Возможности ускорения GiST: патчи, хаки, твики

GiST speedup: patches, hacks and tweaks

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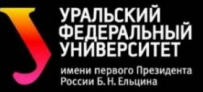


Multidimensional access methods

Windows search

select *
from table
where table.point
is inside some region

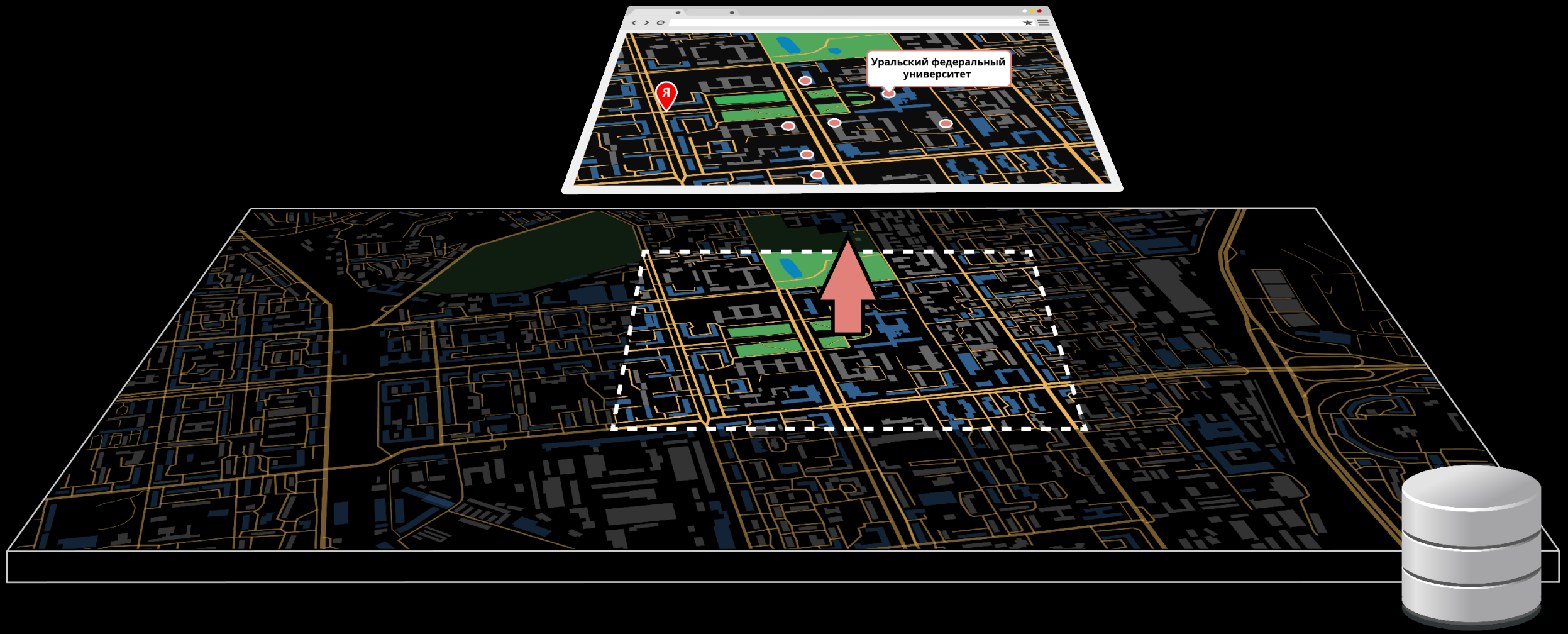
Aggregation

select aggregate(column)
from table
where table.point
is inside some region

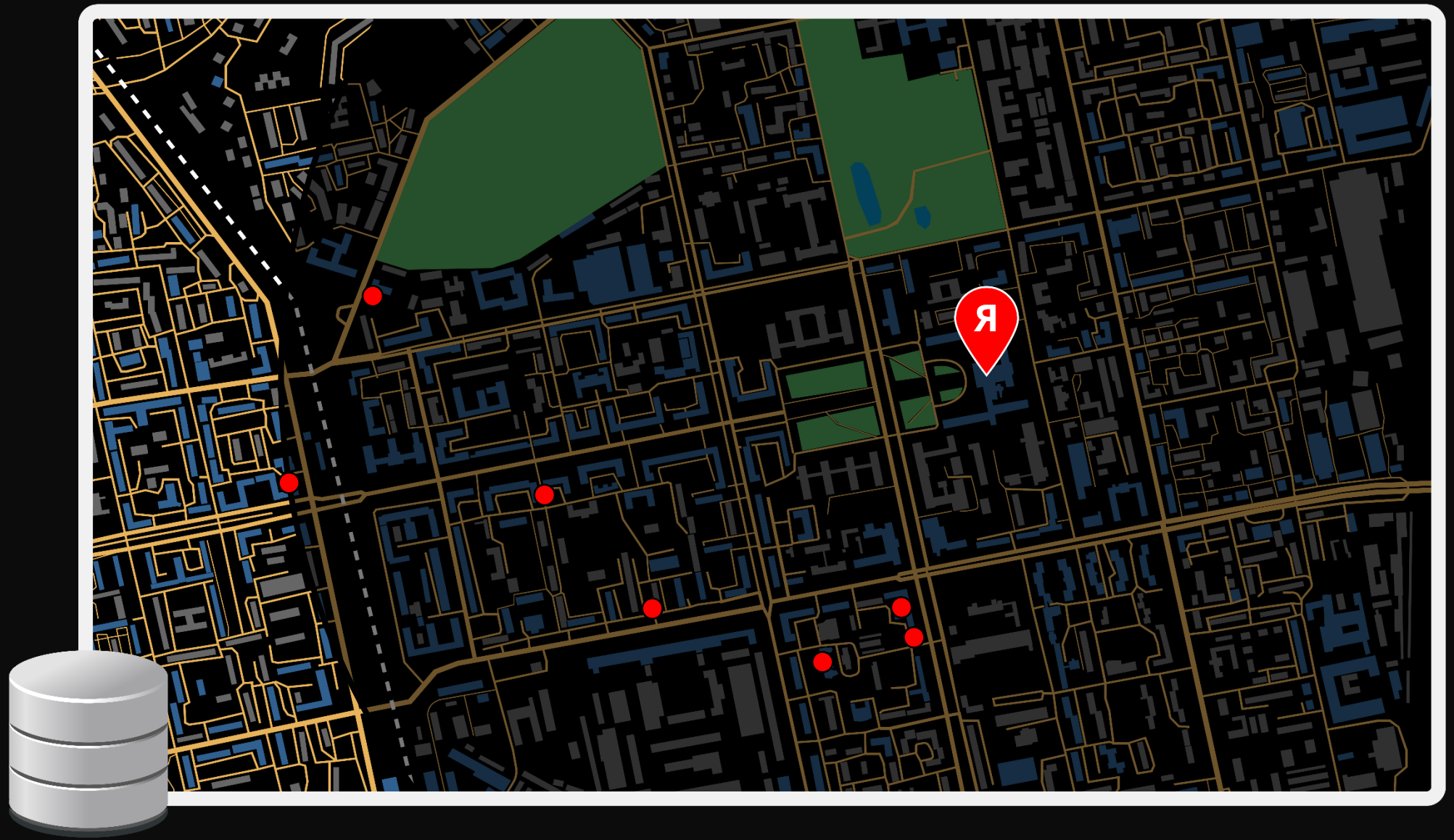
kNN (k Nearest Newburgh)

