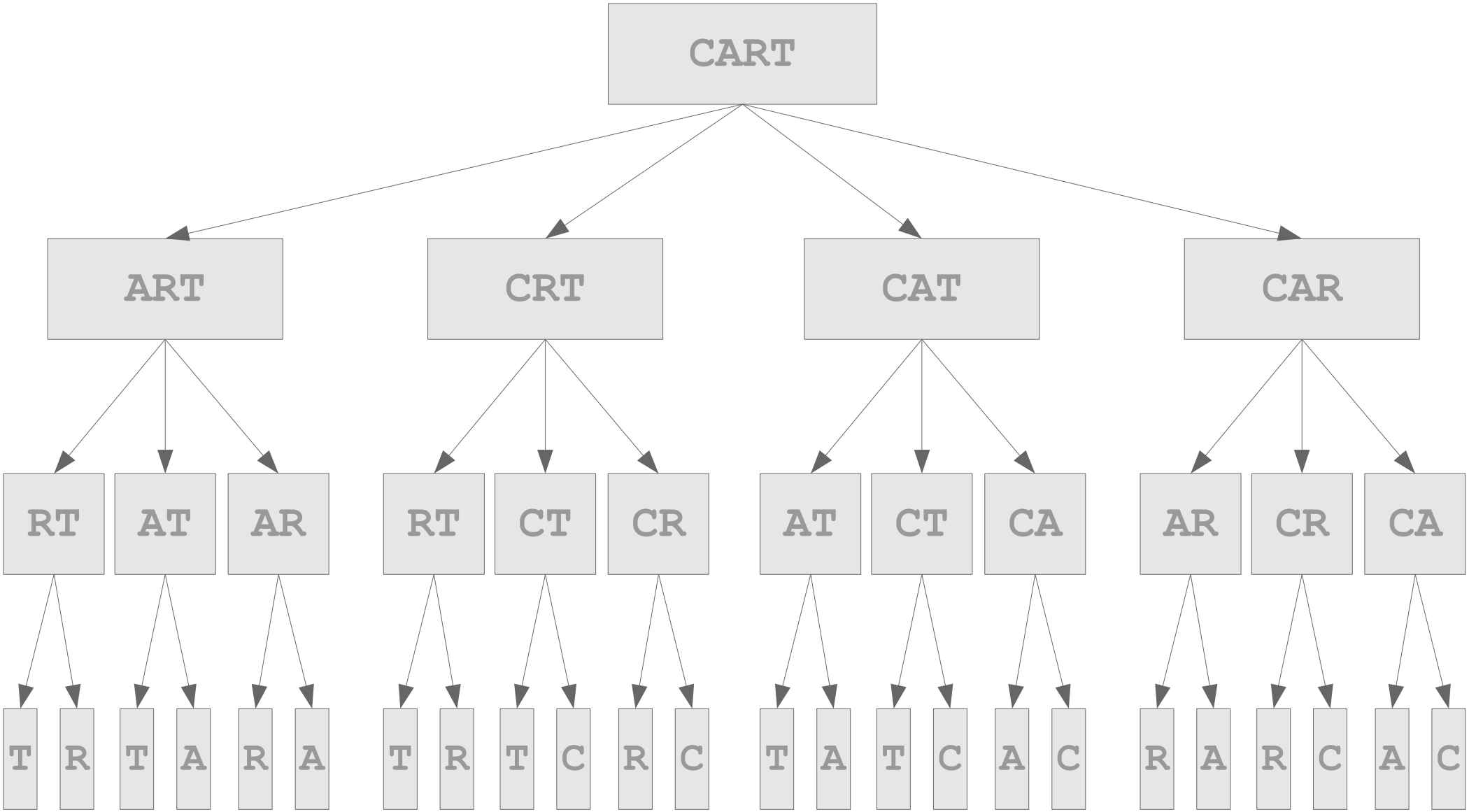

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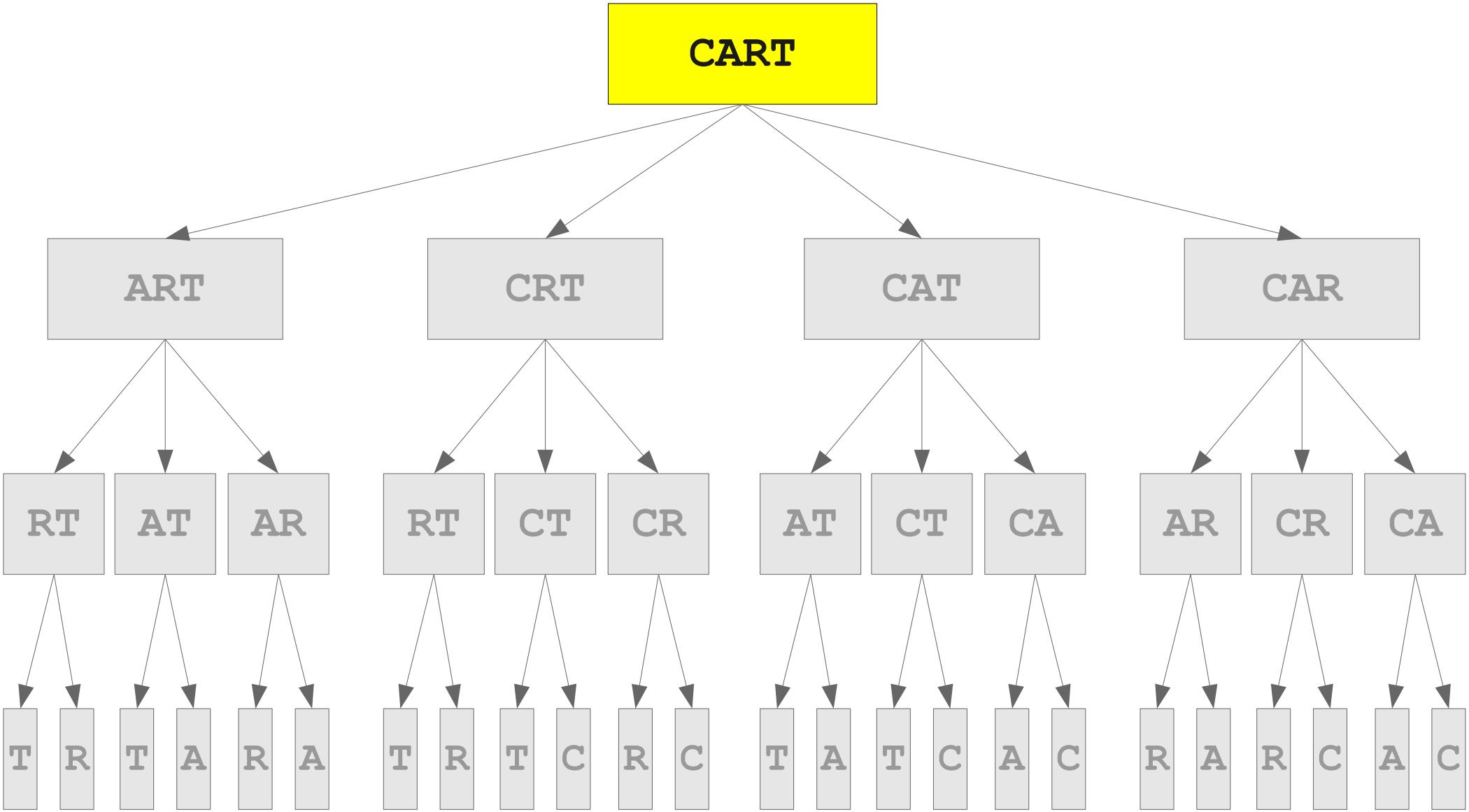

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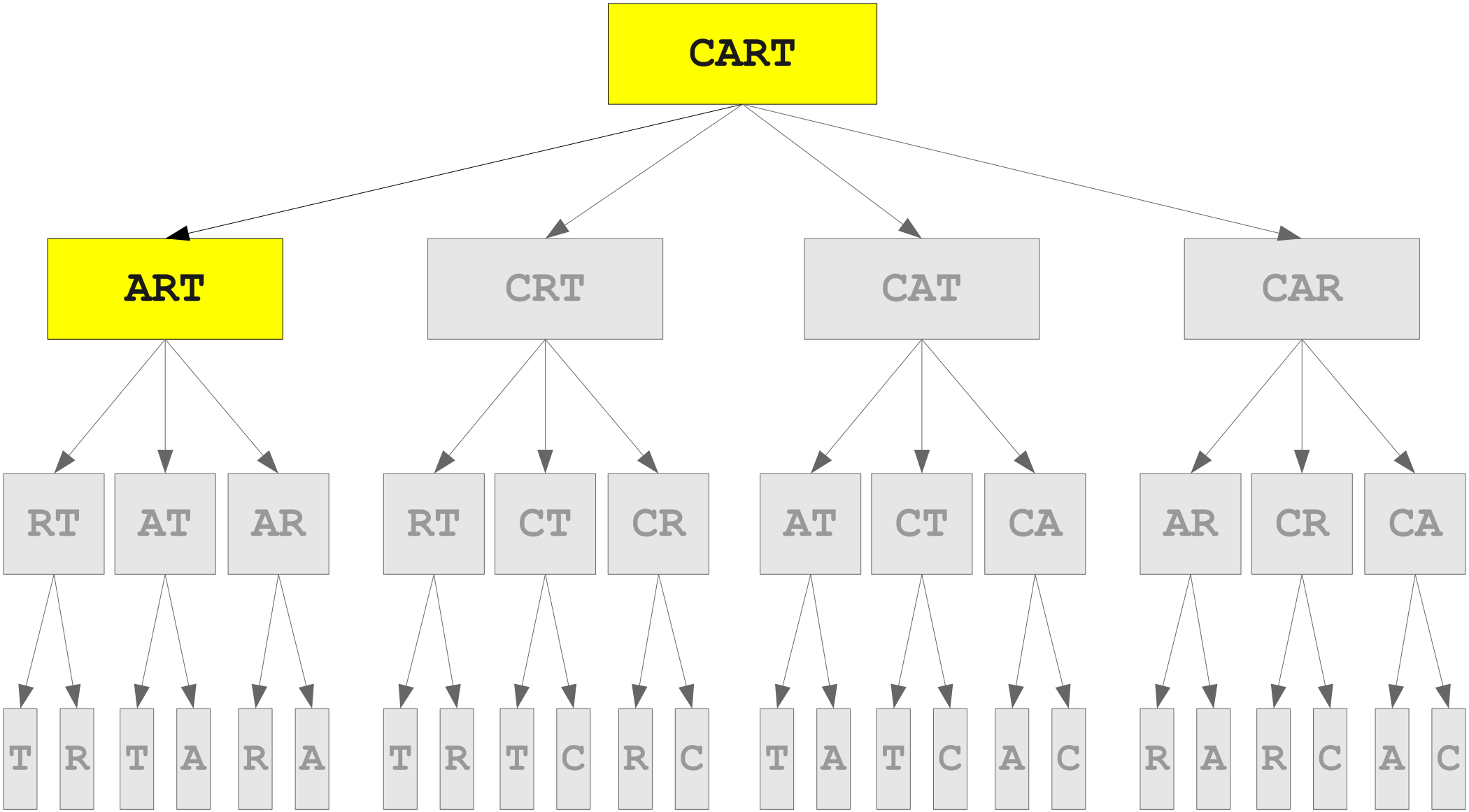

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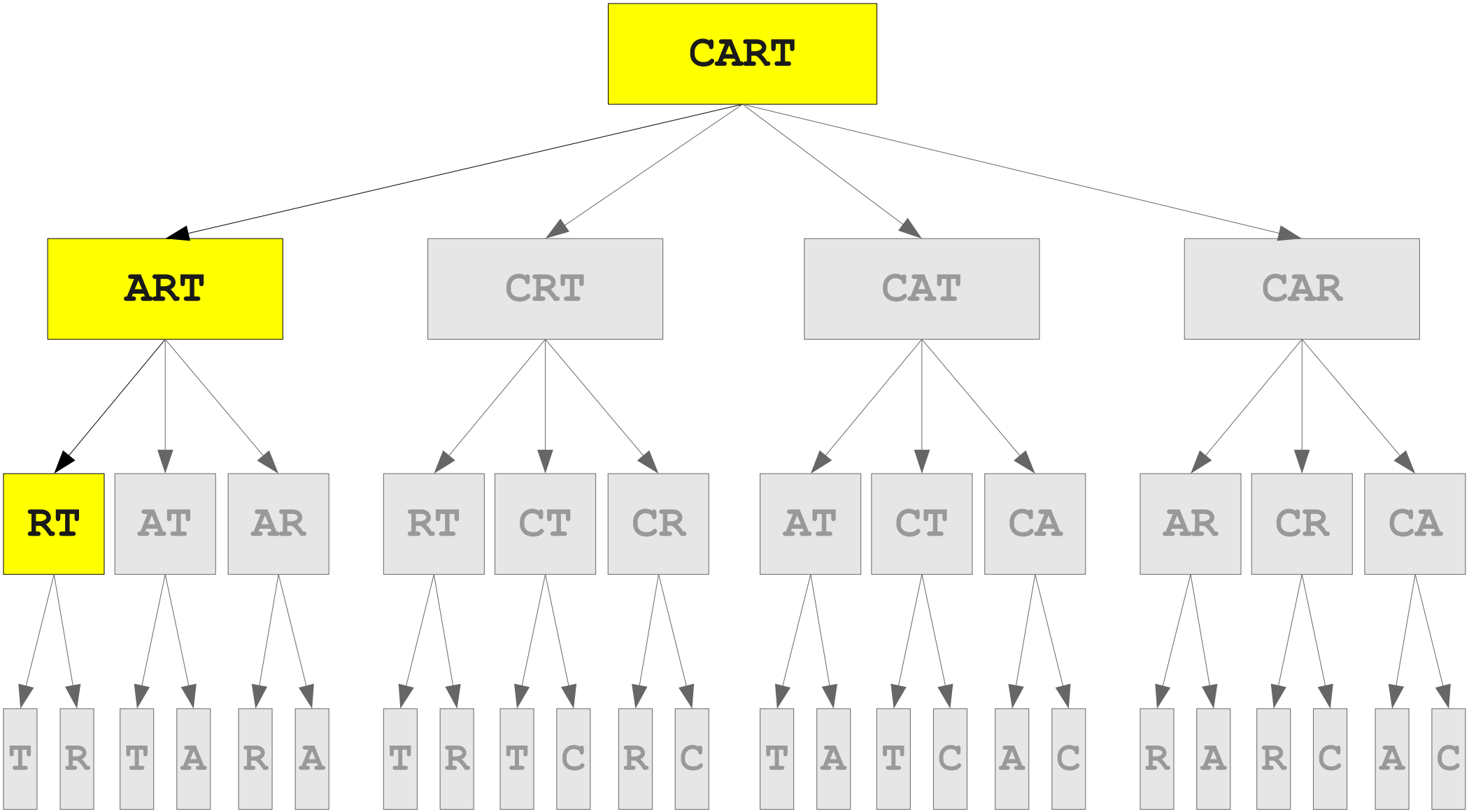

