Query Optimization
Exercise Session 7

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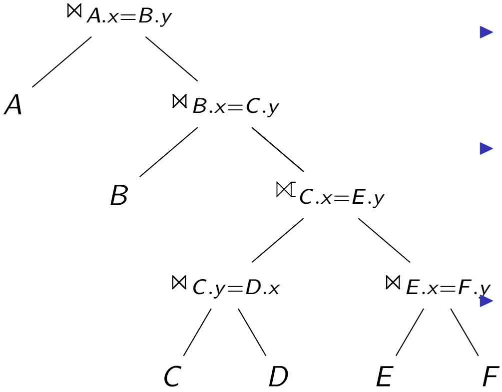
December 1, 2014

Enumerating Complementary Subgraphs

EnumerateCmp(G,S_1)
$X = \mathcal{B}_{\min(S_1)} \cup S_1$;
$N = \mathcal{N}(S_1) \setminus X$;
for all ($v_i \in N$ by descending i) {
    emit $\{v_i\}$;
    EnumerateCsgRec(G, $\{v_i\}$, $X \cup (\mathcal{B}_i \cap N)$);
}

- EnumerateCsg+EnumerateCmp produce all ccp
- resulting algorithm DPccp considers exactly #ccp pairs
- which is the lower bound for all DP enumeration algorithms

Homework

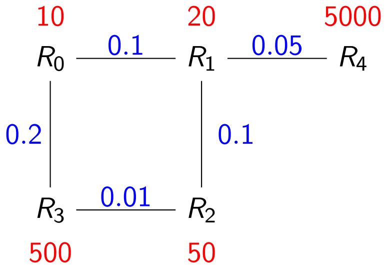


- Syntactic eligibility set - relations that have to be in the input
- Total eligibility set - captures also reordering restrictions, construct bottom-up
- Conflicts: $⟖_{C.x=E.y}$ and $\bowtie_{C.y=D.x}$, $⟖_{C.x=E.y}$ and $\bowtie_{B.x=C.y}$

Homework: Graph Simplification

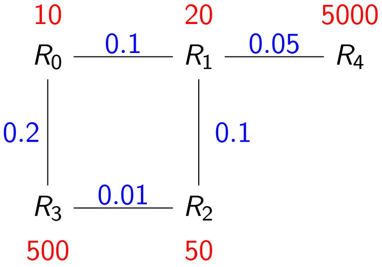
Important: consider all possible edge combinations, that is, $benefit(R_0 \bowtie R_1, R_0 \bowtie R_2)$ together with $benefit(R_0 \bowtie R_2, R_0 \bowtie R_1)$

Homework: Graph Simplification



- $benefit(R_0 \bowtie R_1, R_0 \bowtie R_3) = \frac{202}{300}$
- $b(R_0 \bowtie R_3, R_0 \bowtie R_1) = 300/202$
- $b(R_1 \bowtie R_2, R_1 \bowtie R_0) = 20/12$
- $b(R_3 \bowtie R_0, R_3 \bowtie R_2) = 2$
- $b(R_2 \bowtie R_3, R_2 \bowtie R_1) = 5/4$
- $b(R_1 \bowtie R_4, R_1 \bowtie R_0) = 500/251$
- $b(R_1 \bowtie R_4, R_1 \bowtie R_3) = 300/251$
- $R_3 \bowtie R_2$ before $R_3 \bowtie R_0$. Remove $R_3 - R_0$

Homework: Graph Simplification



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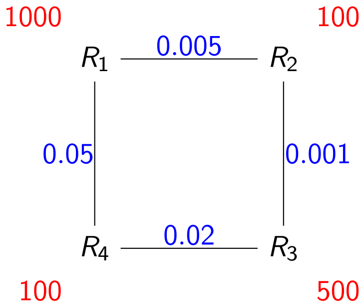
- $b(R_1 \bowtie R_4, R_1 \bowtie R_3) = 300/251$
- $b(R_0 \bowtie (R_3 \bowtie R_2), R_0 \bowtie R_1) = \frac{C((R_0 \bowtie (R_3 \bowtie R_2)) \bowtie R_1)}{C((R_0 \bowtie R_1) \bowtie (R_3 \bowtie R_2))} = 850/370$
- $b((R_2 \bowtie R_3) \bowtie R_0, R_2 \bowtie R_1) = \frac{C(((R_2 \bowtie R_3) \bowtie R_0) \bowtie R_1)}{C((R_2 \bowtie R_3) \bowtie R_1) \bowtie R_0)} = 1$
- $R_0 \bowtie R_1$ before $R_0 \bowtie (R_3 \bowtie R_2)$

Generating Permutations

ConstructPermutationsRec(P, R, B)
Input: a prefix P, remaining relations R, best plan B
Output: side effects on B

if $|R| = 0$ $\{$
  if $B = \epsilon \vee C(B) > C(P)$ $\{$
    $B = P$
  $\}$
$\}$ **else** $\{$
  for each $R_i \in R$ $\{$
    if $C(P \circ < R_i >) \leq C(P[1 : |P| - 1] \circ < R_i, P[|P|] >)$ $\{$
      ConstructPermutationsRec($P \circ < R_i >, R \setminus \{R_i\}, B$)
    $\}$
  $\}$
$\}$