select *
from table
order by distance from some point
limit N

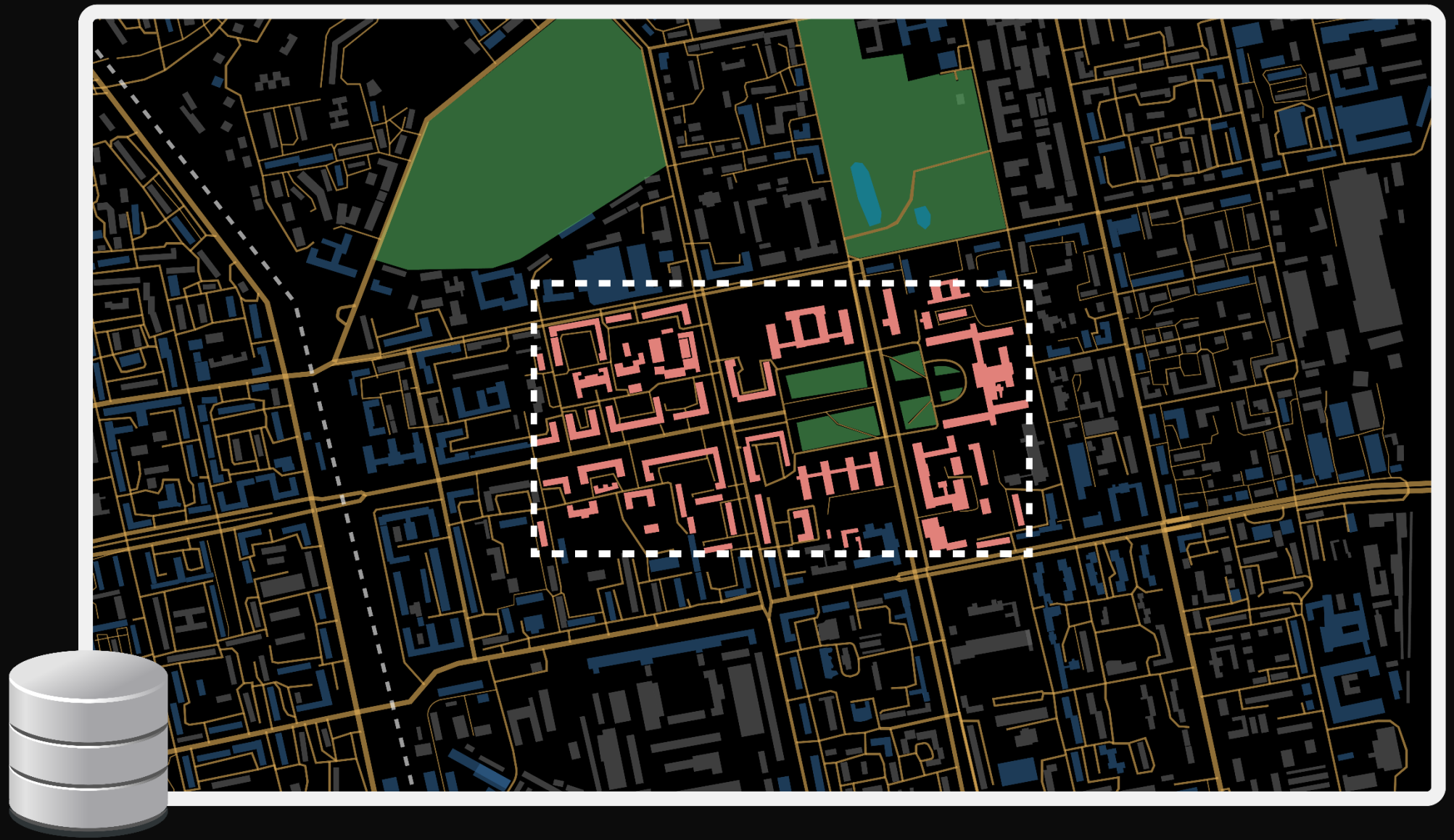
Windows search



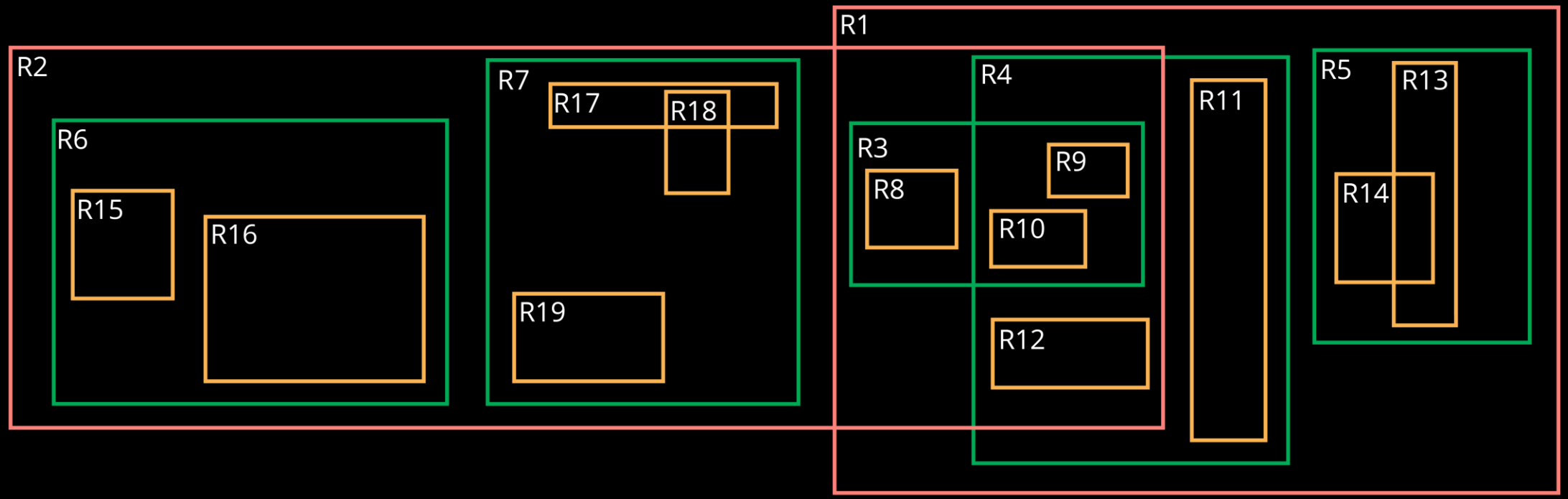
kNN search