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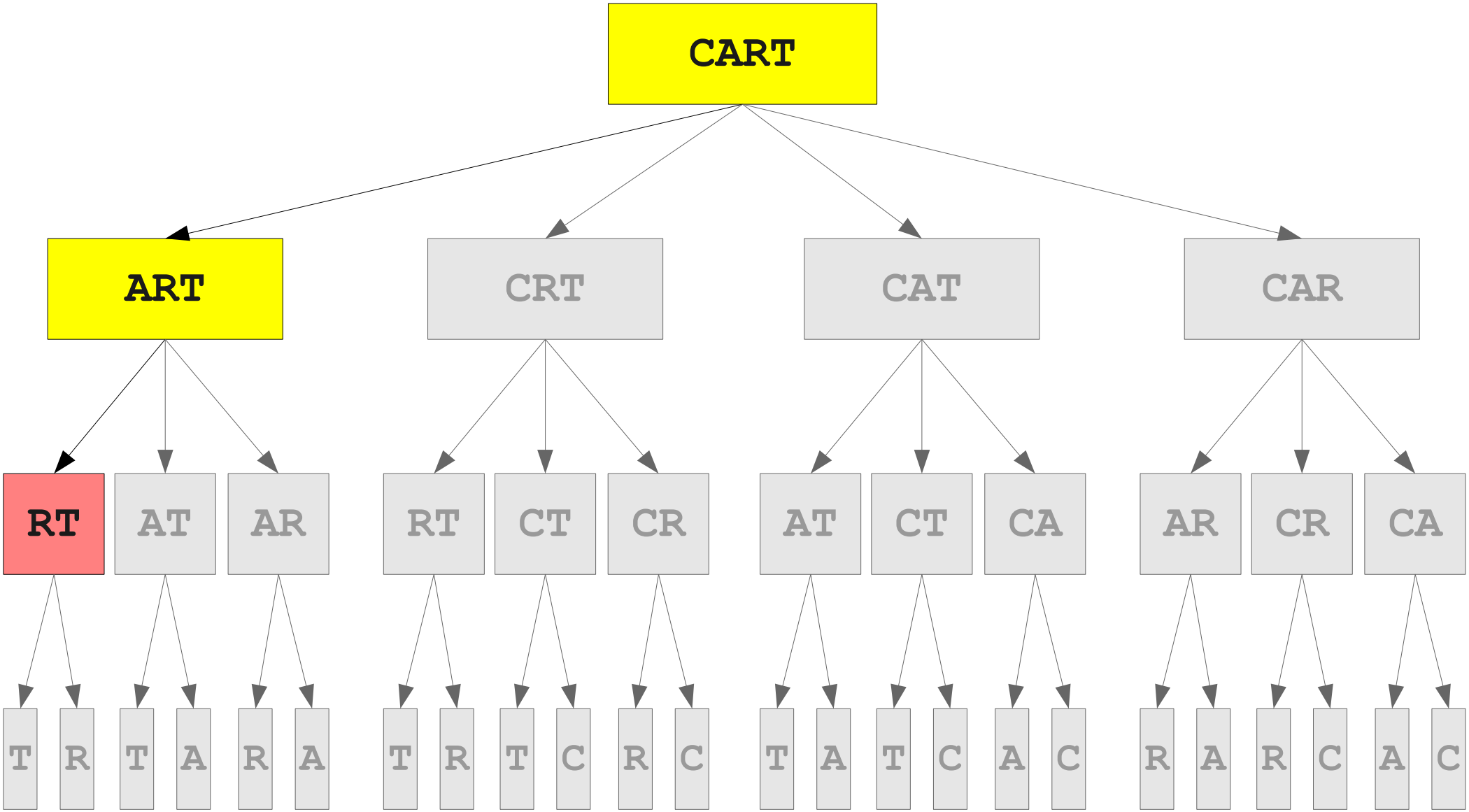

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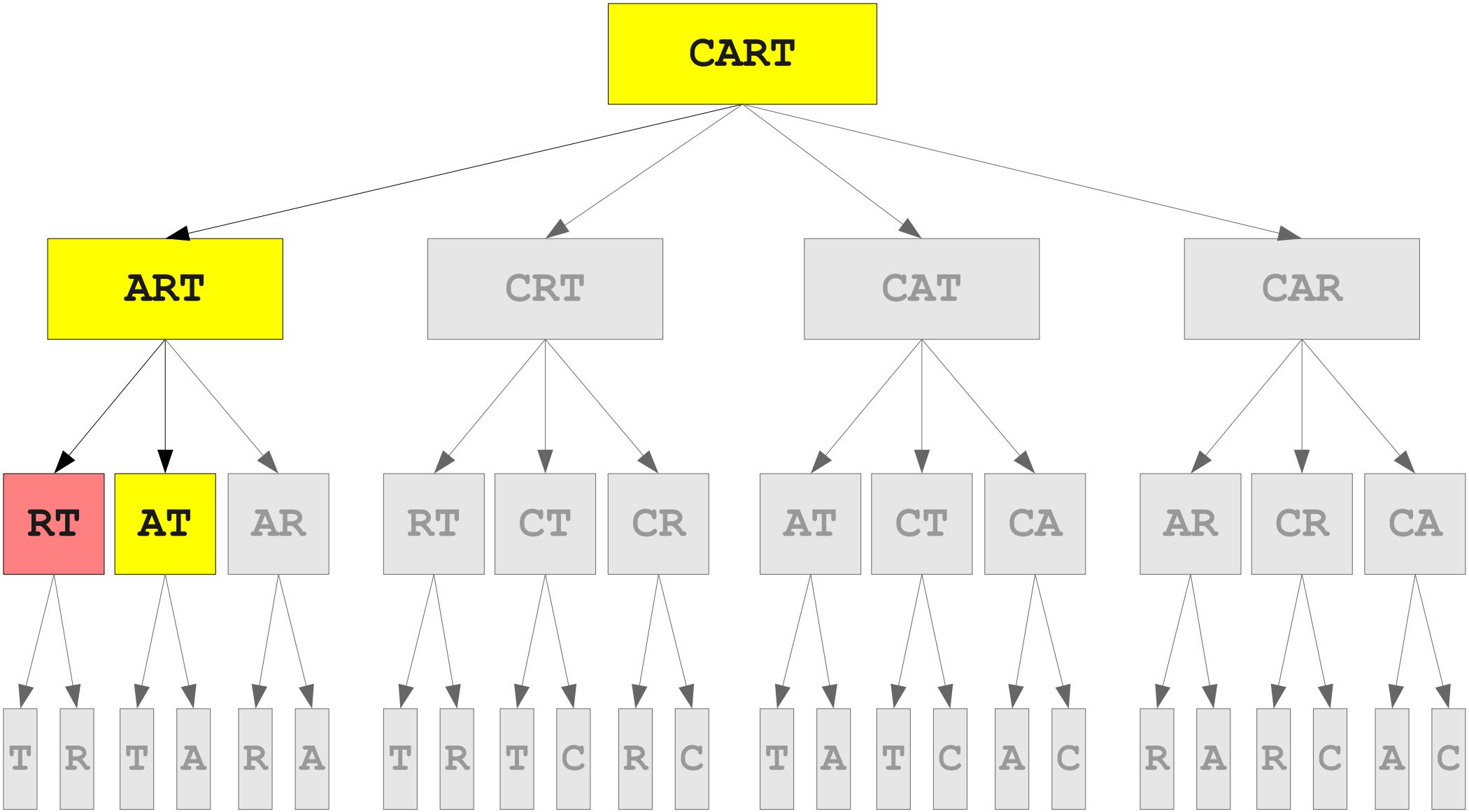
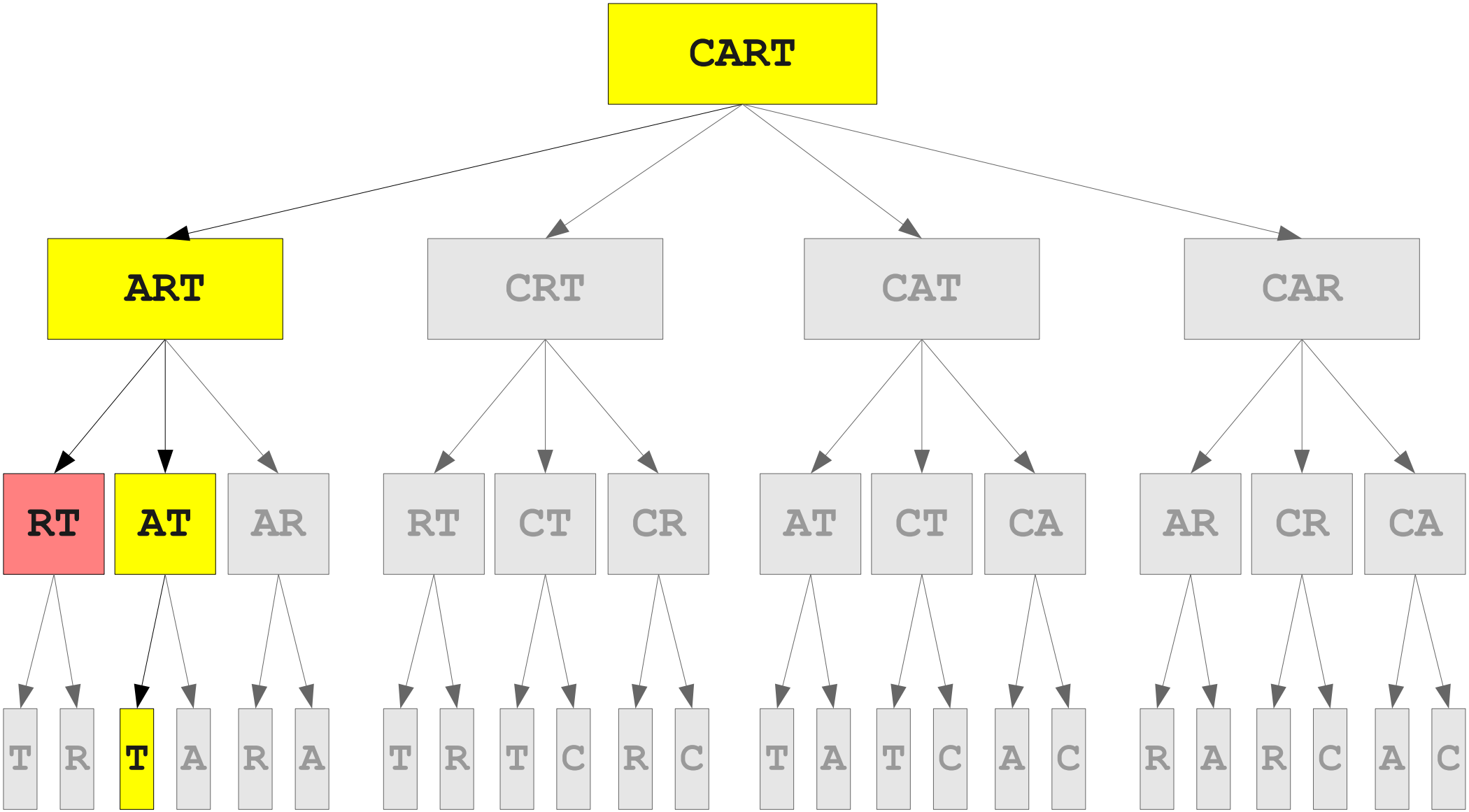


A Better Idea



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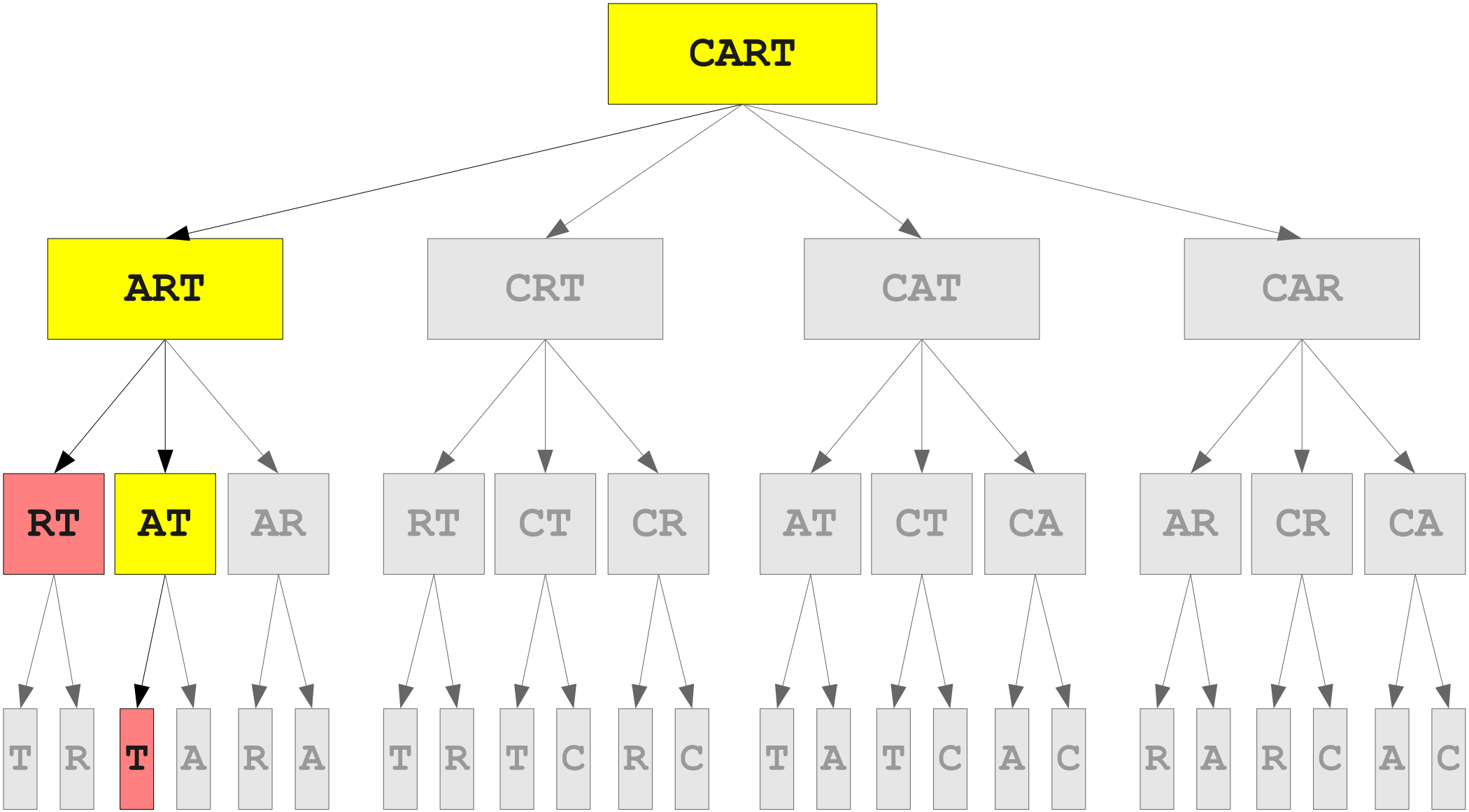

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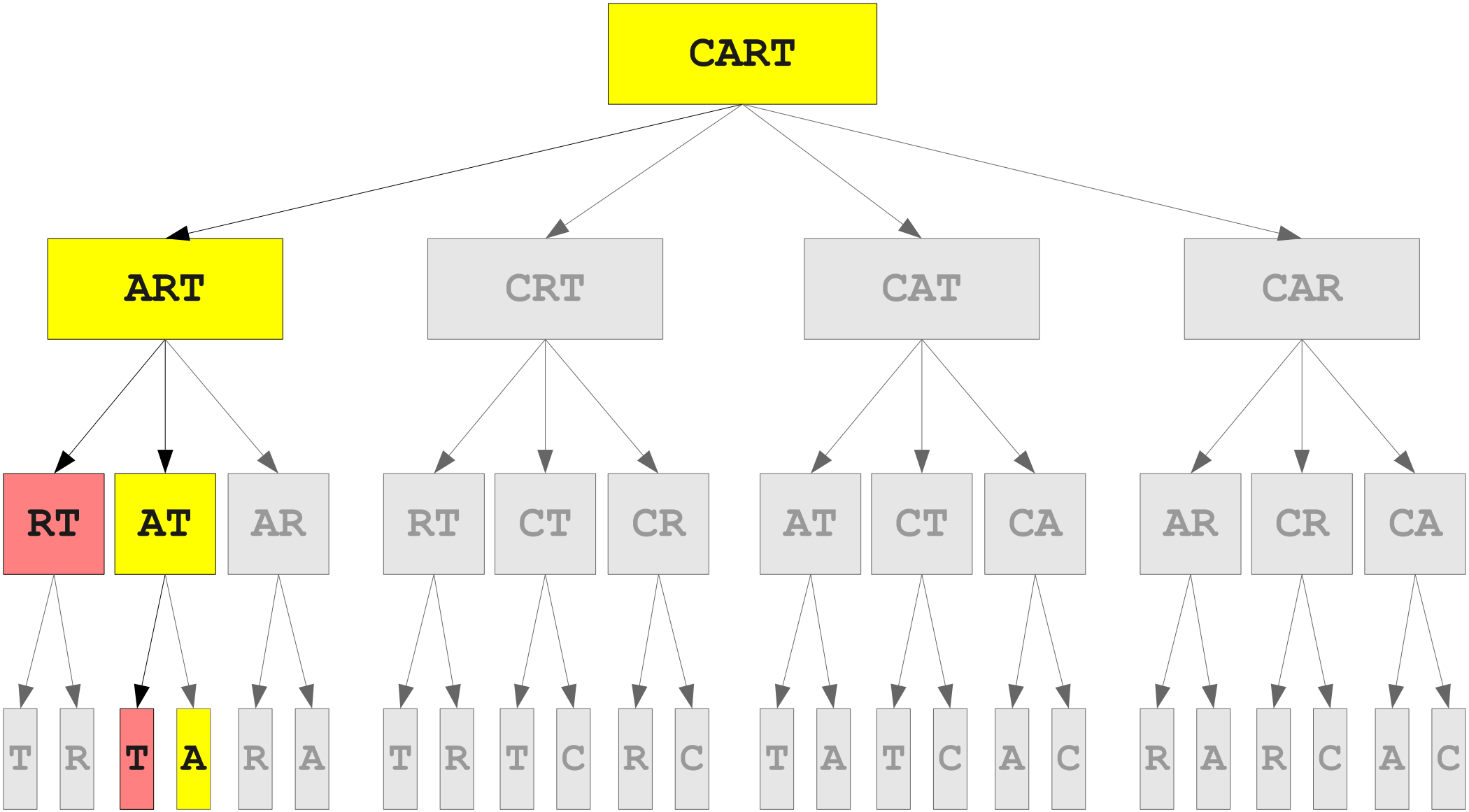

