CSCA48 Summer 2017

Recursion

Brian Harrington

University of Toronto Scarborough

June 26 - 30, 2017

UNIVERSITY OF TORONTO SCARBOROUGH

Recursion

- Definition:
  - See: Recursion
- A way of breaking down a problem into smaller self-similar sub-problems
- Each sub-problem gets broken down in the same way
- Eventually, the problems become small enough to be trivial

A (Hopefully Not) Real Life Example

- Worlwide Pandemic

- Your job is to vaccinate everyone on earth
- Non-Recursive Approach:
  - Line up every person on Earth
  - Vaccinate one person at a time
- Recursive Approach:
  - Divide area into regions
  - For each region, assign one person
  - Each person will follow the same strategy as you
  - Eventually area will become small enough for one person to vaccinate everyone

VACCINATE PSEUDO CODE

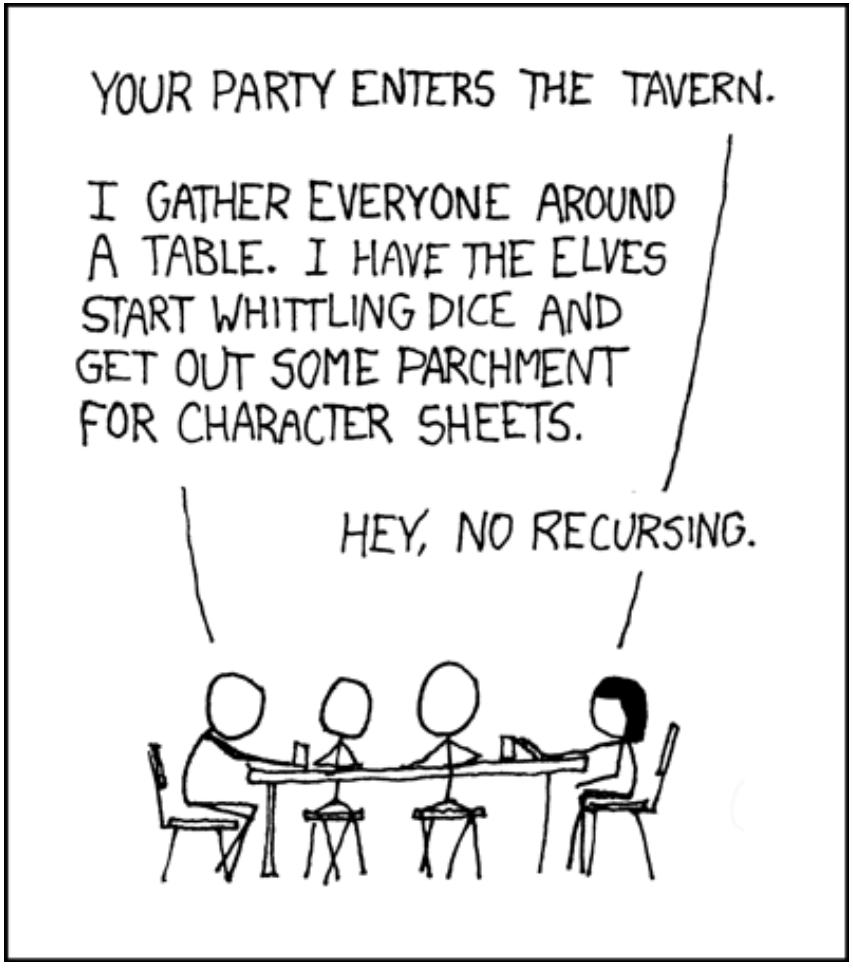
```
vaccinateEveryone(Region):
        if(Region is small enough):
                Vaccinate everyone manually
        else:
                Divide Region into sub-regions
                for (each sub-region r):
                        vaccinateEveryone(r):
```

Recursion

```
learn_recursion():
     if(understand):
          return "Eureka!"
     read()
     practice()
     learn_recursion()
```

Tower of Hanoi

Break


YOUR PARTY ENTERS THE TAVERN.
I GATHER EVERYONE AROUND A TABLE. I HAVE THE ELVES START WHITTLING DICE AND GET OUT SOME PARCHMENT FOR CHARACTER SHEETS.
HEY, NO RECURSING.