Generating Permutations



- Keep current prefix and the rest of relations
- Extend the prefix only if exchanging the last two relations does not result in a cheaper sequence

Memoization

- DP: bottom-up construction of the join tree
- Memoization: top-down construction
- Memoize already generated join tree to avoid duplicate work
- Sometimes more efficient

Algorithms: Roadmap

- Deterministic
  - Exact (IKKBZ, DP, Permutations, Memoization,...)
  - Heuristics (GOO, MVP, Query Simplification,...)
- Probabilistic
- Hybrid

Random left-deep trees with cross products

- there are $n!$ trees (every tree - permutation)
- let's generate a random number in $[0, n![$
- *unranking* - for a generated number construct a tree
- *ranking* - for a tree define it's number

Generating random permutations

for each $k \in [0, n[$ **descending**
  $\text{swap}(\pi[k], \pi[\text{random}(k)])$

Array π initialized with elements $[0, n[$.
`random`(k) generates a random number in $[0, k]$.

Unranking

```
Unrank(n, r)
Input:  the number n of elements to be permuted
        and the rank r of the permutation to be constructed
Output: a permutation π
for each 0 ≤ i < n
  π[i] = i
for each n ≥ i > 0 descending {
  swap(π[i − 1], π[r mod i])
  r = ⌊r/i⌋
}
return π;
```

Random join trees with cross products

- Generate a tree, then generate a permutation: $C(n-1)$ trees, $n!$ permutations
- Pick a random number $b \in [0, C(n-1)[$, *unrank* b
- Pick a random number $p \in [0, n![$, *unrank* p
- Attach the permutation to the leaves

Unranking

- every tree is a word in $\{(,)\}$
- map such words to the grid, every step up is (, down)

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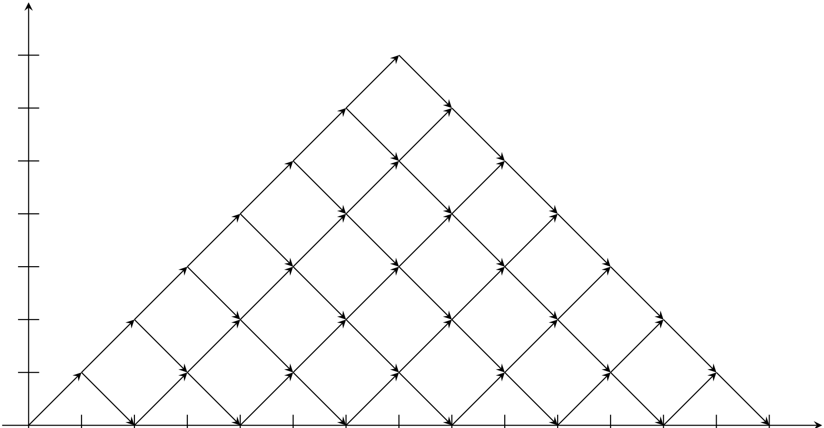


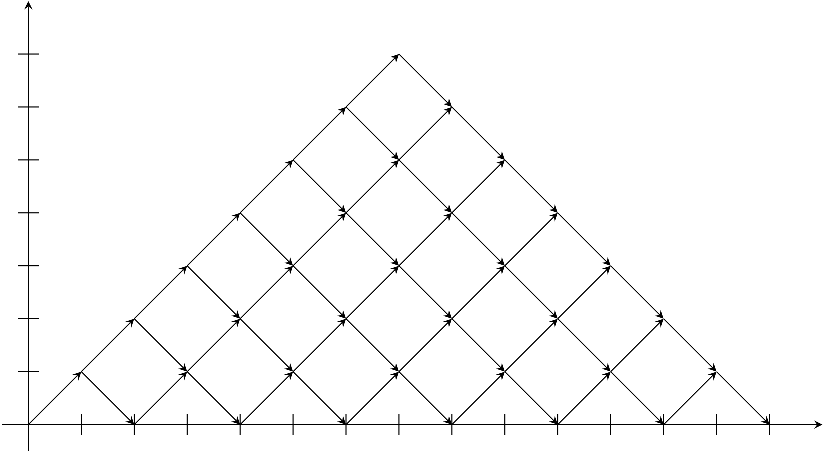
Unranking

- every tree is a word in $\{(,)\}$
- map such words to the grid, every step up is (, down)
- the number of different paths q can be computed (see lectures)
- Procedure: start in (0,0), walk up as long as rank is smaller than q. When it is bigger, step down, $rank=rank$-q