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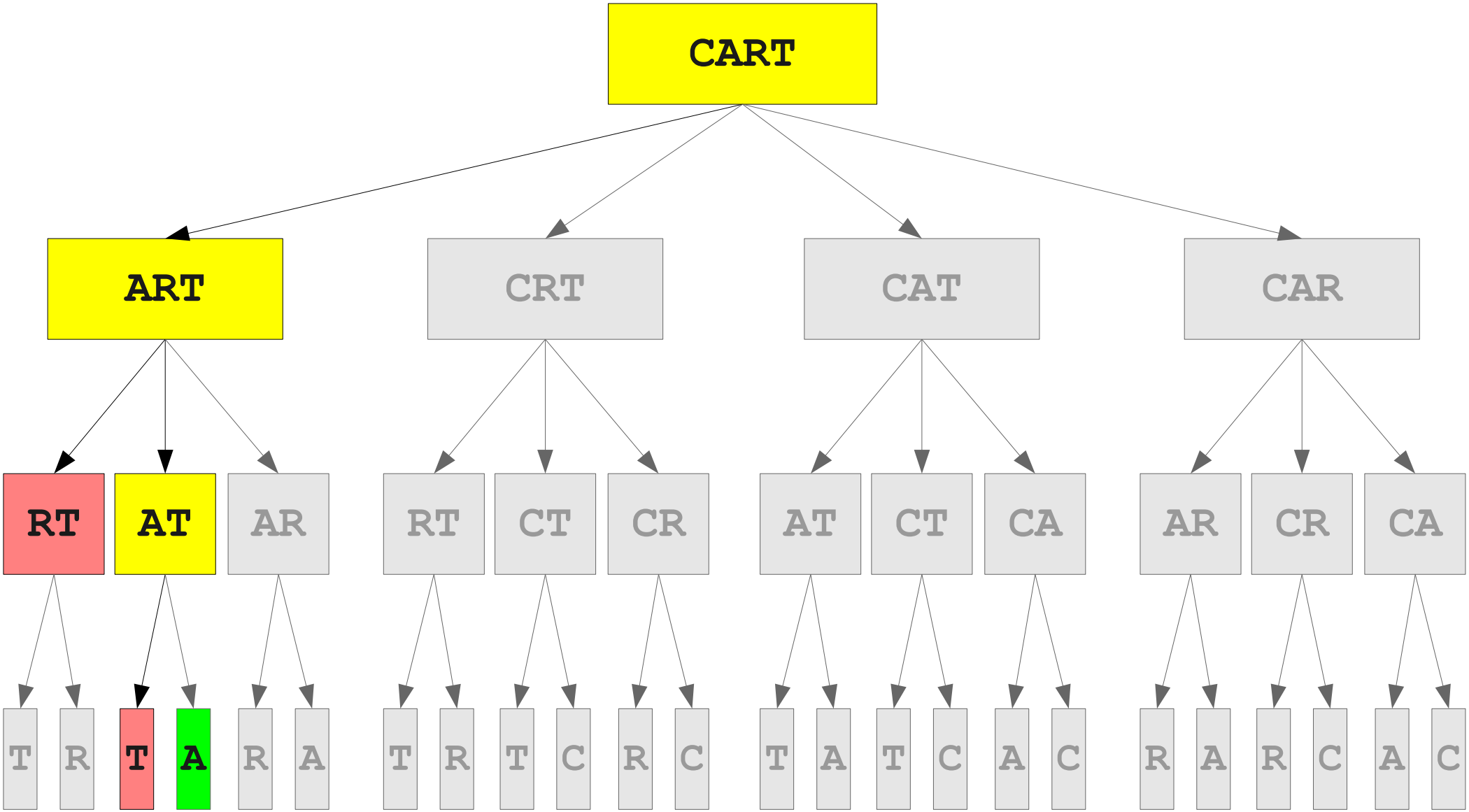

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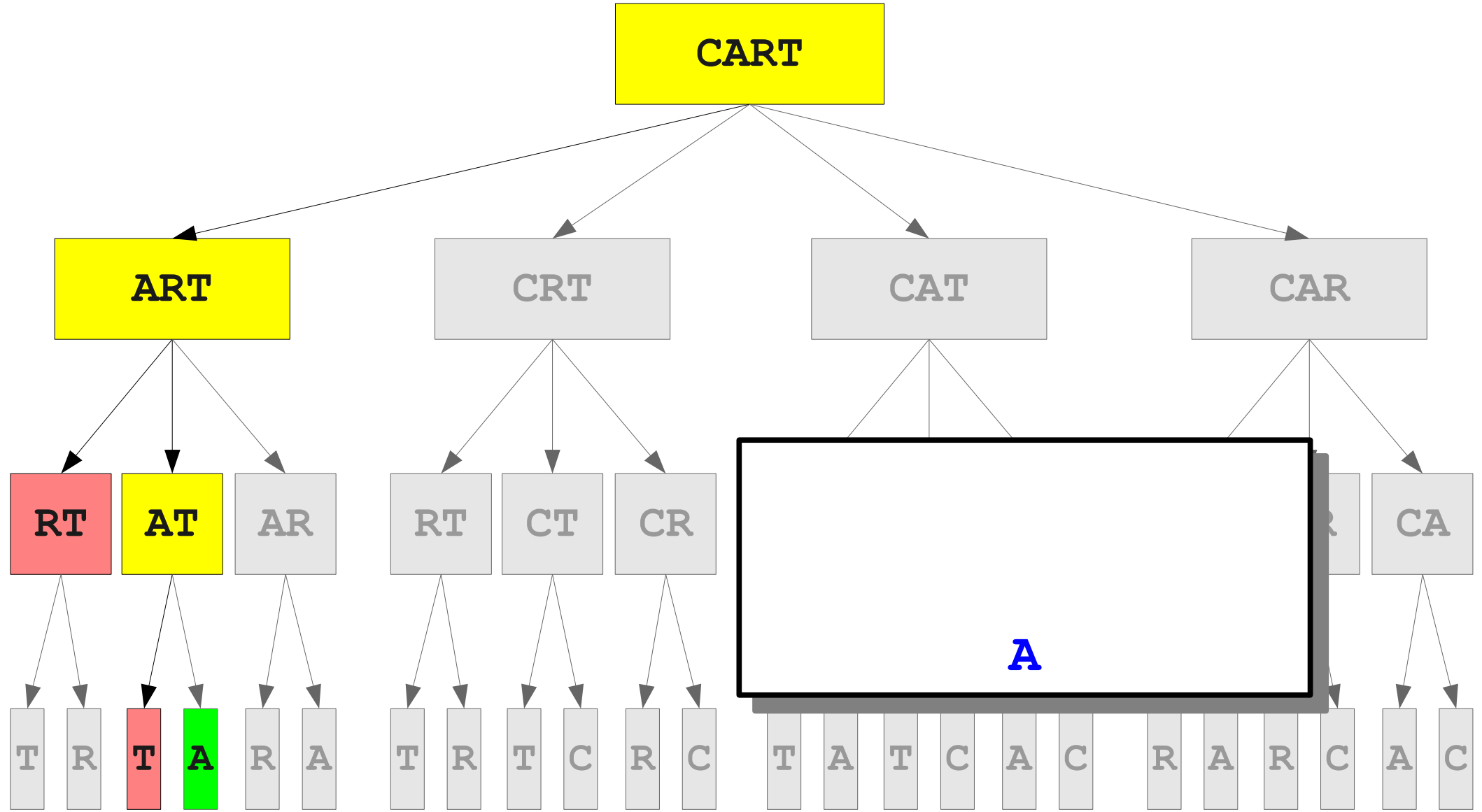

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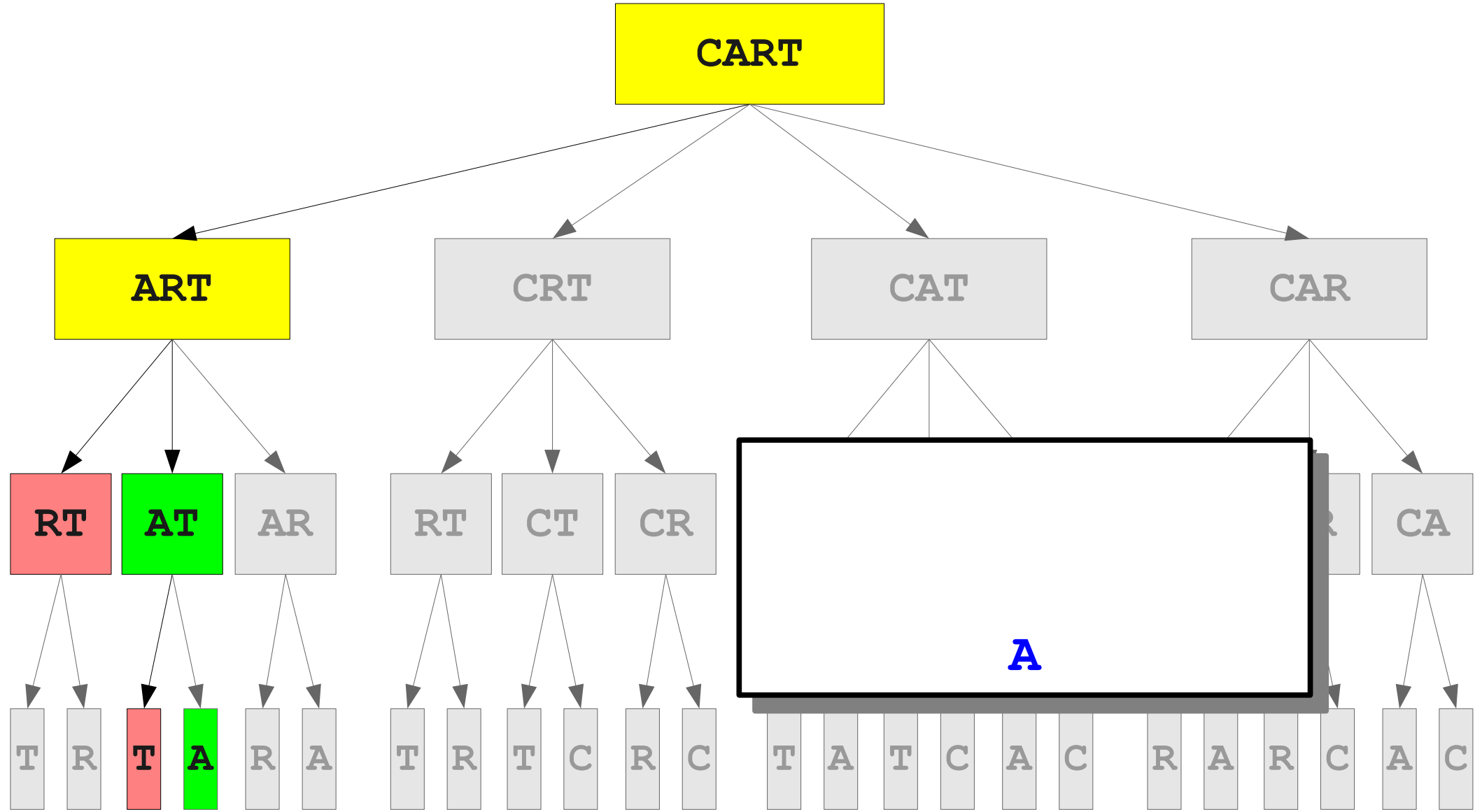

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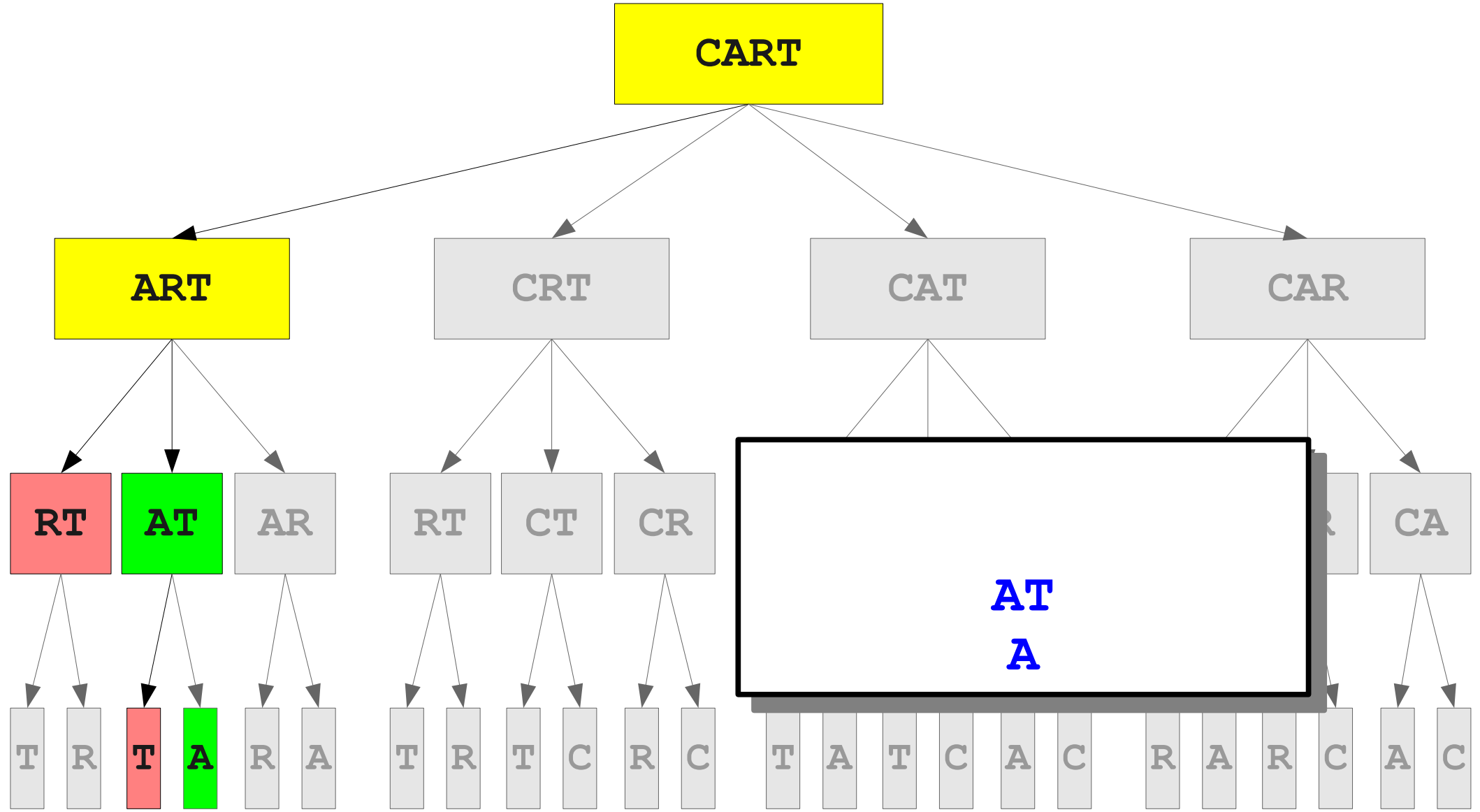

