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Immutable Data Structures

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Immutable Data Structures

- why, how, structural sharing
- Linked list (F# list)
- Tree (F# Set, Map)
- tuples, records, classes

Immutable Data Structures

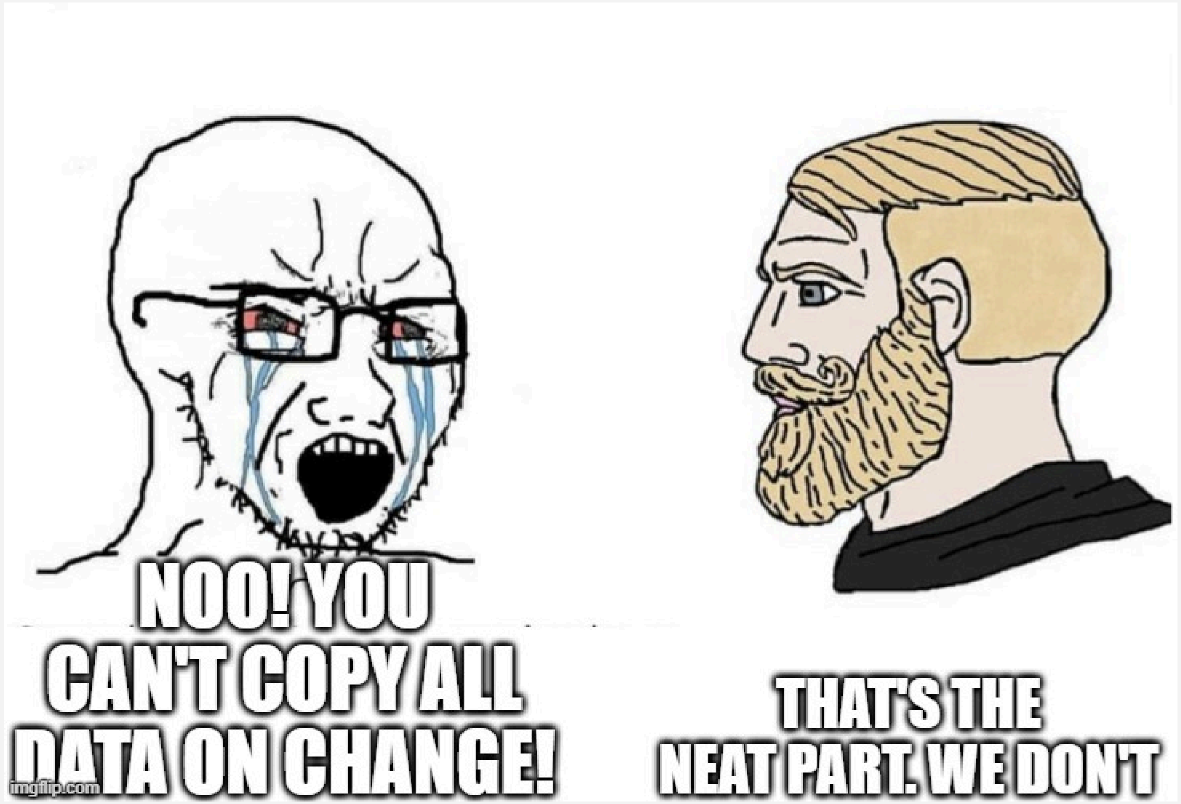
Definition

- no part of object can be changed after it’s created

Why?