Example

- Bushy tree number 56, 8 leaves

Random Join Tree Selection



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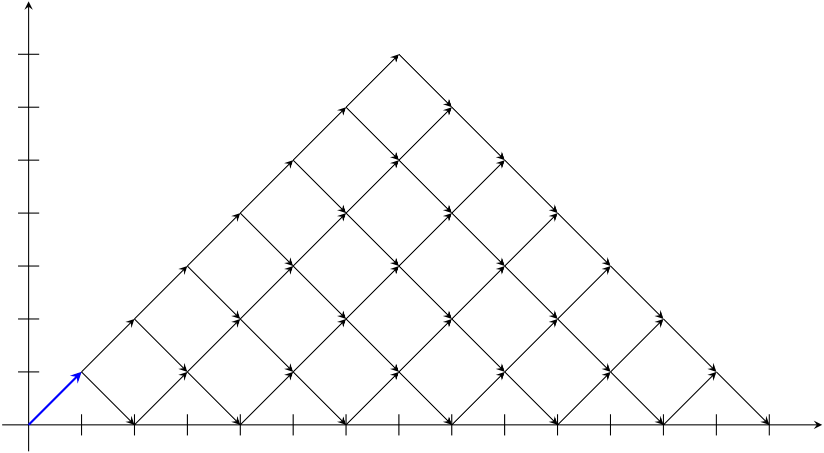

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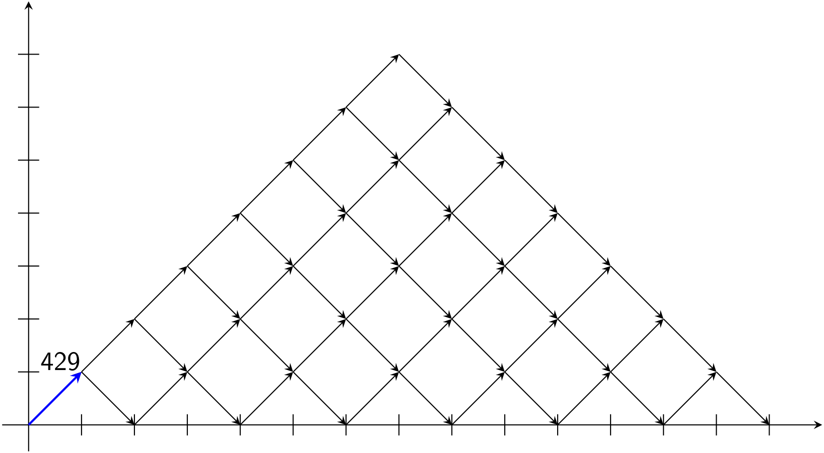

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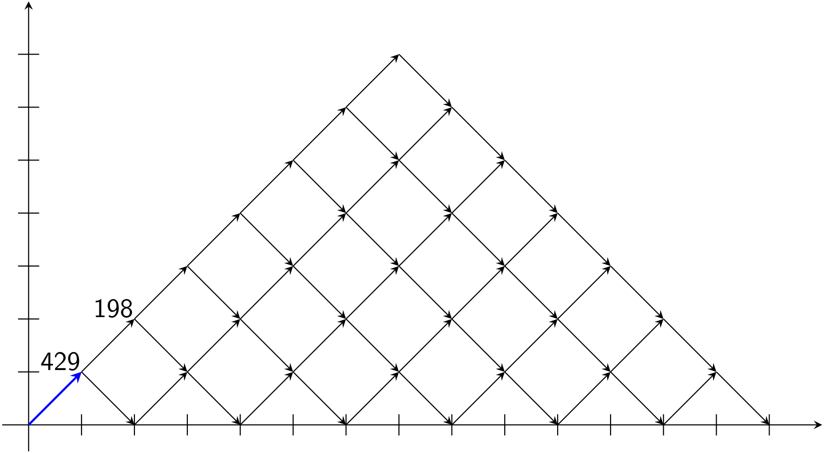

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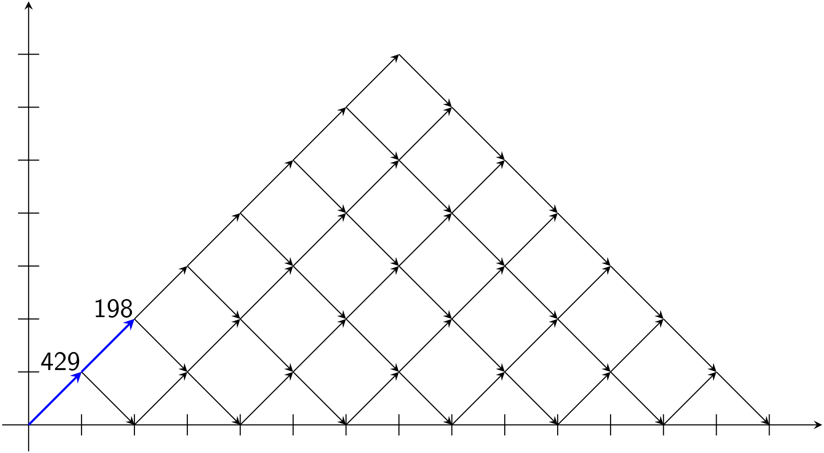