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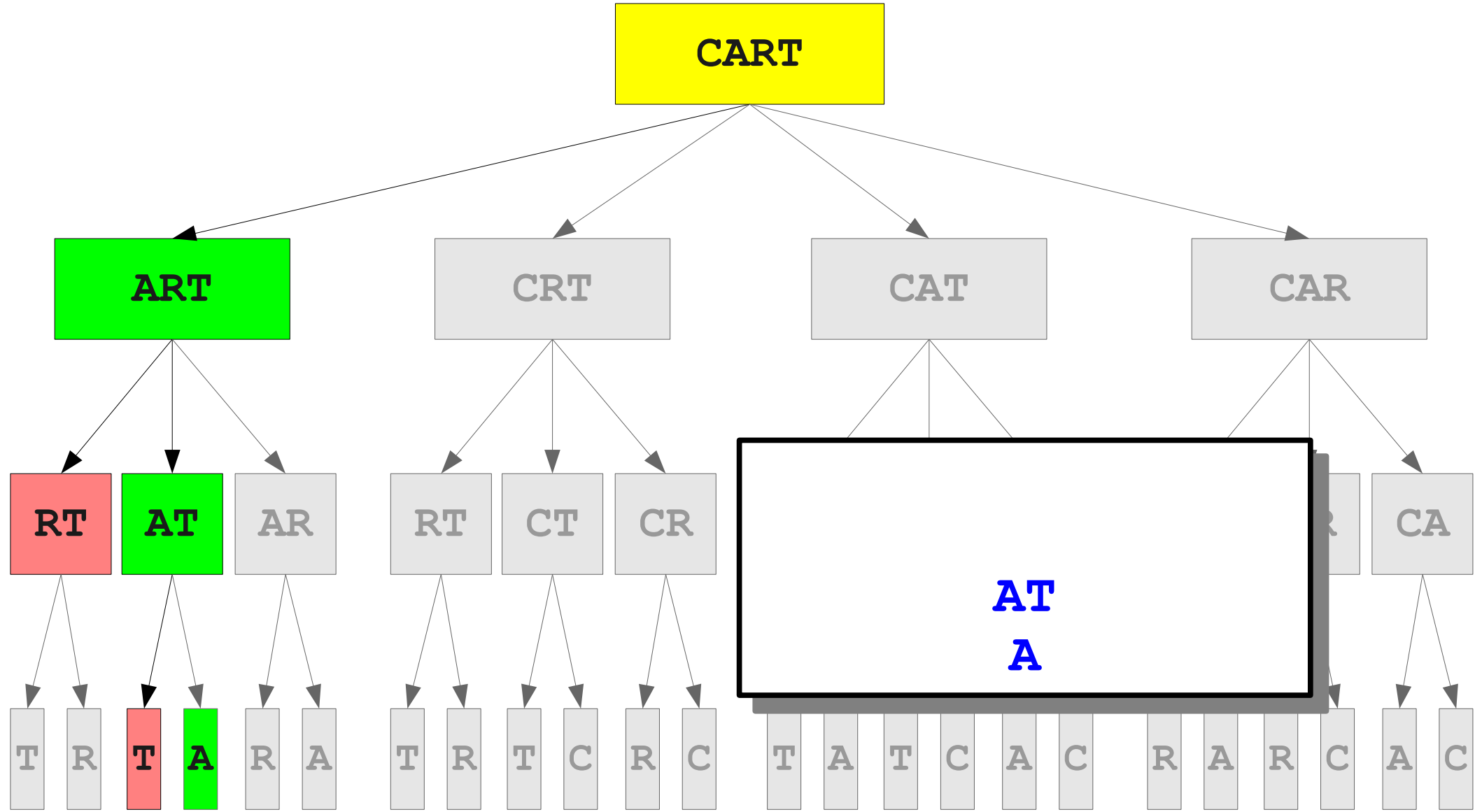

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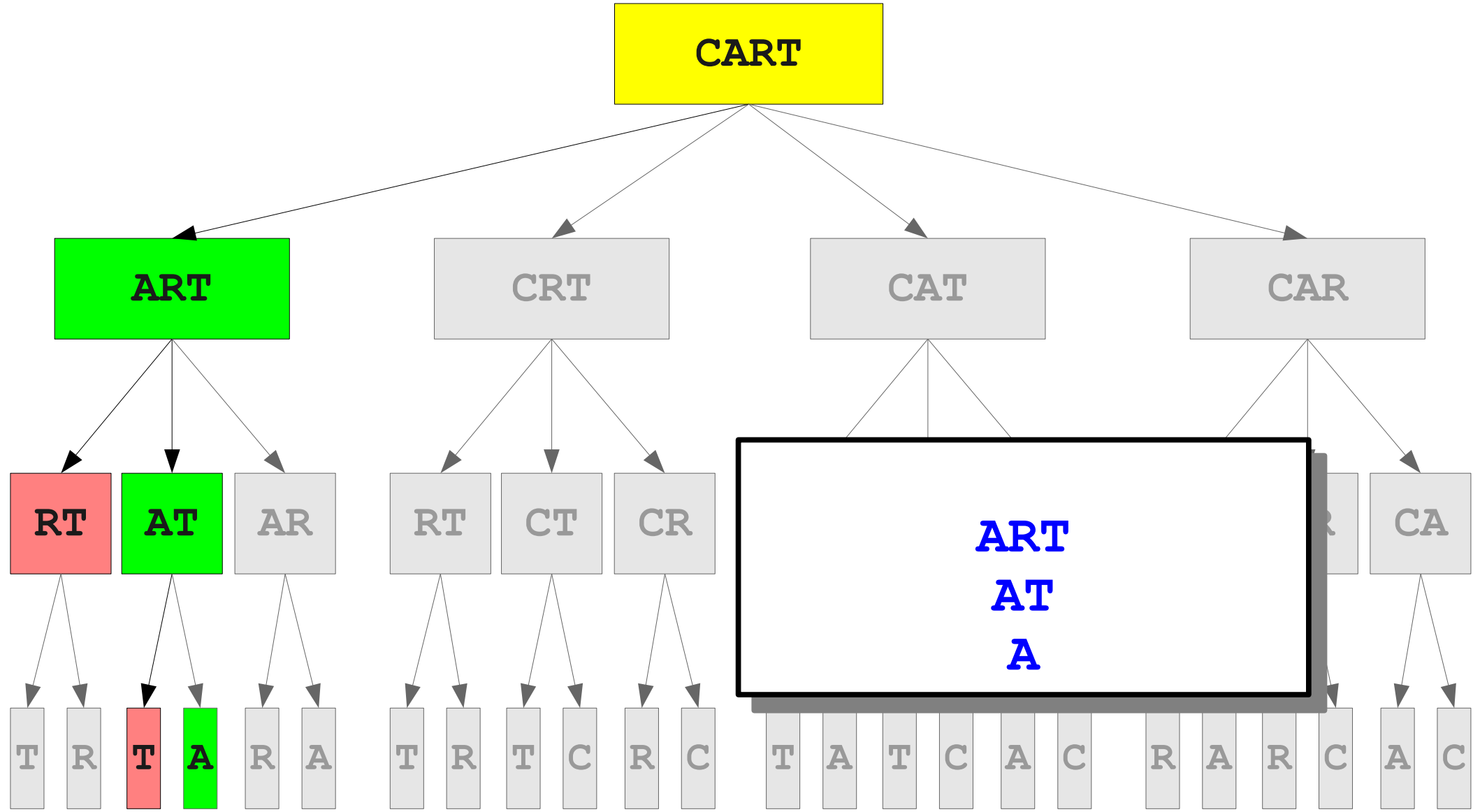

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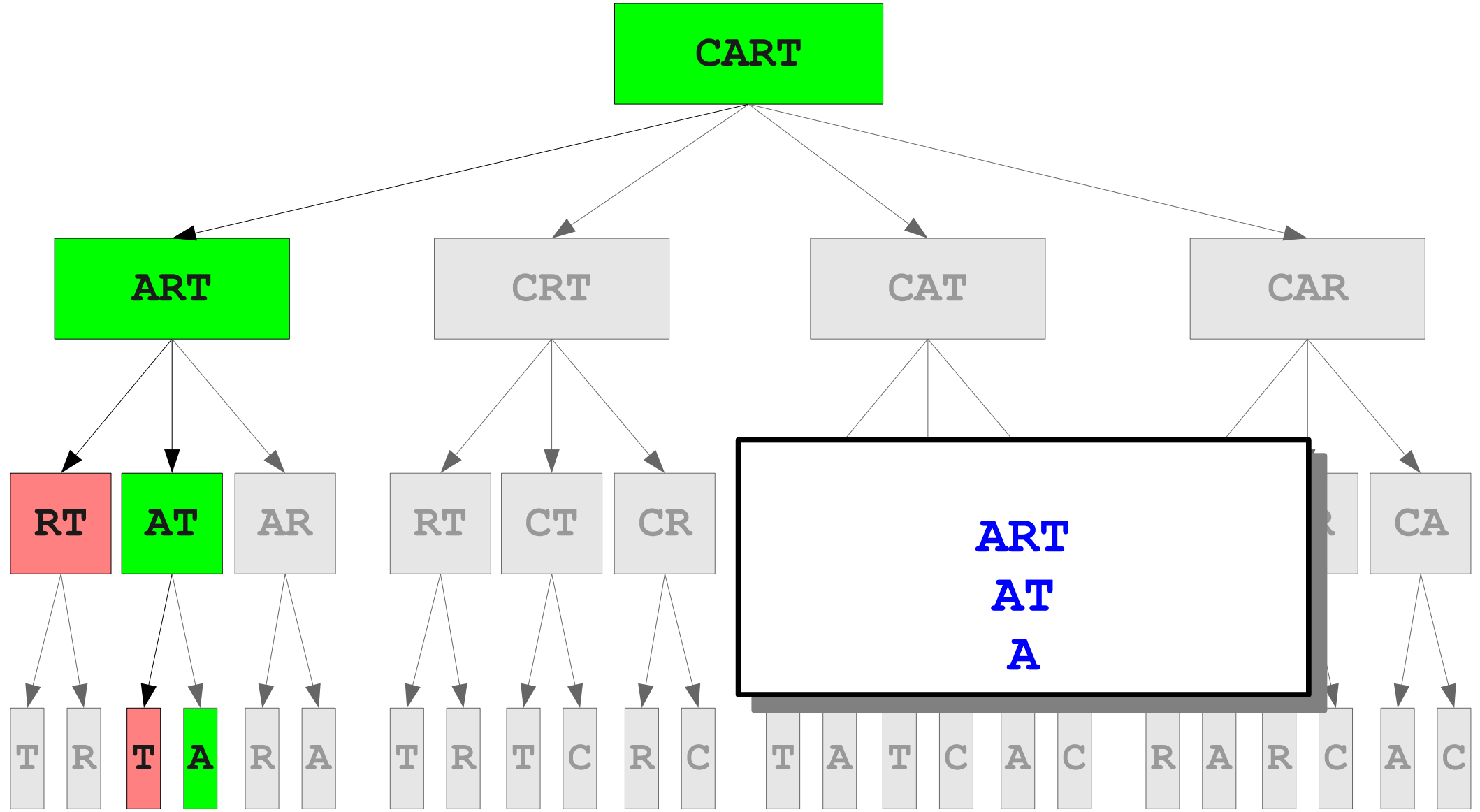

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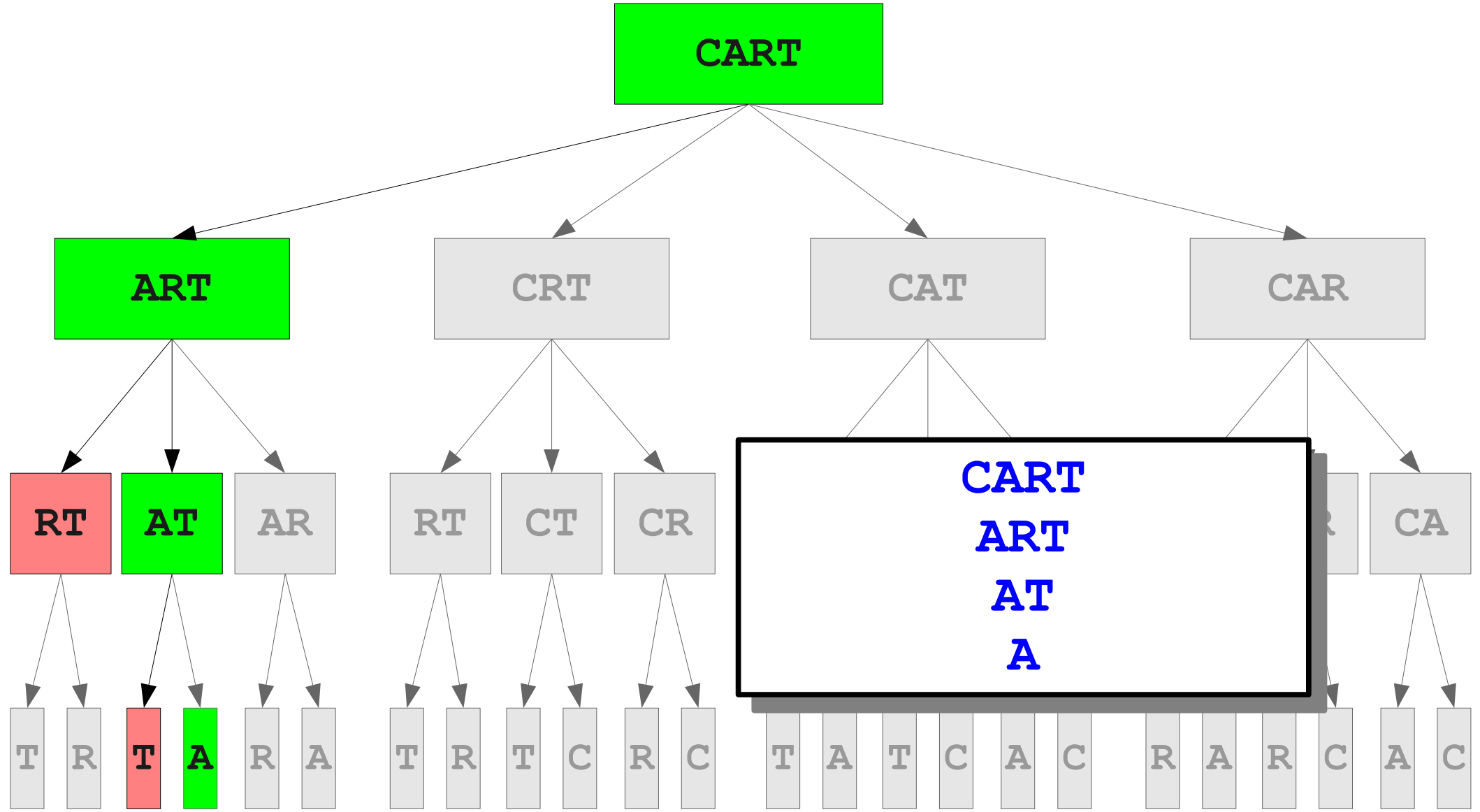