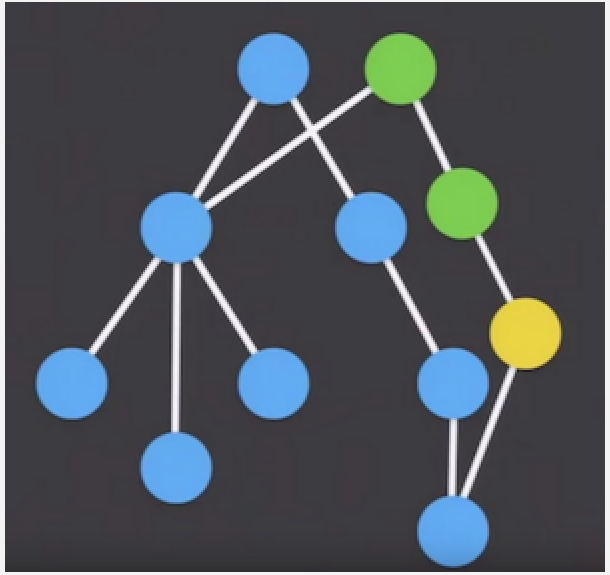
- mutation is common source of bugs
- immutable data structures are easier to reason about
  - value passed to a function, can’t be changed
- immutable data structures are thread-safe
- bonus: memory efficient time traveling

MYTH: to create new immutable value, you need to copy the whole thing


NOO! YOU CAN'T COPY ALL DATA ON CHANGE!
THAT'S THE NEAT PART. WE DON'T
imgflip.com

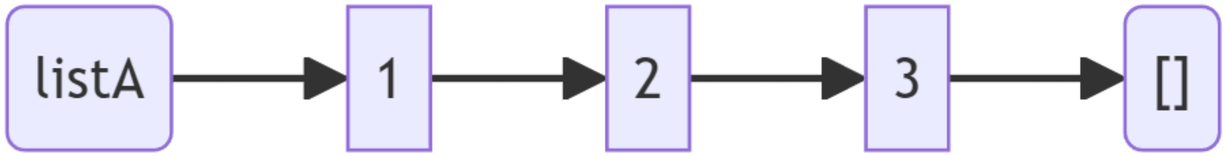
How?

- we can share parts of the structure between old and new value
- **Structural sharing**



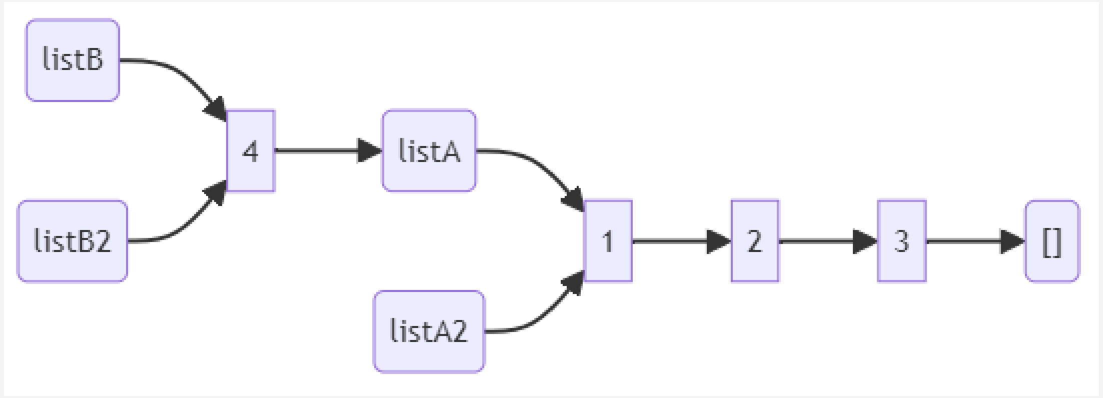
(Linked) list

```fsharp
let listA = [1; 2; 3]
let listA = 1 :: 2 :: 3 :: []
```