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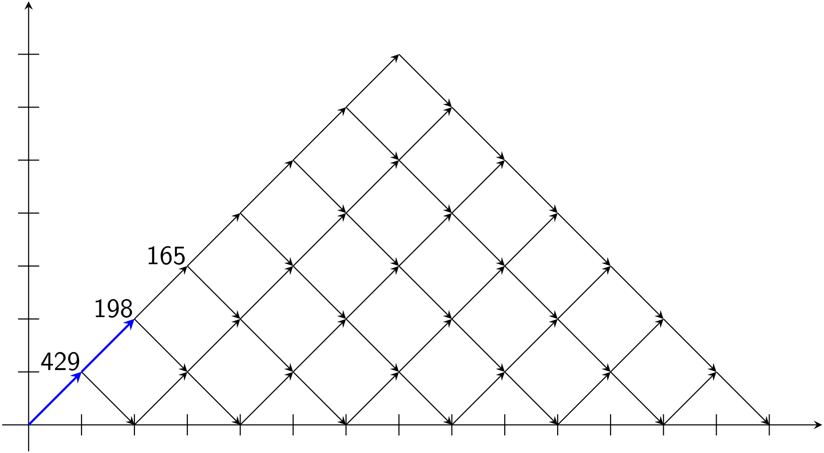

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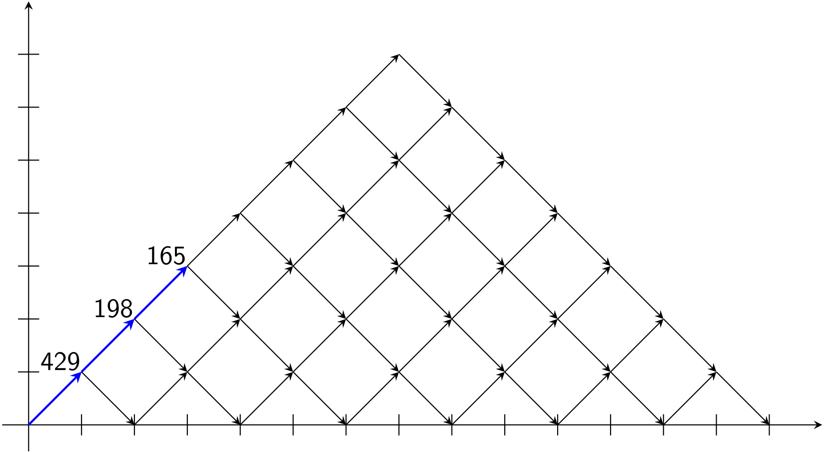

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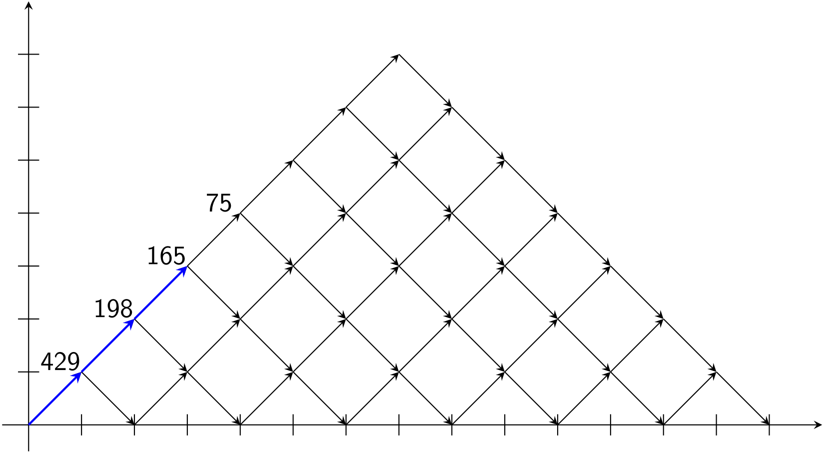

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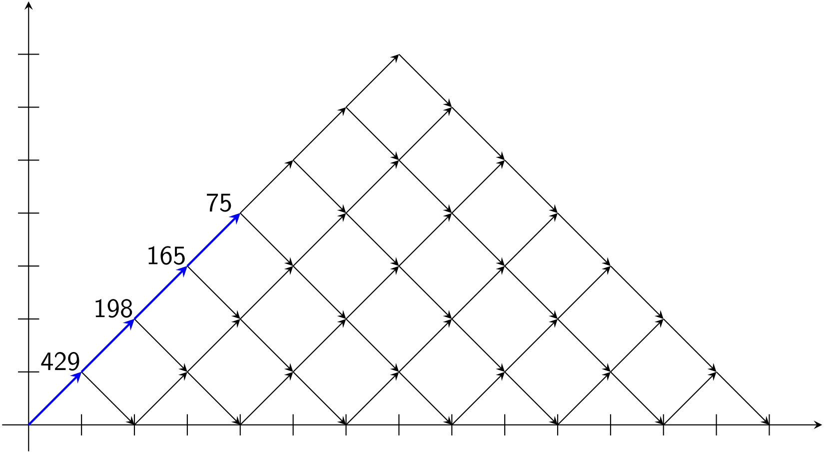