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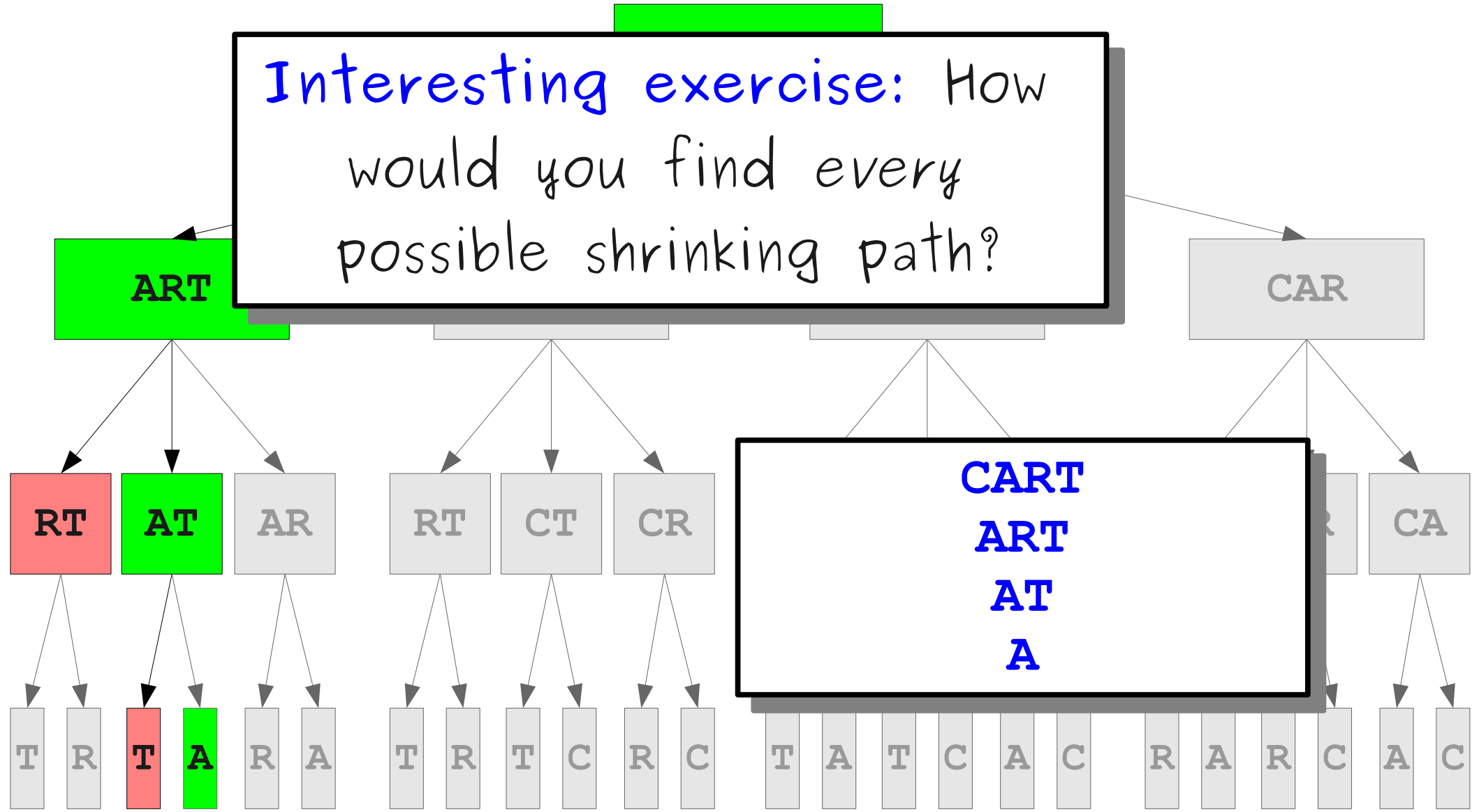


Dense Crosswords

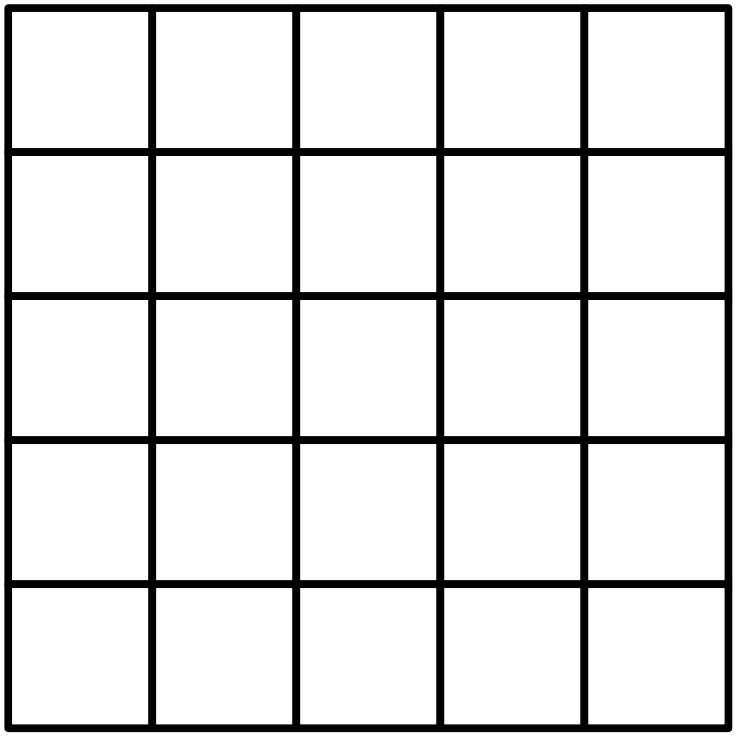
aahs

abet

heme

stem

Generating Dense Crosswords



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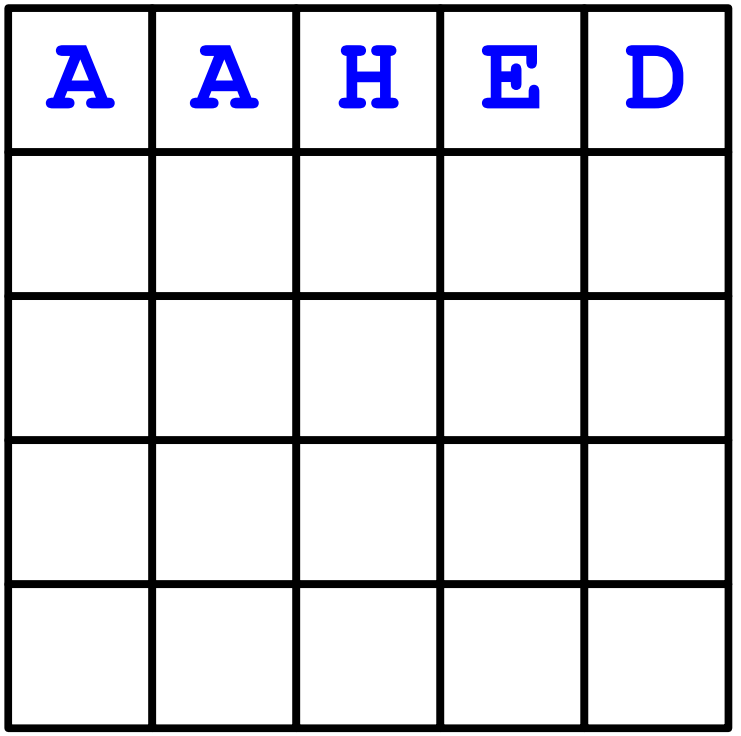

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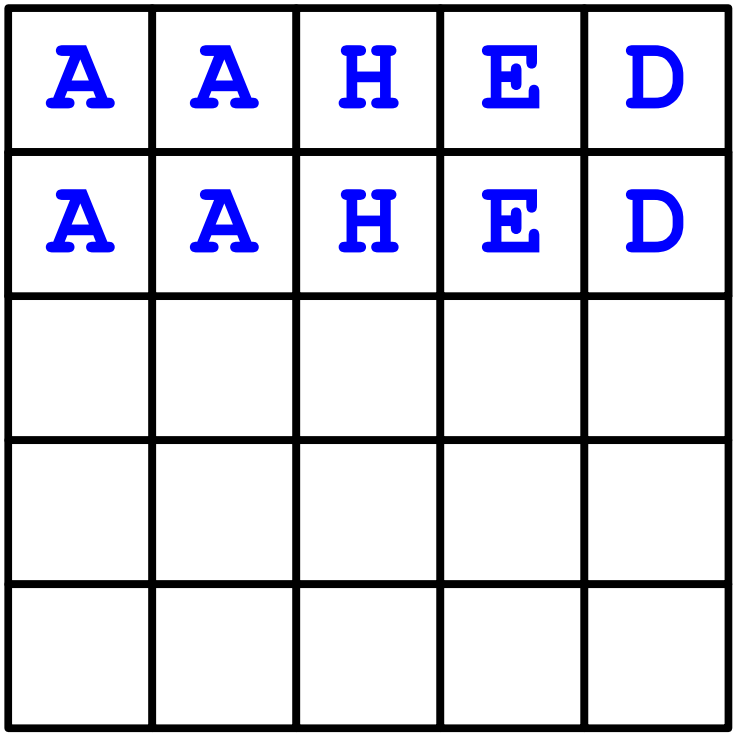

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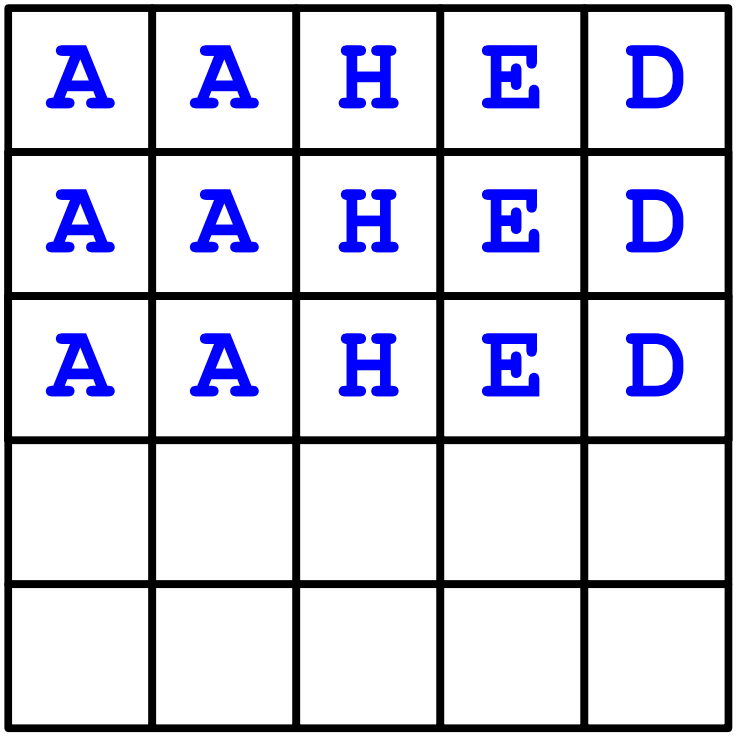

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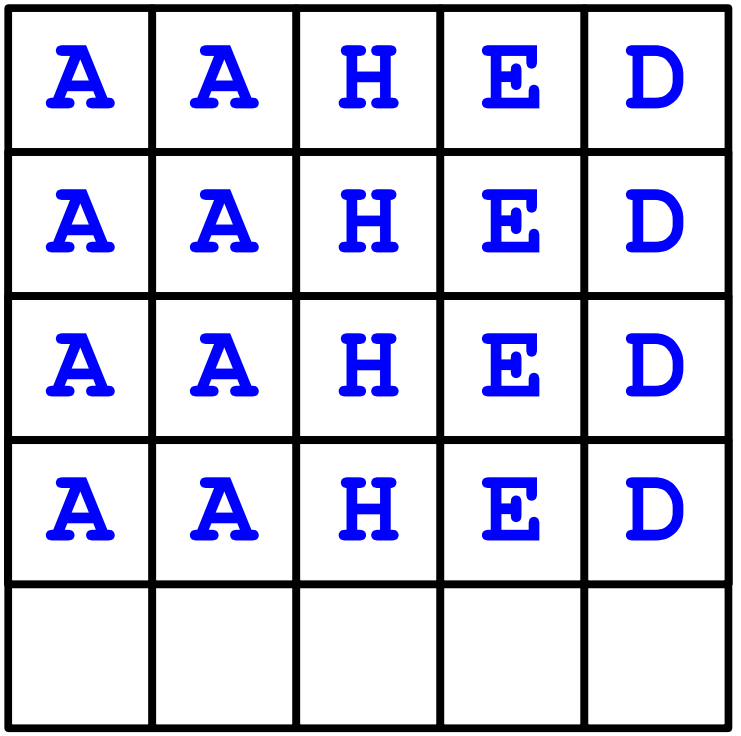

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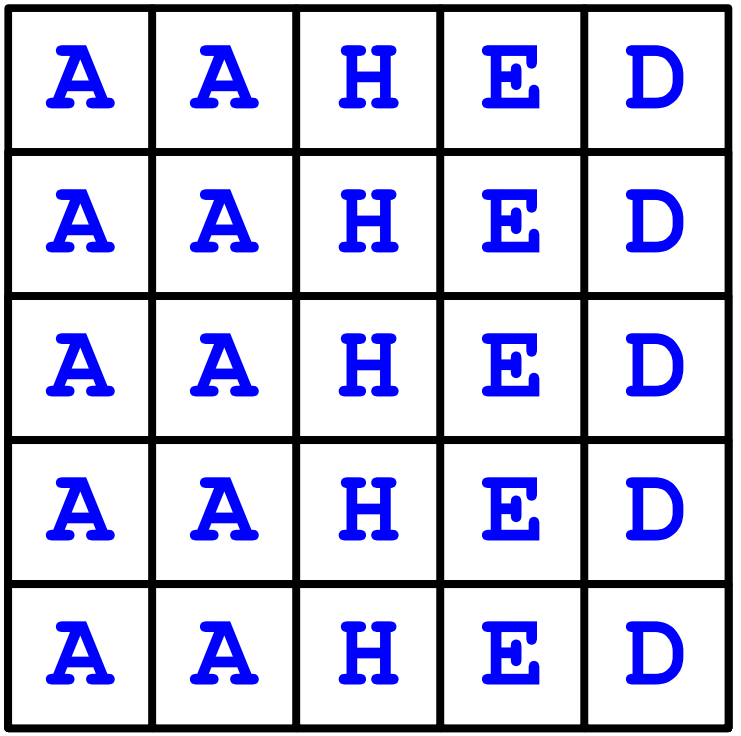