Rules of Recursion

- Recursion consists of 2 phases:
  - Base Case
  - Recursive Decomposition
- Base case should be trivial
- Decomposition must make problems smaller/simpler
- Decomposed problems must be self-similar to original
- Decomposition must eventually lead to base case

Common Patterns

- There are 3 common patterns to recursive decomposition
  - N-1 Approach: Deal with one item (often the first or last), and call the recursion on the remaining N-1
  - Divide and Conquer: Split the problem into 2 or more smaller problems
  - Indirect Recursion: Function 1 calls function 2, which in turn calls function 1

N-1 Approach Example

- 4!

Divide and Conquer Approach Example

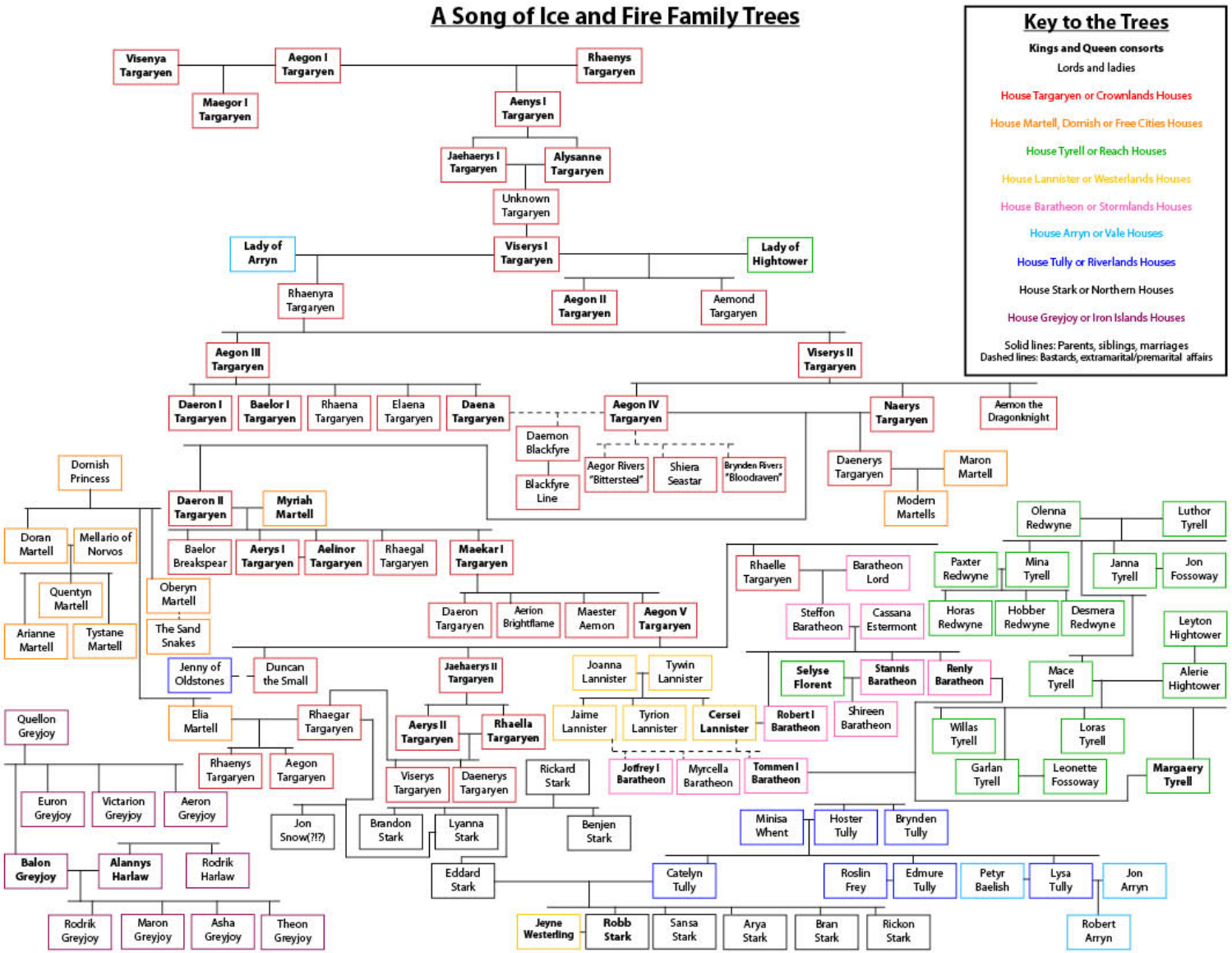
- binary search

Indirect Recursion Approach Example

- language generation

Break

Family Tree


A Song of Ice and Fire Family Trees
Key to the Trees
Kings and Queen consorts
Lords and ladies
House Targaryen or Crownlands Houses
House Martell, Dornish or Free Cities Houses
House Tyrell or Reach Houses
House Lannister or Westerlands Houses
House Baratheon or Stormlands Houses
House Arryn or Vale Houses
House Tully or Riverlands Houses
House Stark or Northern Houses
House Greyjoy or Iron Islands Houses
Solid lines: Parents, siblings, marriages
Dashed lines: Bastards, extramarital/premarital affairs
Visenya Targaryen
Aegon I Targaryen
Rhaenys Targaryen
Maegor I Targaryen
Aenys I Targaryen
Jaehaerys I Targaryen
Alysanne Targaryen
Unknown Targaryen
Lady of Arryn
Viserys I Targaryen
Lady of Hightower
Rhaenyra Targaryen
Aegon II Targaryen
Aemond Targaryen
Aegon III Targaryen
Viserys II Targaryen
Daeron I Targaryen
Baelor I Targaryen
Rhaena Targaryen
Elaena Targaryen
Daena Targaryen