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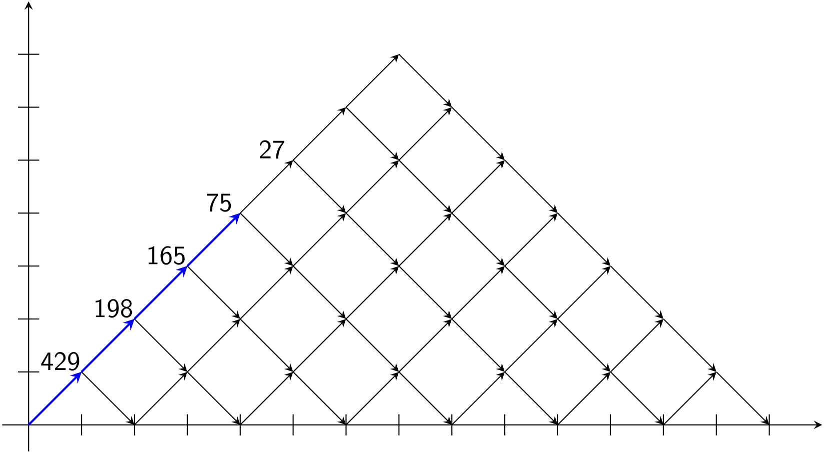

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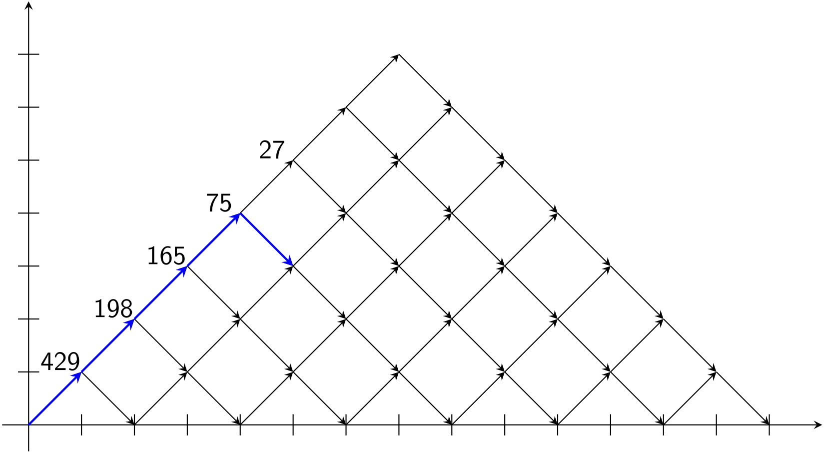

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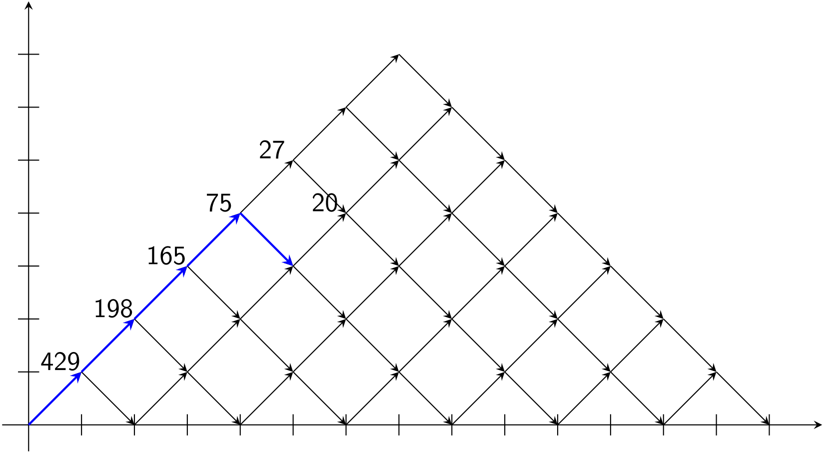

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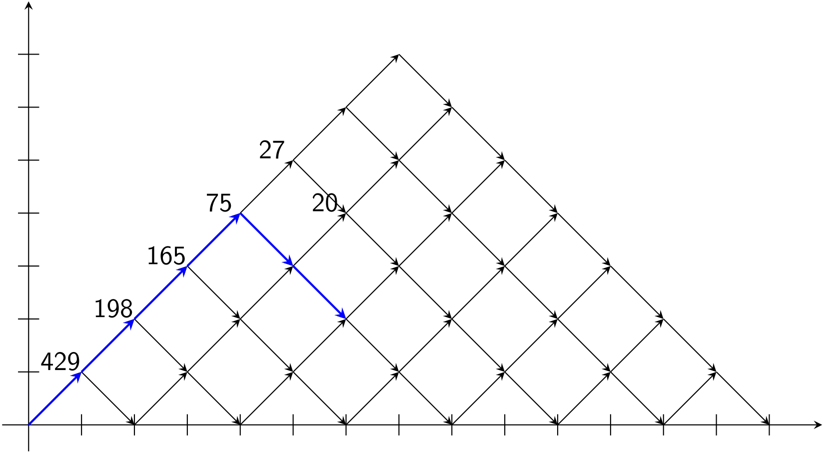