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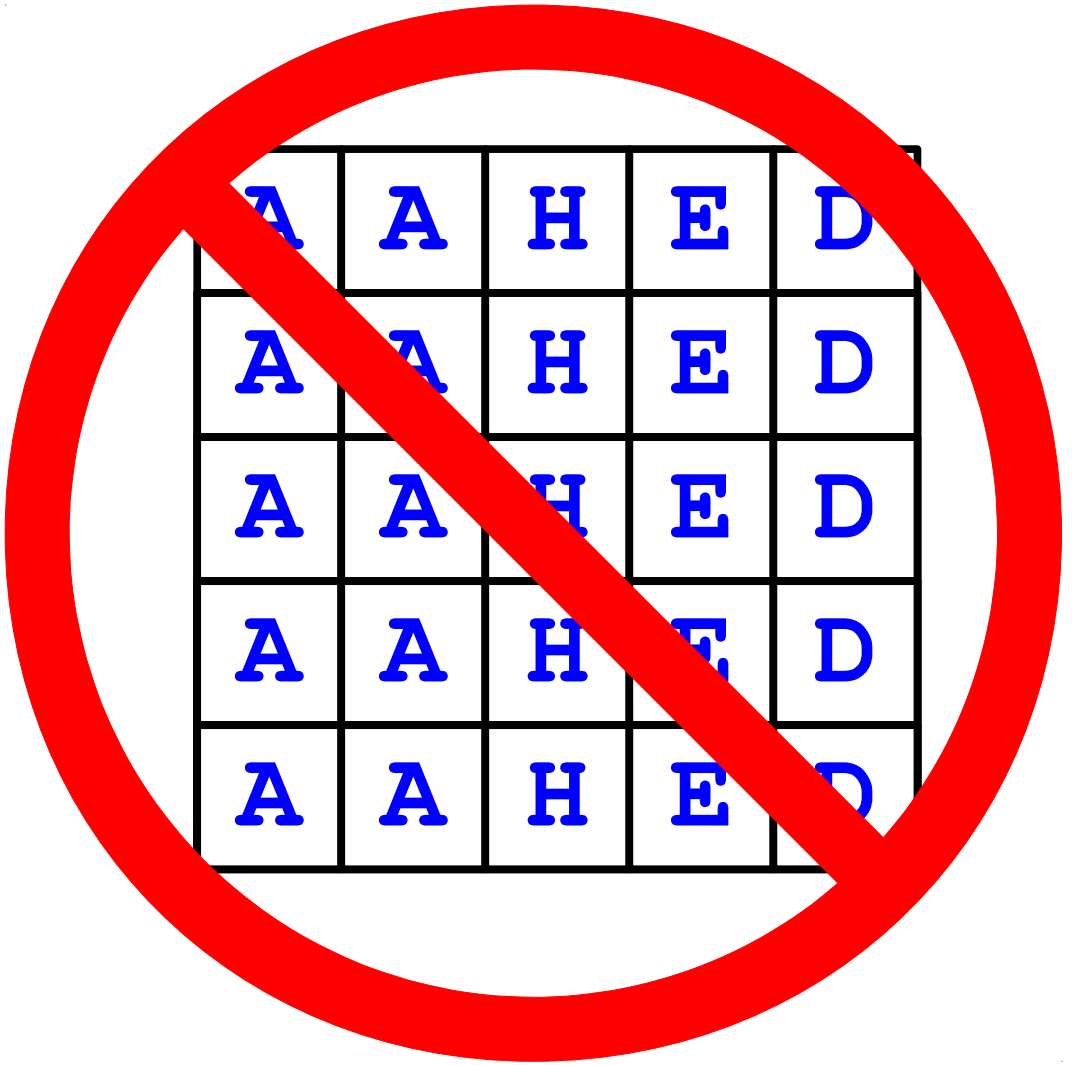

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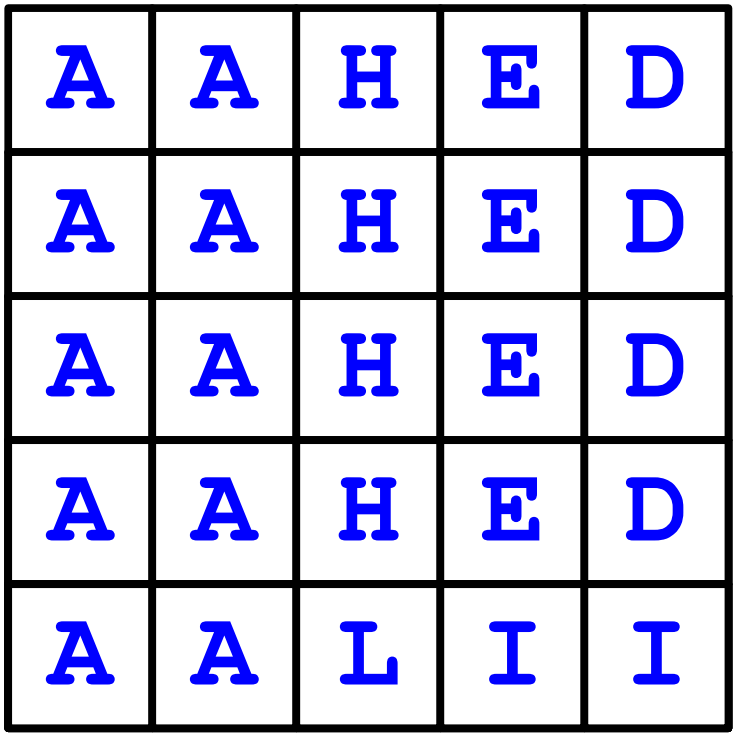

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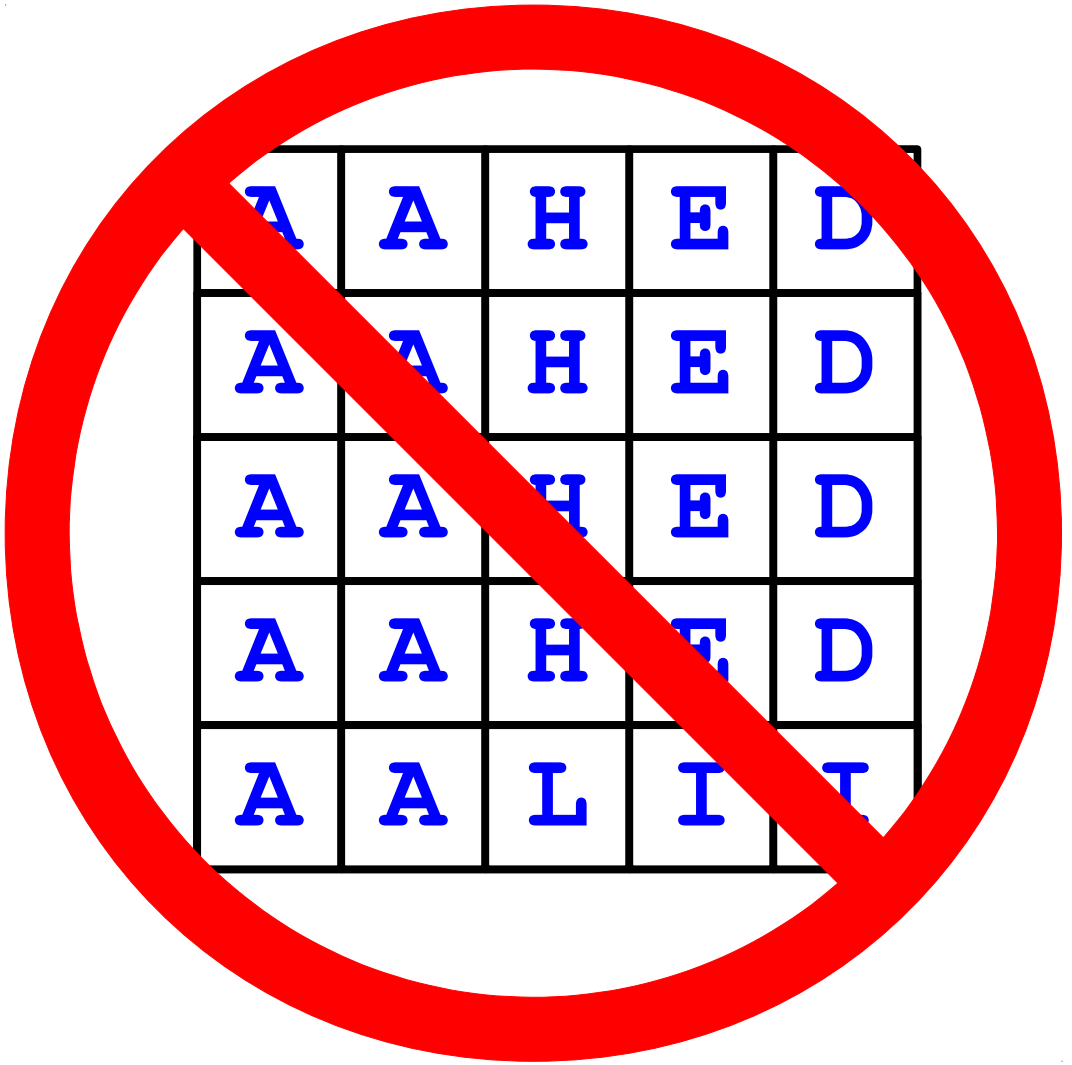

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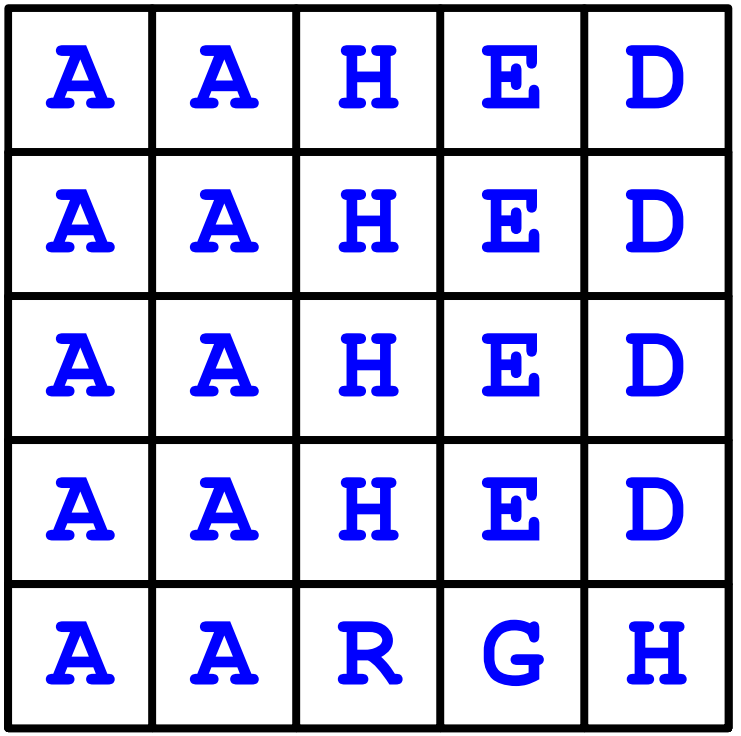

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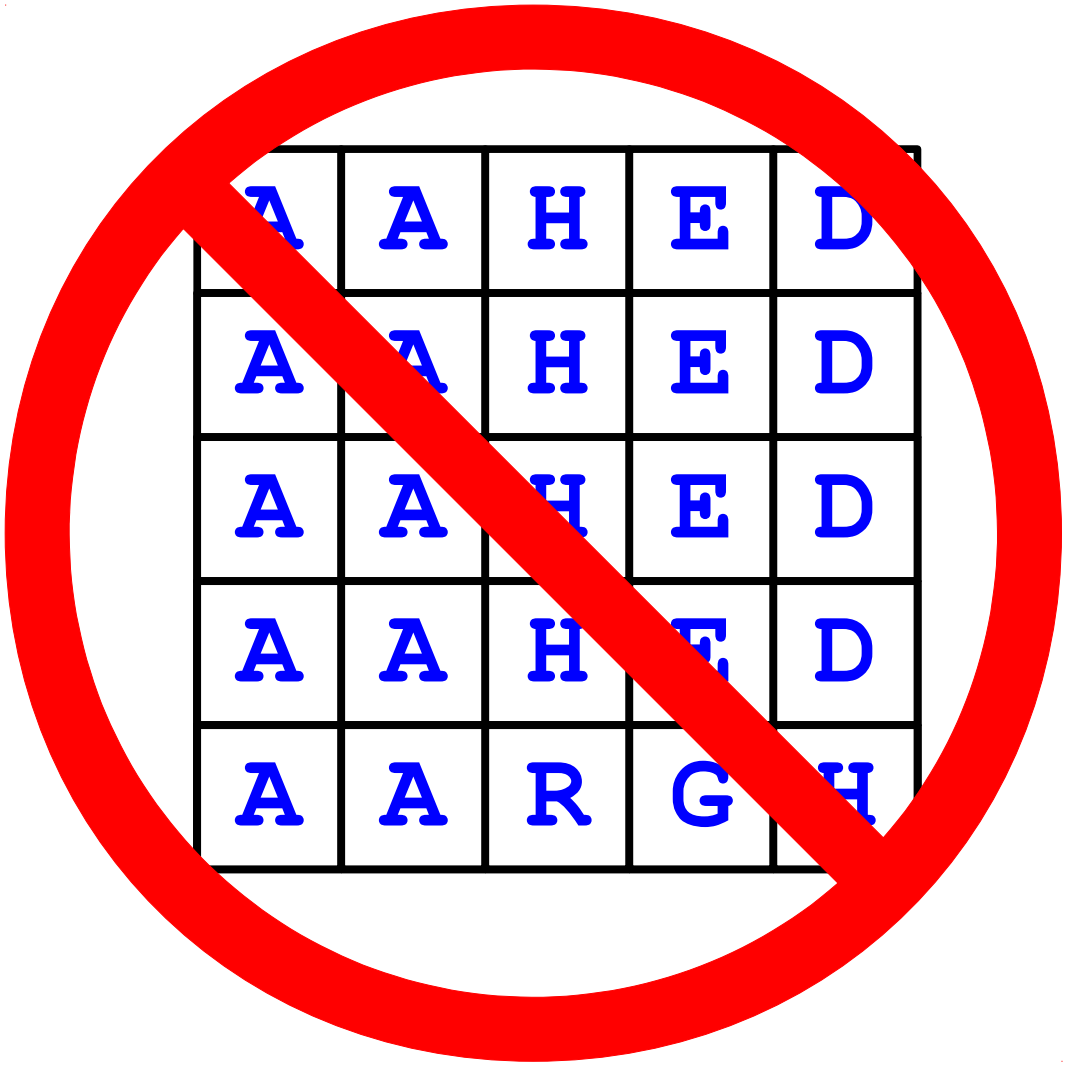

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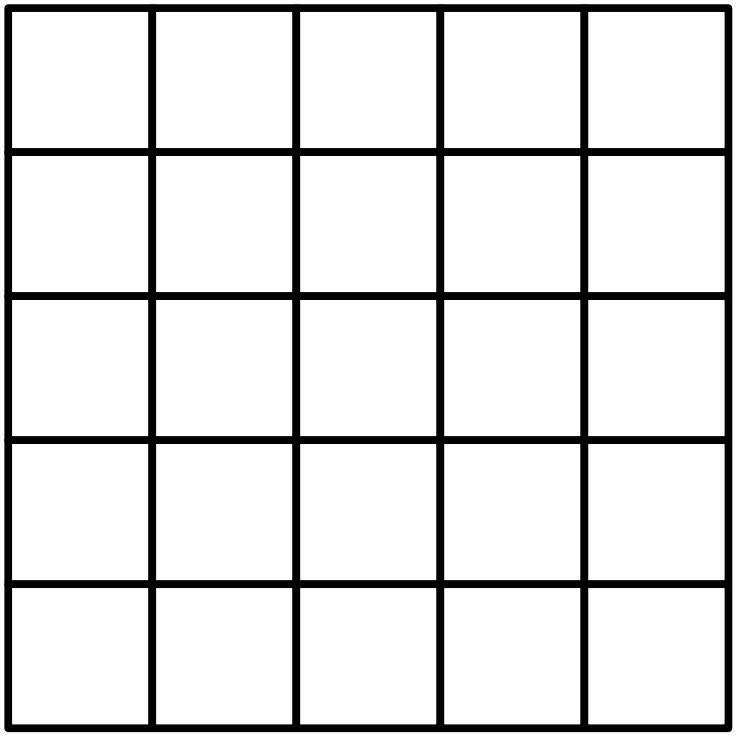

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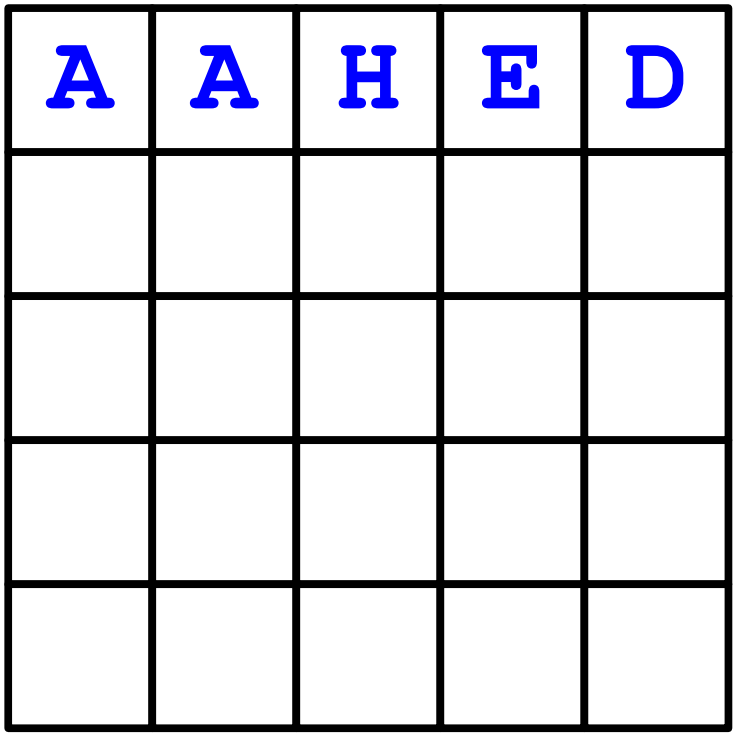