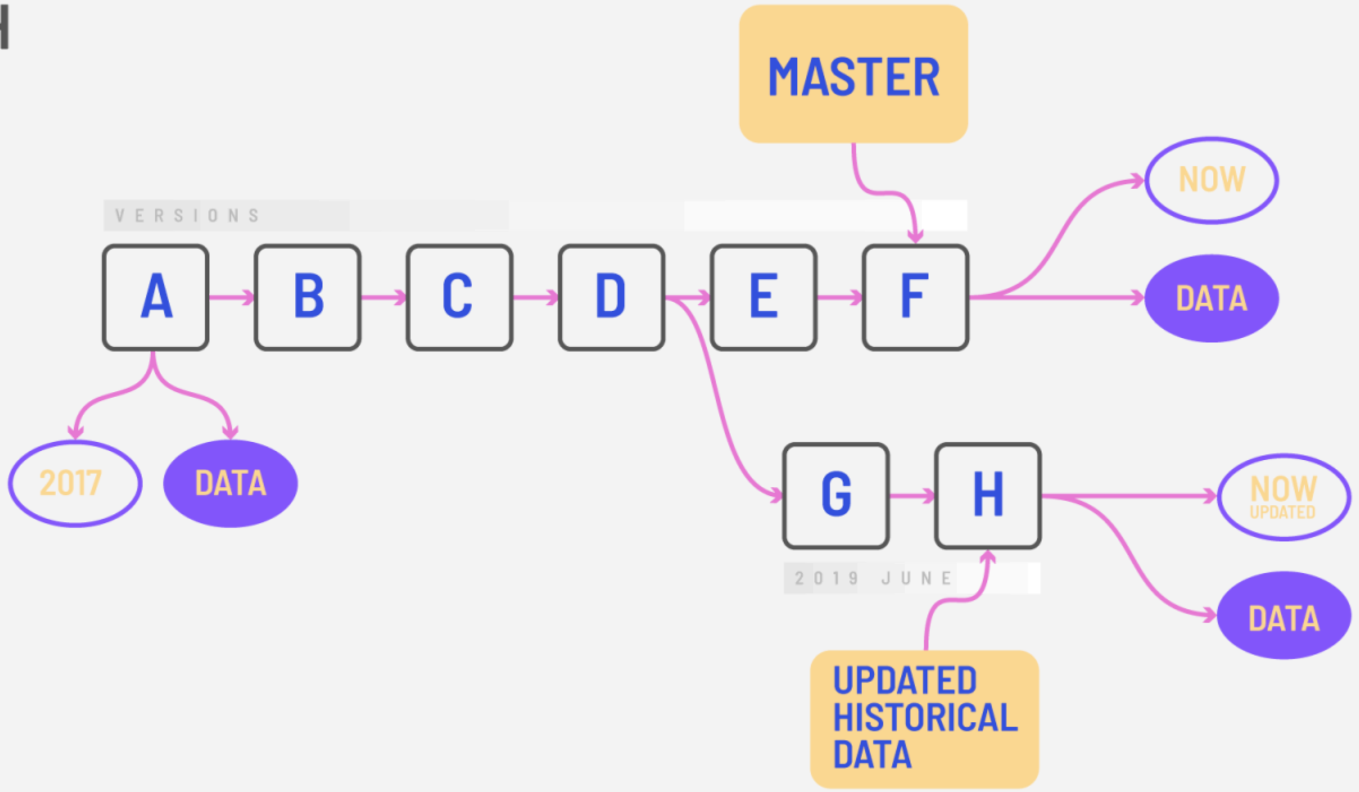


(Linked) list sharing

```
let listA = [1; 2; 3]
let listA = 1 :: 2 :: 3 :: []
let listA2 = listA
let listB = 4 :: listA
let listB2 = [4] @ listA
```