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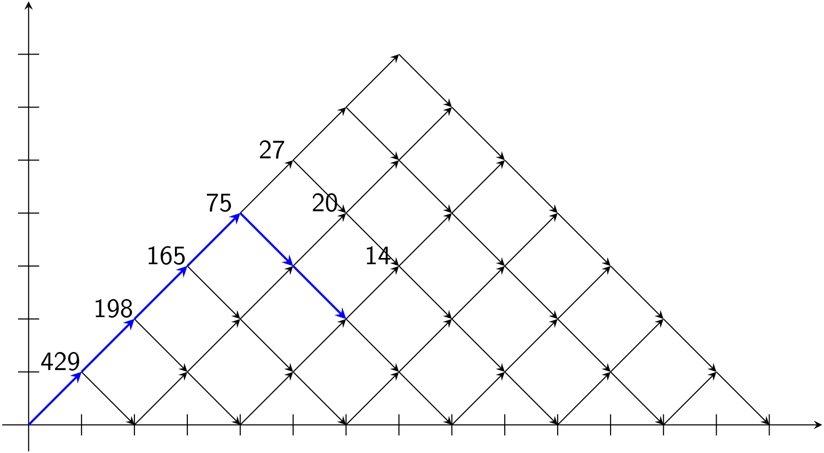

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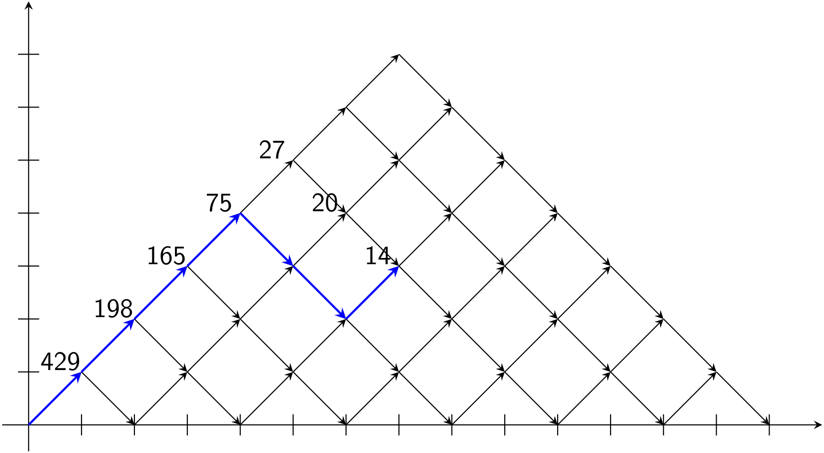

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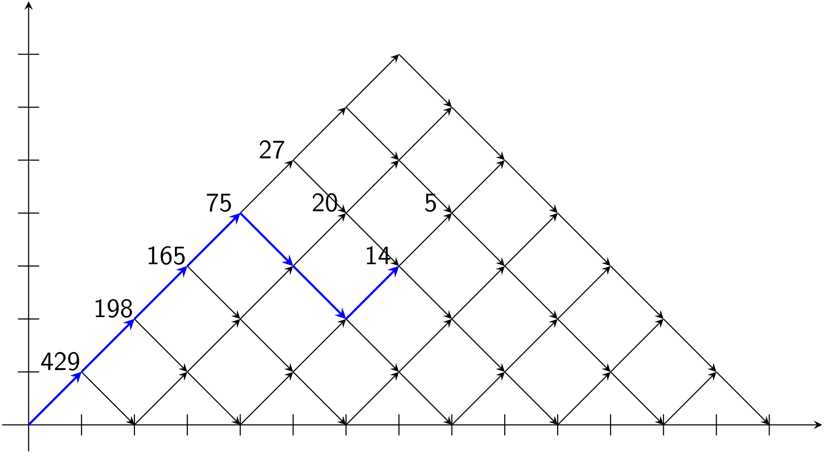

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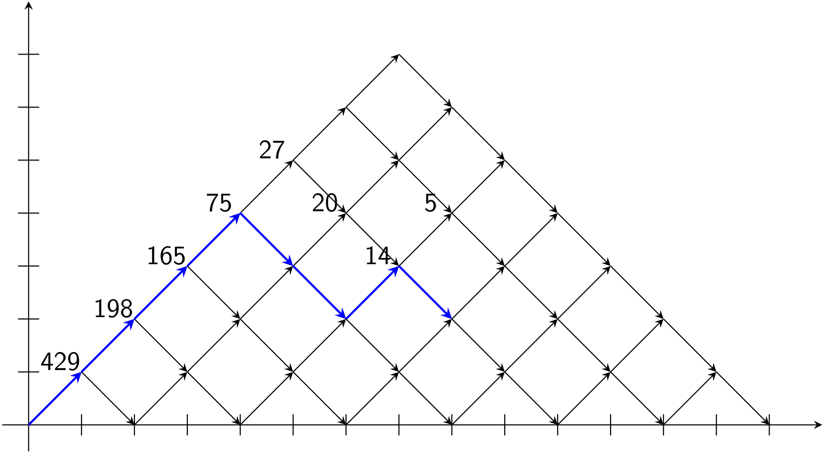