Aegon IV Targaryen
Naerys Targaryen
Aemon the Dragonknight
Daemon Blackfyre
Blackfyre Line
Aegor Rivers "Bittersteel"
Shiera Seastar
Brynden Rivers "Bloodraven"
Daenerys Targaryen
Maron Martell
Modern Martells
Dornish Princess
Daeron II Targaryen
Myriah Martell
Doran Martell
Mellario of Norvos
Baelor Breakspear
Aerys I Targaryen
Aelinor Targaryen
Rhaegal Targaryen
Maekar I Targaryen
Quentyn Martell
Oberyn Martell
The Sand Snakes
Arianne Martell
Tystane Martell
Daeron Targaryen
Aerion Brightflame
Maester Aemon
Aegon V Targaryen
Jenny of Oldstones
Duncan the Small
Jaehaerys II Targaryen
Joanna Lannister
Tywin Lannister
Quellon Greyjoy
Elia Martell
Rhaegar Targaryen
Aerys II Targaryen
Rhaella Targaryen
Jaime Lannister
Tyrion Lannister
Cersei Lannister
Robert I Baratheon
Shireen Baratheon
Rhaenys Targaryen
Aegon Targaryen
Viserys Targaryen
Daenerys Targaryen
Rickard Stark
Joffrey I Baratheon
Myrcella Baratheon
Tommen I Baratheon
Euron Greyjoy
Victarion Greyjoy
Aeron Greyjoy
Jon Snow(?!?)
Brandon Stark
Lyanna Stark
Benjen Stark
Balon Greyjoy
Alannys Harlaw
Rodrik Harlaw
Eddard Stark
Catelyn Tully
Rodrik Greyjoy
Maron Greyjoy
Asha Greyjoy
Theon Greyjoy
Jeyne Westerling
Robb Stark
Sansa Stark
Arya Stark
Bran Stark
Rickon Stark
Rhaelle Targaryen
Baratheon Lord
Steffon Baratheon
Cassana Estermont
Selyse Florent
Stannis Baratheon
Renly Baratheon
Olenna Redwyne
Luthor Tyrell
Paxter Redwyne
Mina Tyrell
Janna Tyrell
Jon Fossoway
Horas Redwyne
Hobber Redwyne
Desmera Redwyne
Leyton Hightower
Mace Tyrell
Alerie Hightower
Willas Tyrell
Loras Tyrell
Garlan Tyrell
Leonette Fossoway
Margaery Tyrell
Minisa Whent
Hoster Tully
Brynden Tully
Roslin Frey
Edmure Tully
Petyr Baelish
Lysa Tully
Jon Arryn
Robert Arryn

Sierpinksi Triangle