(Data) STRUCTURES

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Static, 2D: O(lglg n) [Alstrup, Brodal, Rauhe FOCS'00]

Dynamic, 2D: Ω(lg n / lglg n) [Alstrup,Husfeldt, Rauhe FOCS'98]

SELECT * FROM employees WHERE salary <= 70000 startdate <= 1998</pre> AND 71000 70000 69000 68000

Static, 2D: O(lglg n) [Alstrup, Brodal, Rauhe FOCS'00]

Dynamic, 2D: Ω(lg n / lglg n) [Alstrup,Husfeldt, Rauhe FOCS'98]



```
Marked Ancestor: * mark(v) / unmark(v)
 * query(v): ∃? marked ancestor
Dyn. 1D Stabbing: * insert/delete segment
 * query(x): does x stab a
segment?
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Dyn. 2D Range Reporting

Static, 2D: O(lglg n) [Alstrup, Brodal, Rauhe FOCS'00]

Dynamic, 2D: Ω(lg n / lglg n) [Alstrup,Husfeldt, Rauhe FOCS'98]

Static 3D \approx Dynamic 2D?

Persistence

Persistent : { static data struct. } \mapsto { dynamic data struct. }

Given problem \mathbb{P} with update_P(x), query_P(y) *Persistent*(\mathbb{P}) = the problem "preprocess (x₁, x₂, ..., x_N) to answer: query(y, t): answer query_P(y) after update_P(x₁), ..., update_P(x_t)"

Persistent(incremental 2D range reporting) = static 3D range reporting

Static, 2D: O(lglg n) [Alstrup, Brodal, Rauhe FOCS'00]

Dynamic, 2D: Ω(lg n / lglg n) [Alstrup,Husfeldt, Rauhe FOCS'98]

Static 3D = Persistent(Dynamic 2D)

But: *Persistent*(Marked Ancestor) has O(1) solution...

[Nekrich SoCG'07] static 3D in O(lg²lg n)...

How Could 4D be Hard?

Fully-persistent data structures:



FullyPersistent(Marked Ancestor)

≤ Static 2D Stabbing

≤ Static 4D Reporting

FullyPersistent (Marked Ancestor)





FullyPersistent (Marked Ancestor)







FullyPersistent (Marked Ancestor)





"reachability oracles"



Lopsided Set Disjointness

Review: Communication Complexity



set S

set T

"is $S \cap T = \emptyset$?"

LSD Lower Bounds



Say Alice sends εS·lg B bits

- \Rightarrow in average block, Alice's value is uncertain in a set of $B^{1-\epsilon'}$
- ⇒ Bob must identify his elements in uncertainty sets, sending $\Omega(S \cdot B^{1-\epsilon'})$ bits

LSD → Reachability Oracles



LSD → Reachability Oracles



 $T = \{X\} = deleted edges$

LSD → Reachability Oracles



T = {**X**} = deleted edges S = { ∕ } = one out-edge / node