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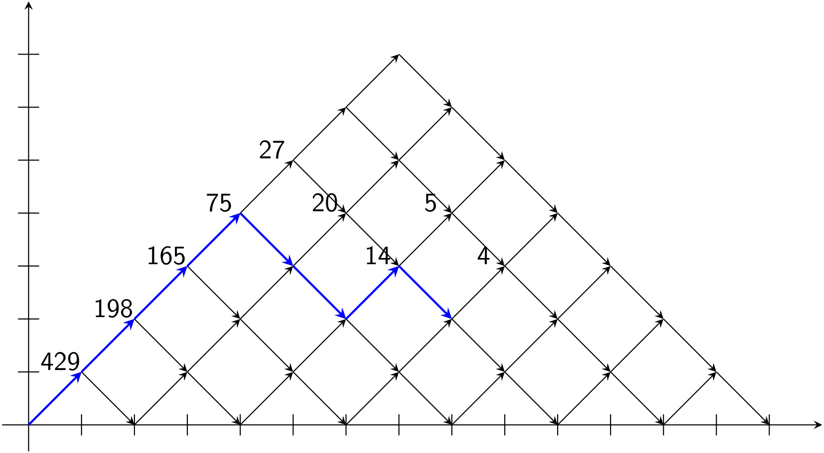

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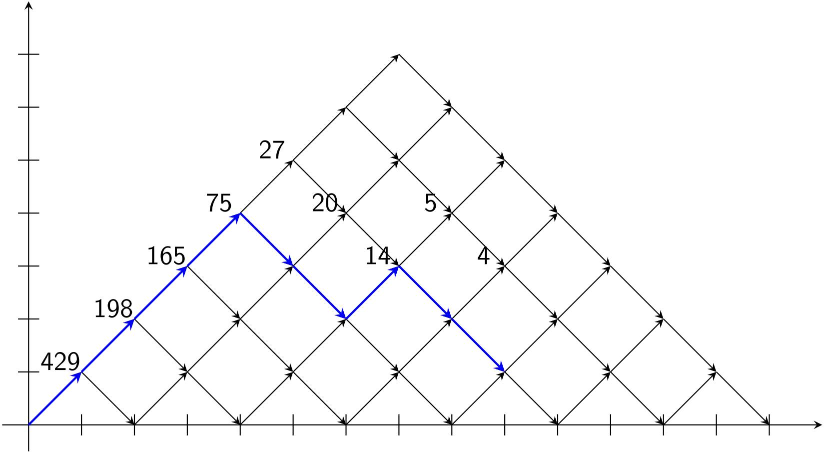

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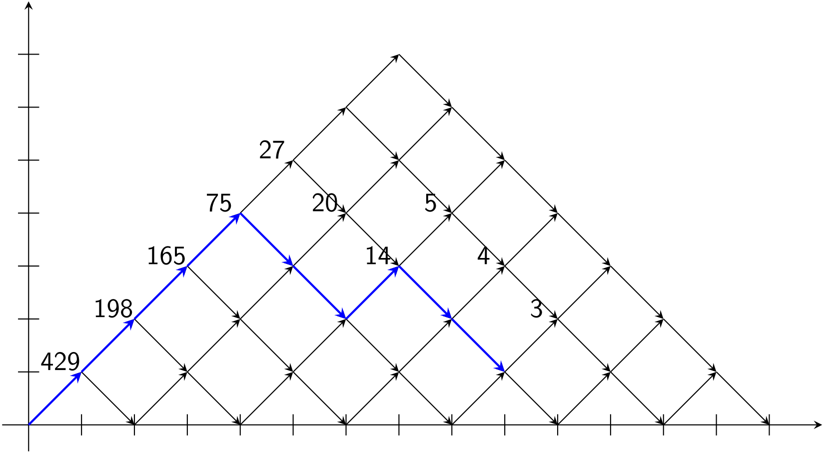

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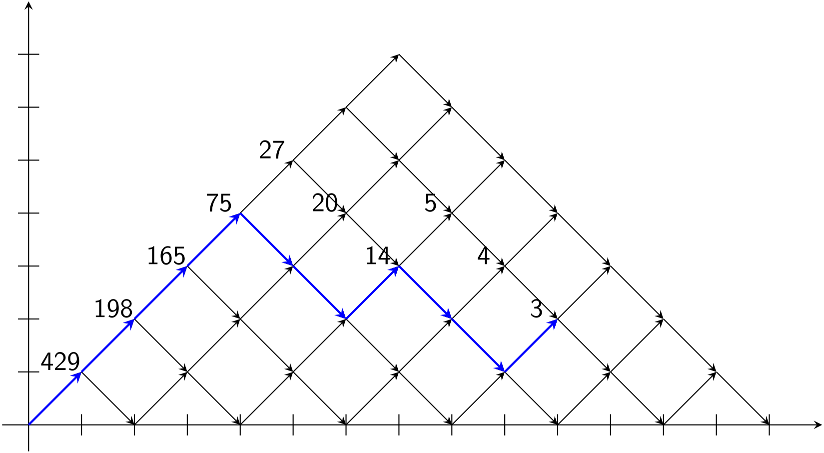