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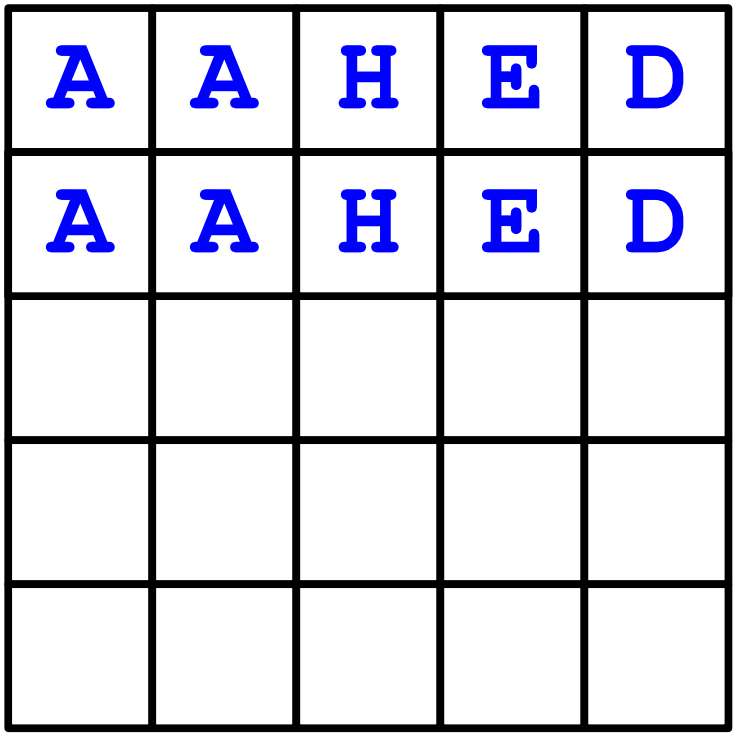

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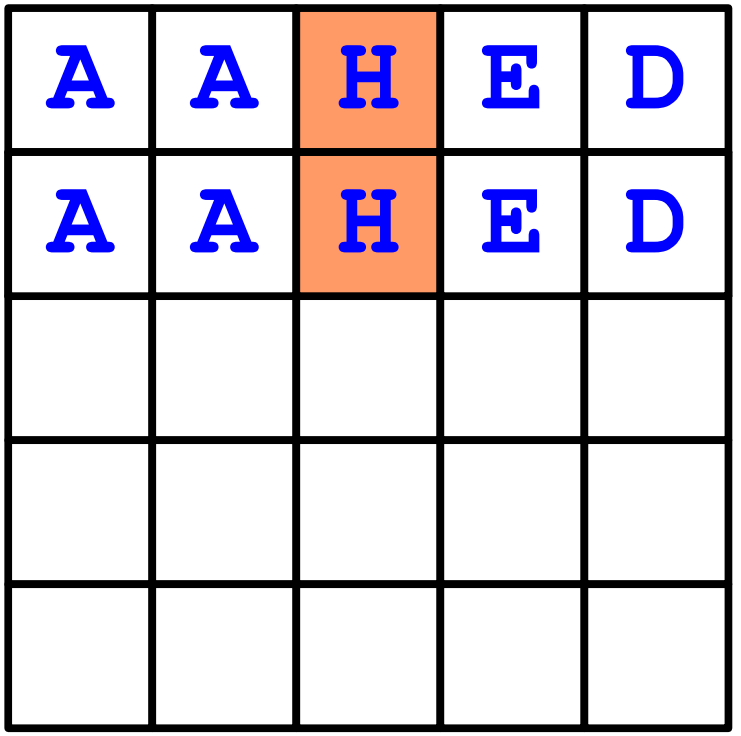

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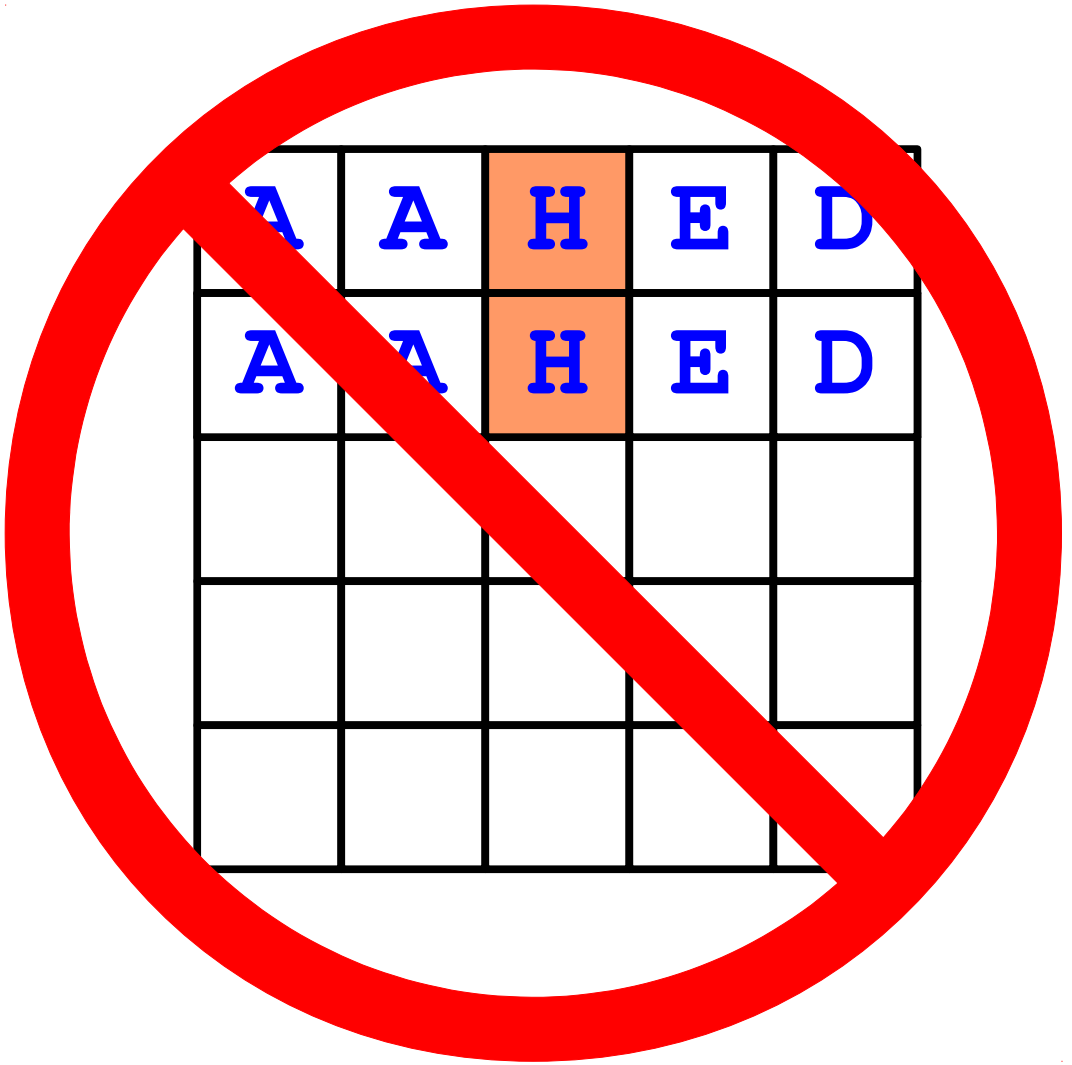

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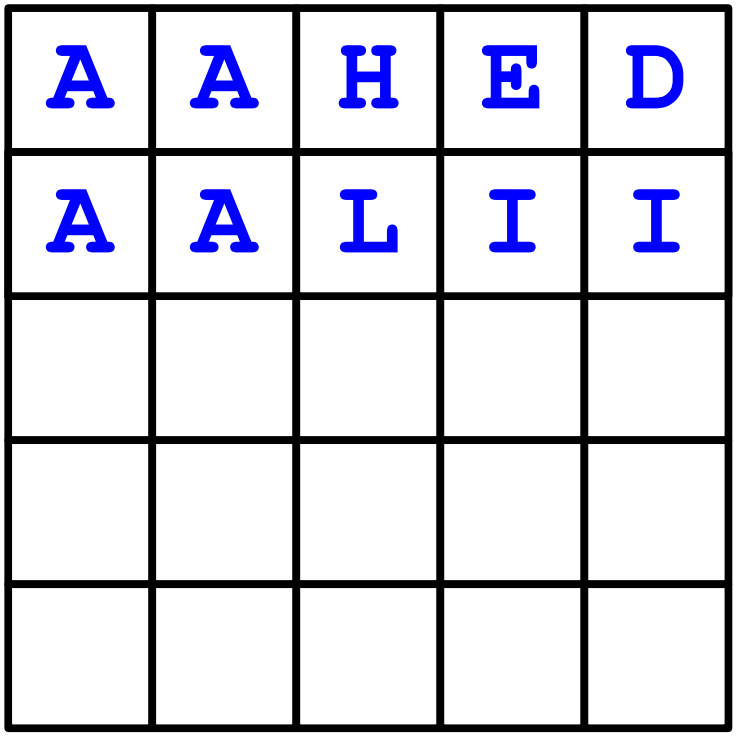

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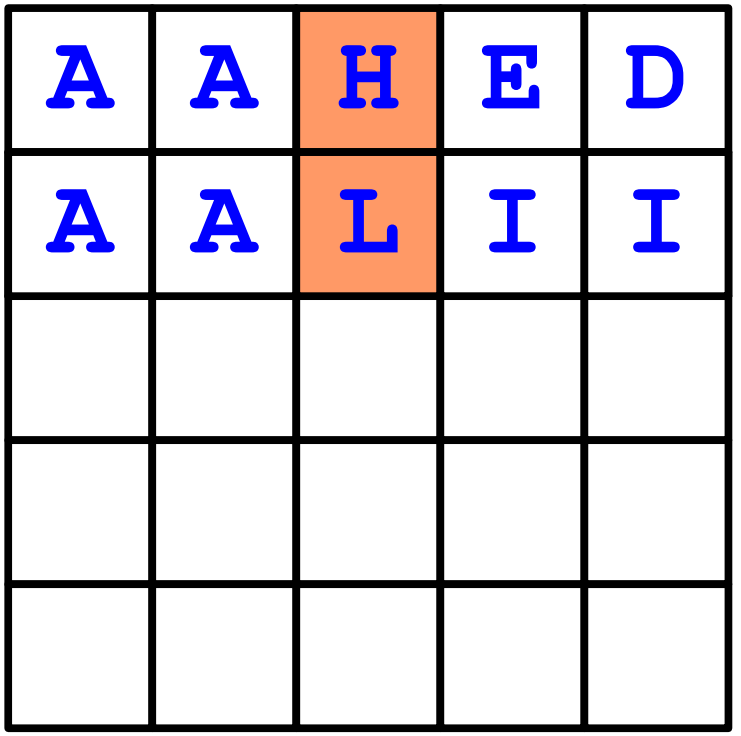

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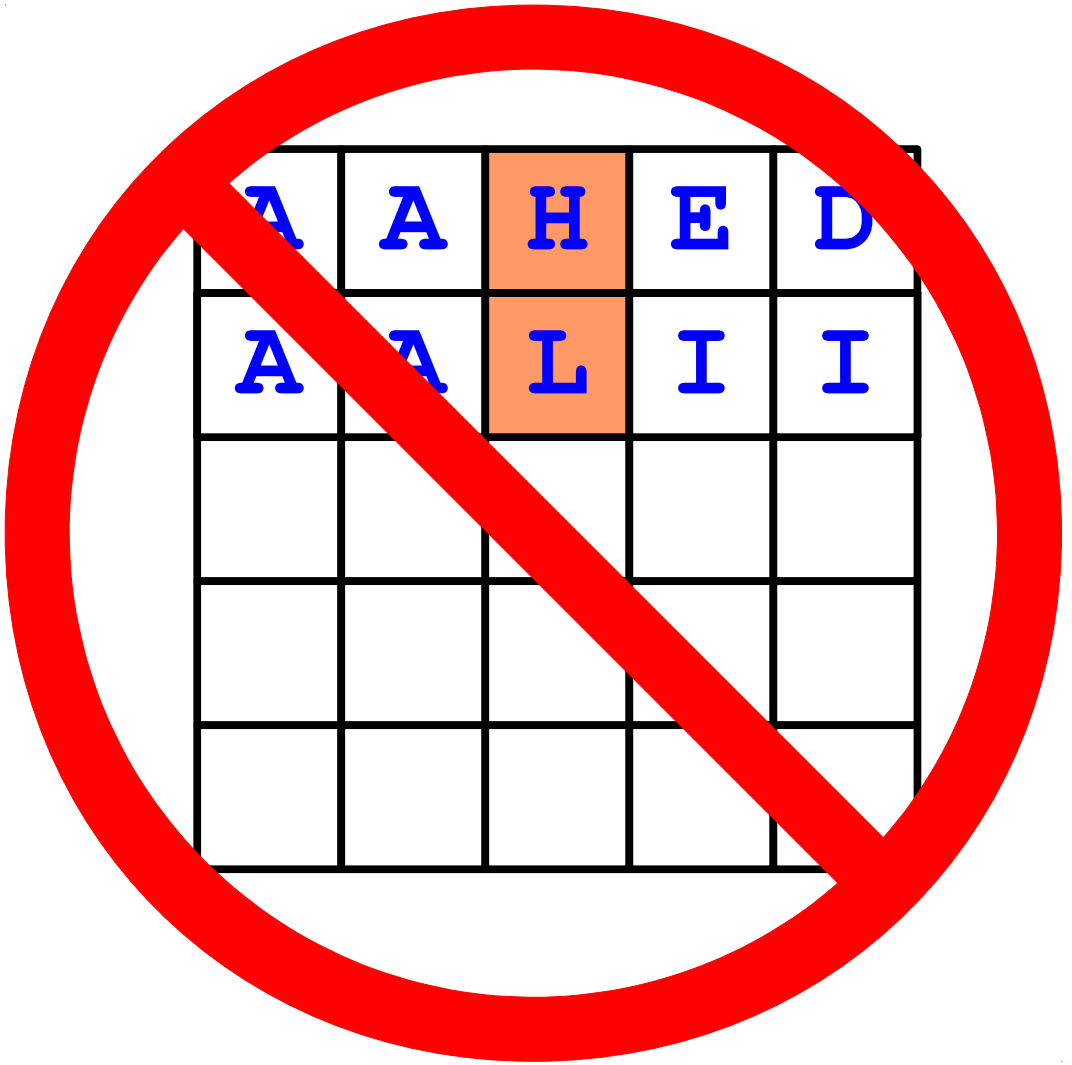

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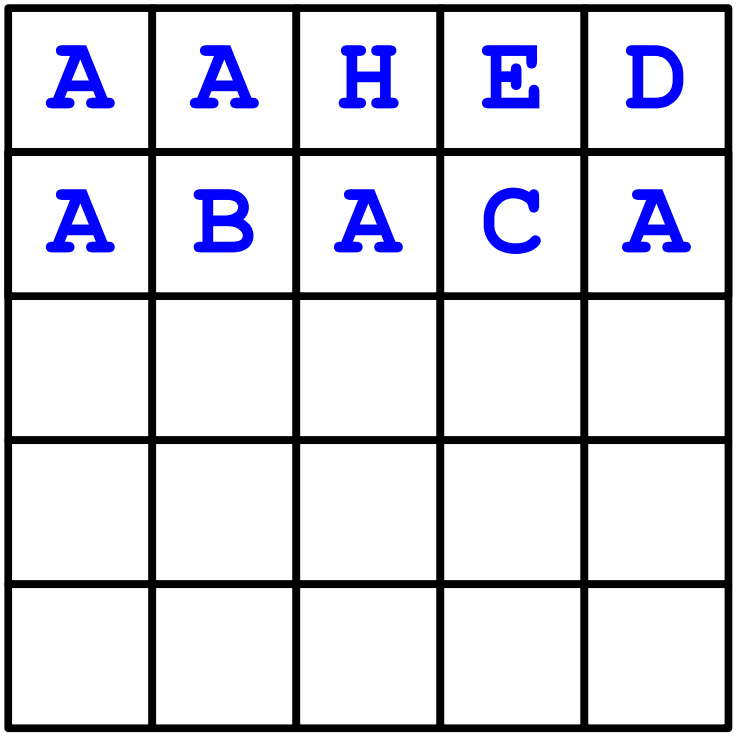