COMMIT GRAPH



List Benchmark

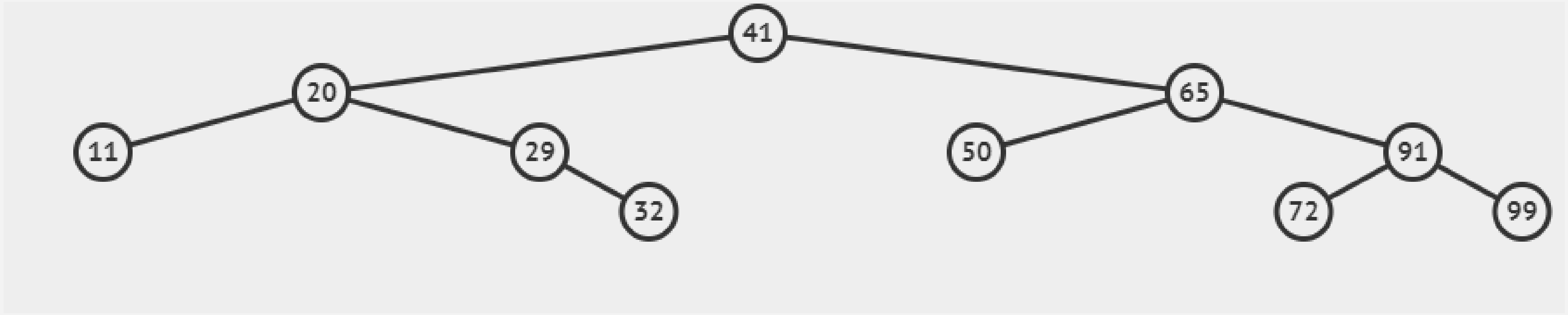
TODO

Set

Unordered set of values

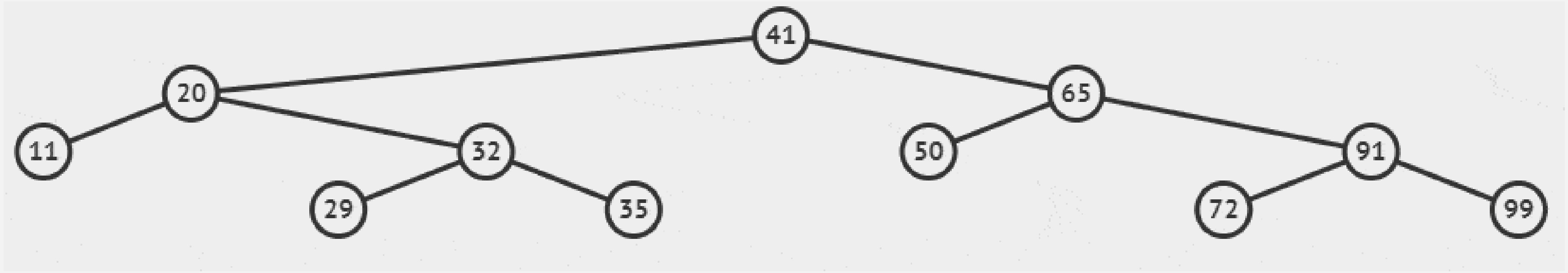
Typically implemented as a (balanced) tree

```
let s = [11; 20; 29; 32; 41; 50; 65; 72; 91; 99] |> set
```