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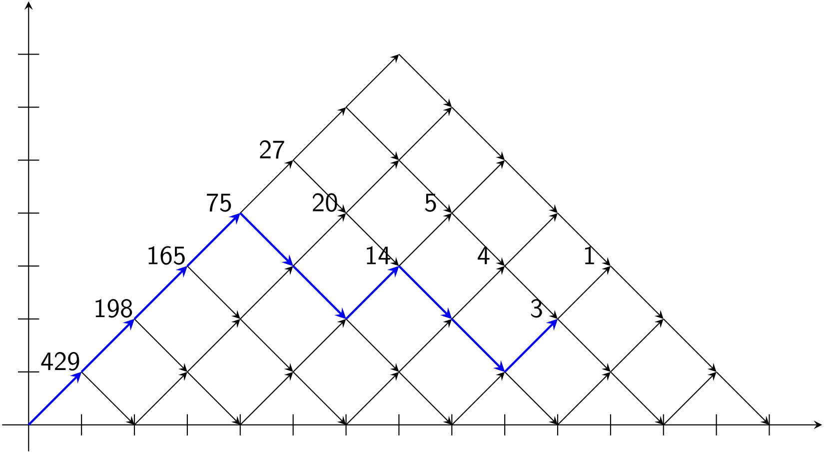

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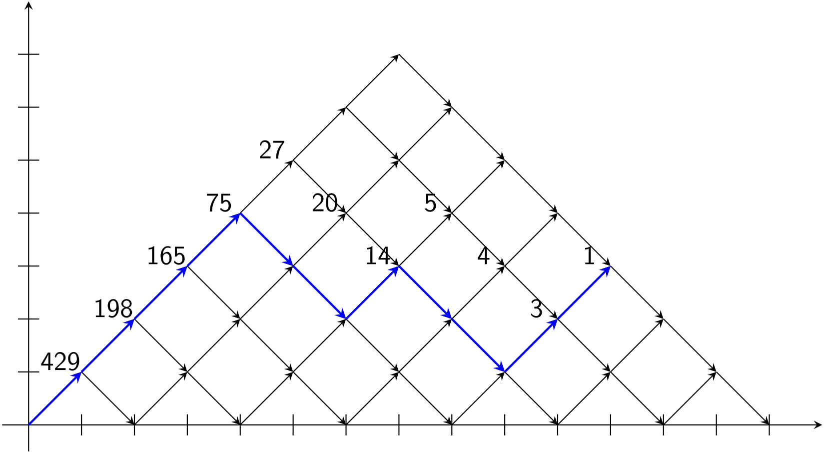

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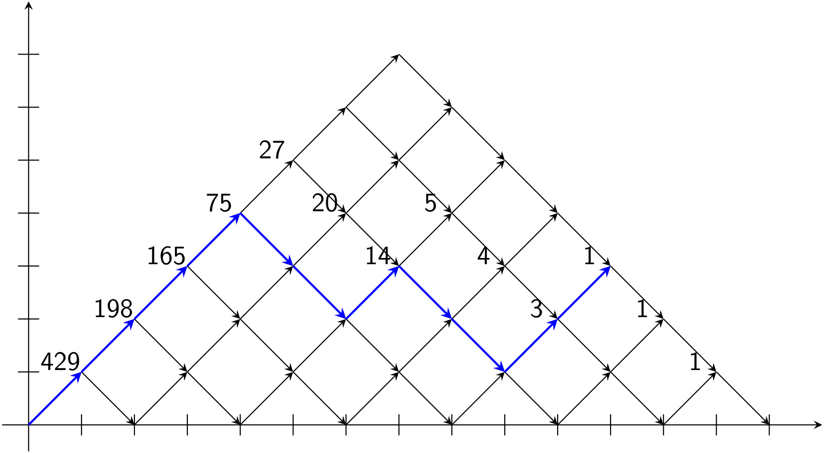

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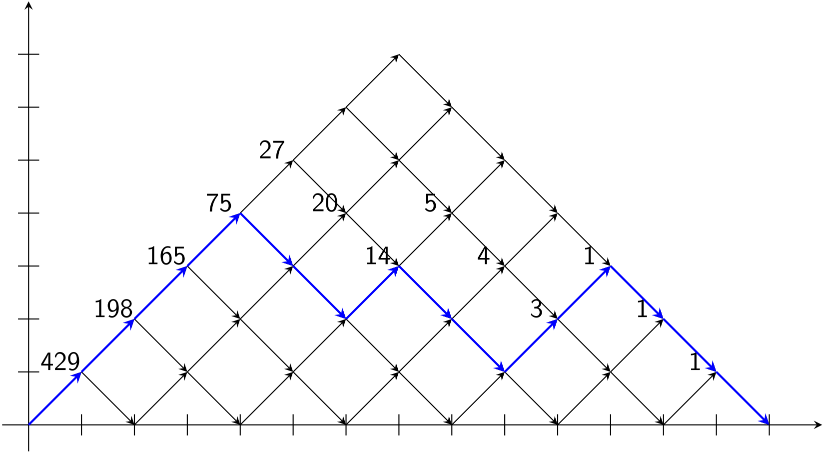

Info

- Exercises due: 9 AM, December 8, 2014