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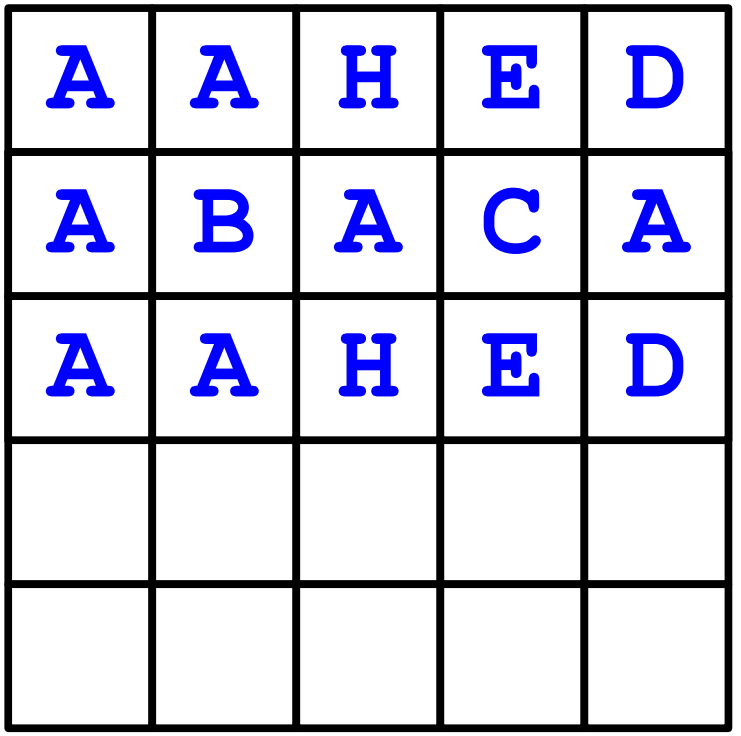

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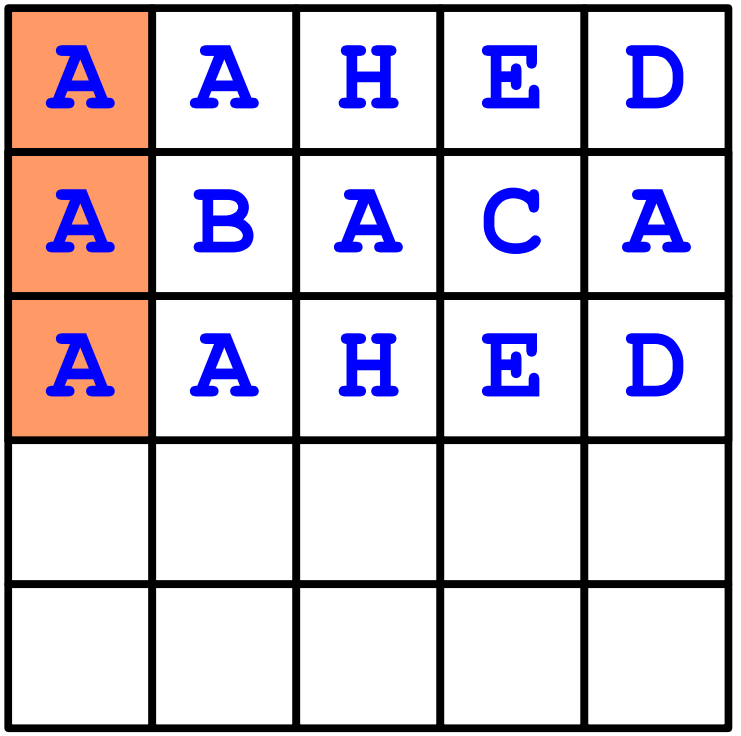

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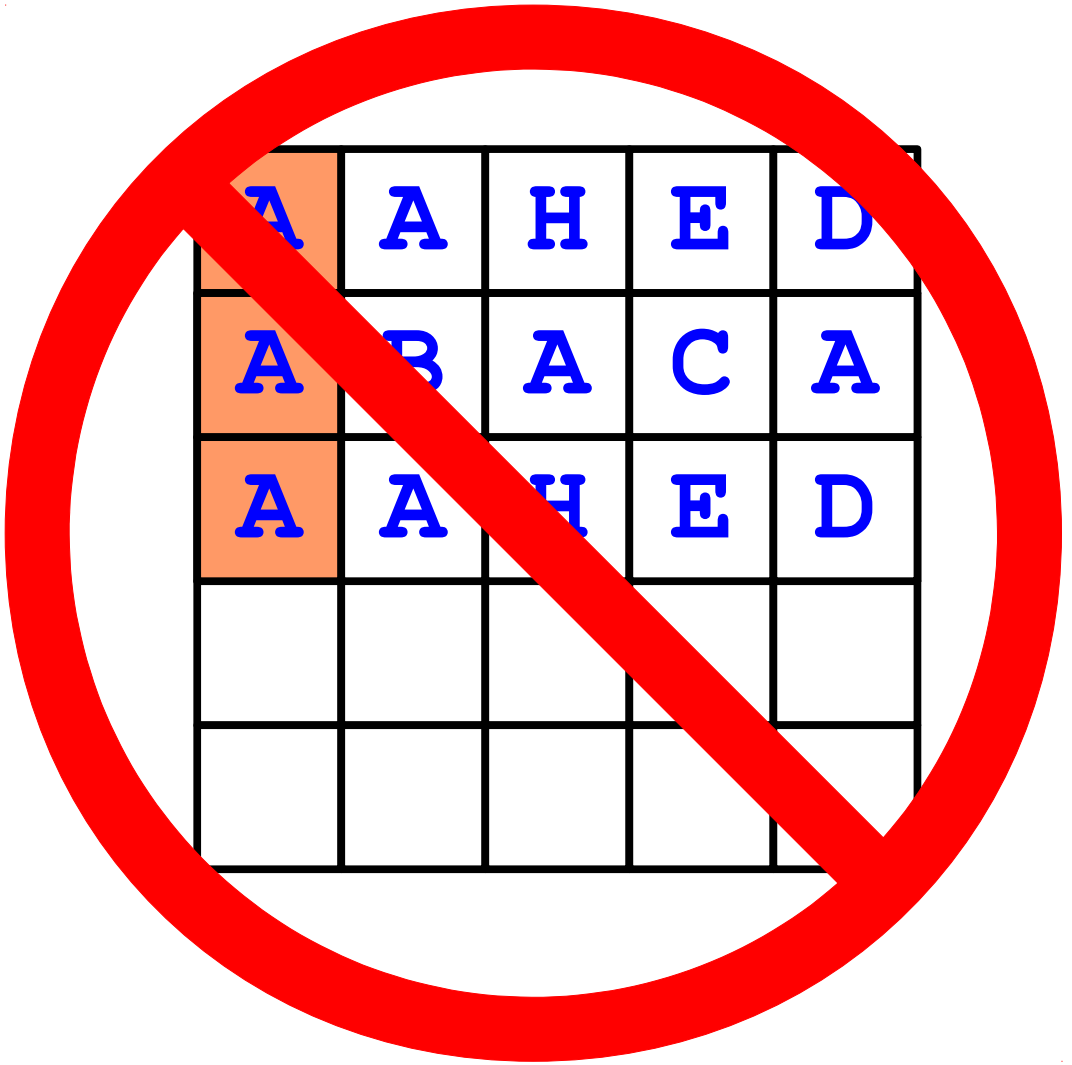

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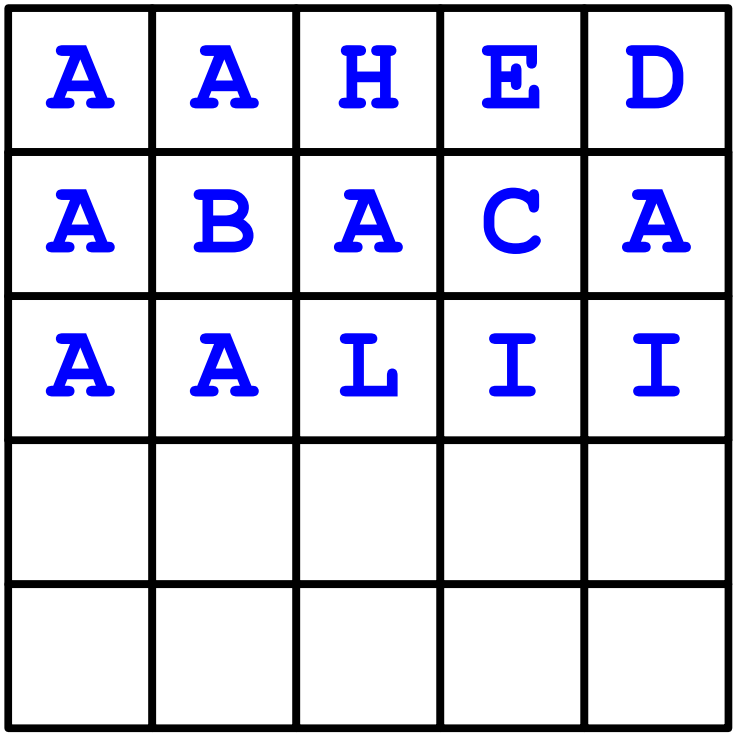

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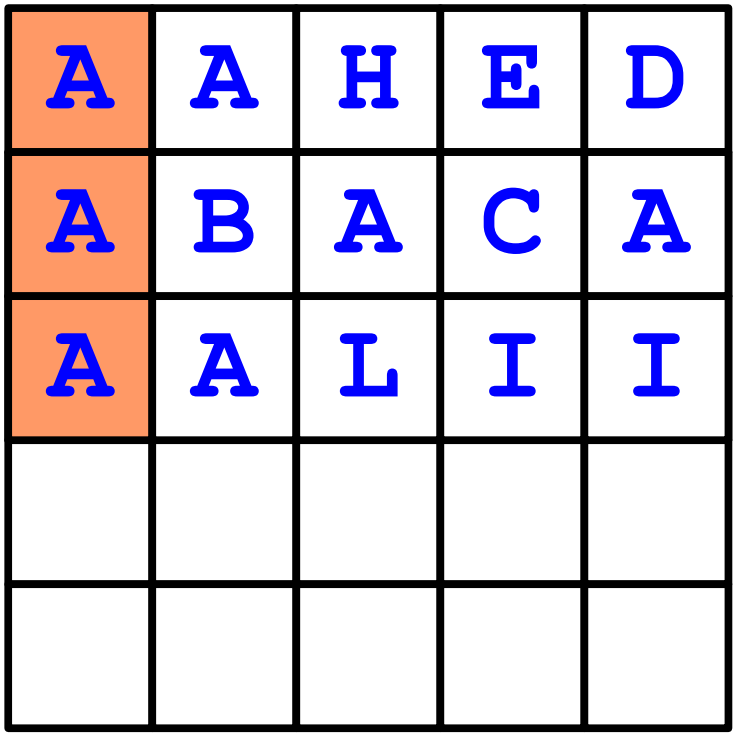

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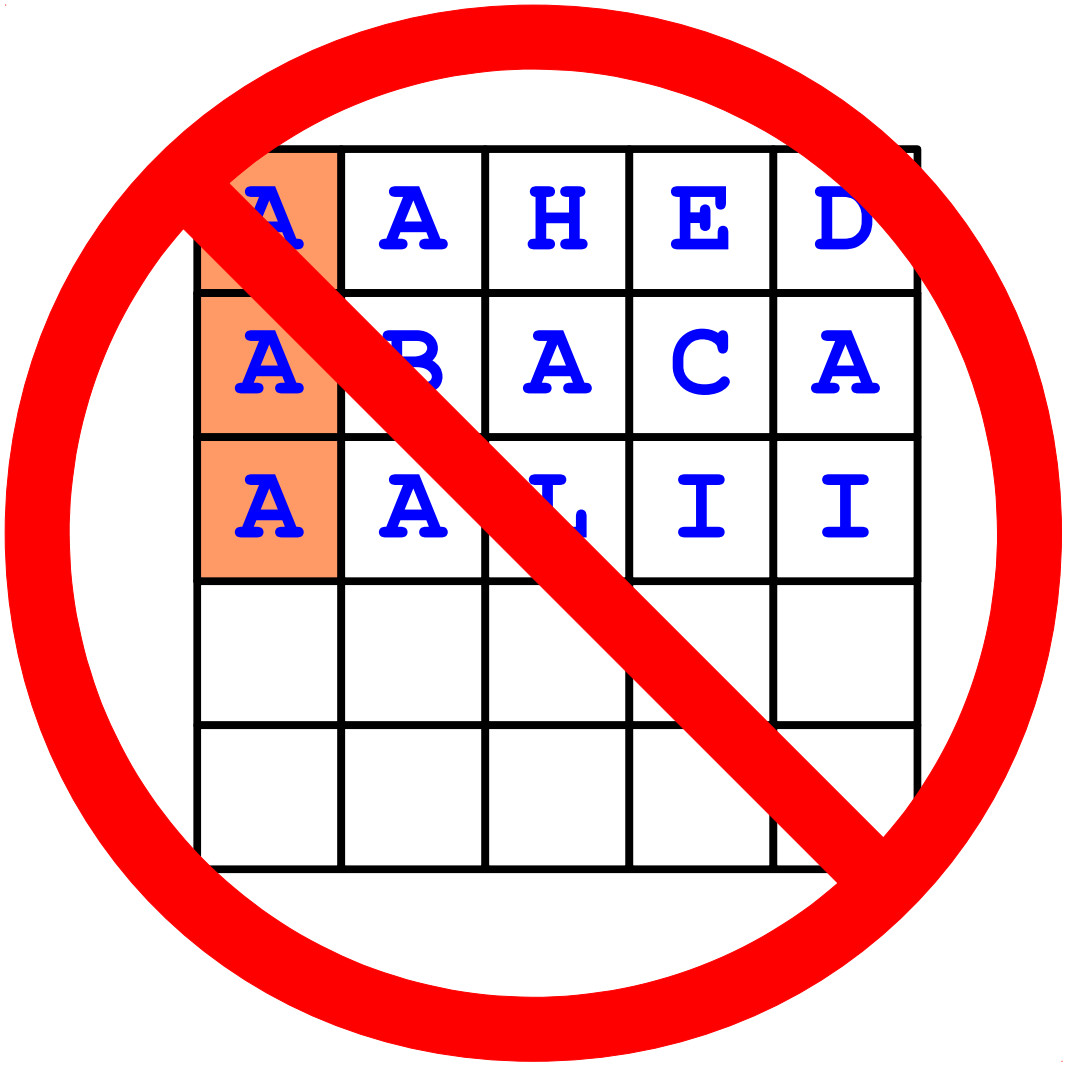

Generating Dense Crosswords

- Work downward one row at a time, at each point ensuring the columns are valid prefixes of a word.
- **Base Case:**
  - If all rows have been filled in legally, we're done!
- **Recursive Step:**
  - For each possible next word, try placing that word (checking that it doesn't conflict with a column) and recursively place remaining rows.

Interesting Exercise

- ***Make this program faster!***
  - Right now, it takes a *long* time to find a 7 × 7 or 8 × 8 crossword.
  - What other ways might you prune the search space?
  - Is there a more intelligent way to fill in the grid?

Next Time

- **Algorithmic Analysis**
  - How do we formally analyze the complexity of a piece of code?
  - How can we do so while maintaining sanity?