Insert = search + add

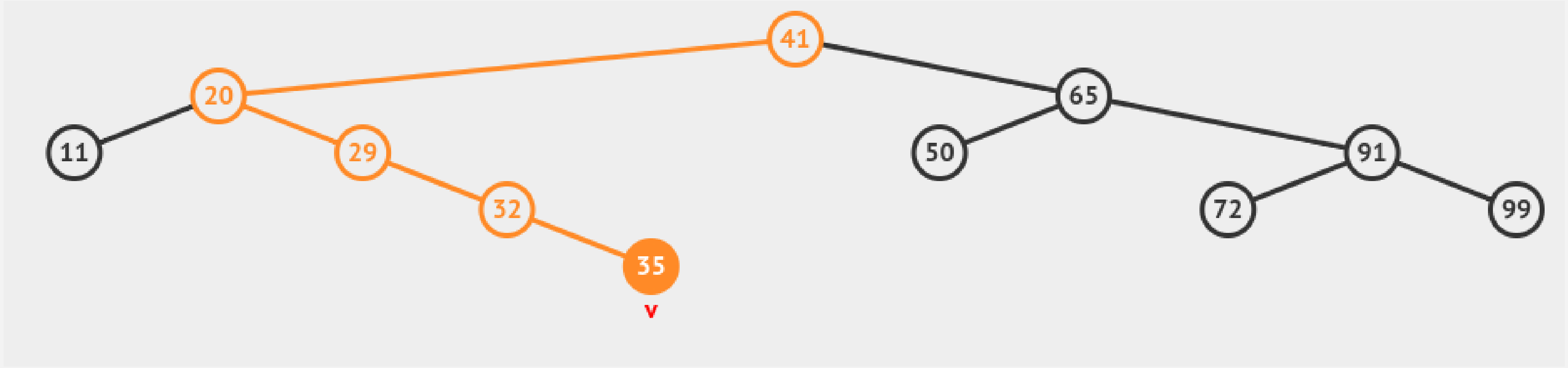
```
let s2 = s |> Set.add 35
```



from https://visualgo.net/en/bst

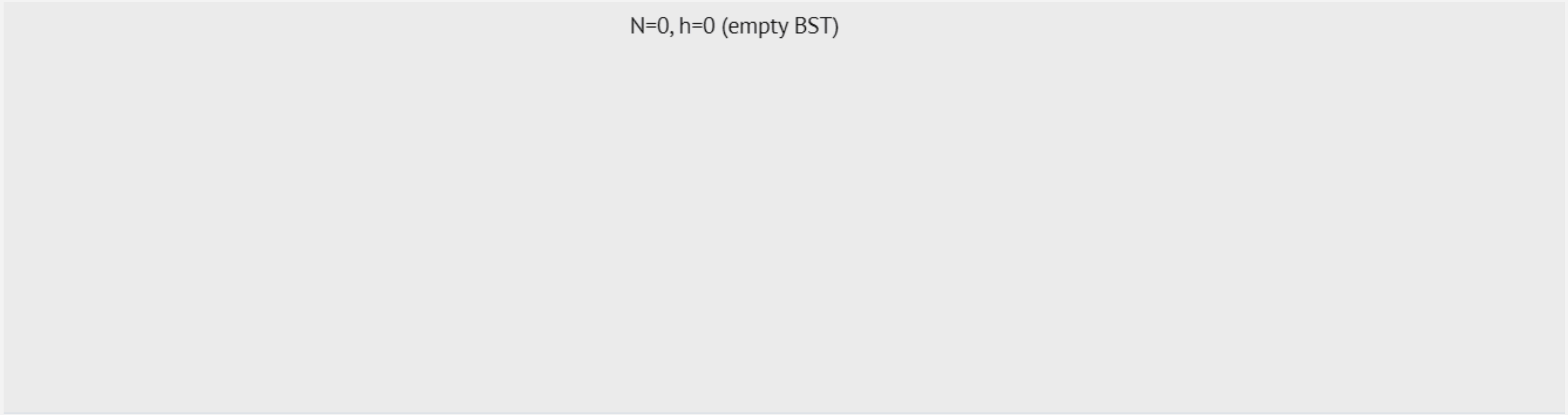
Insert-structural sharing

```
let s2 = s |> Set.add 35
```



Building new Set

```fsharp
let s = [1; 7; 3; 9; 5; 6; 2; 8; 4] |> set
```



from https://visualgo.net/en/bst

Set Benchmark

TODO

Map

- Dictionary like immutable data structure
- Like `Set`, but with value linked with each key (node)

TODO image

Map sharing

```
let mapA = Map.ofList [1, "A"; 2, "B"; 3, "C"]
let mapB = Map.ofList [1, "A"; 2, "B"; 3, "C"; 4, "D"]
let mapB2 = Map.add 4 "D" mapA
mapB = mapB2 // true
```

Map Benchmark

TODO

Records

```
{ Id: int; Name: string }
```

- Immutable by default
- No special immutable structure
- Update syntax create new record with not-changed fields shared with old record
  - `{ oldRecord with Name = "Bob" }`
  - only reference is copied (except for *structs*)

TODO image?

Structural comparison in .NET

- definition of equality based on values, not references
- all F# data types have defined structural comparison and ordering
- only few C# (compound) types have defined structural comparison and ordering
  - Tuples, Records, Array, ImmutableArray
- Immutability and structural comparison are different features, but it is common that immutable data structures have defined structural comparison
  - same value with different references are more common when working with immutable data structures

Questions?

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Thank you!

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