Aggregate Query (OLAP)



R-tree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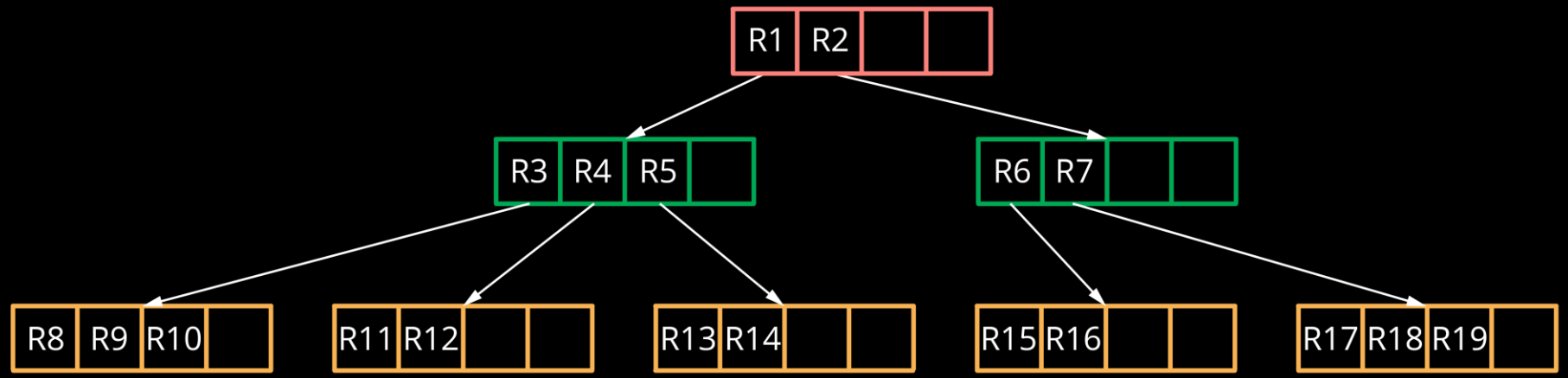
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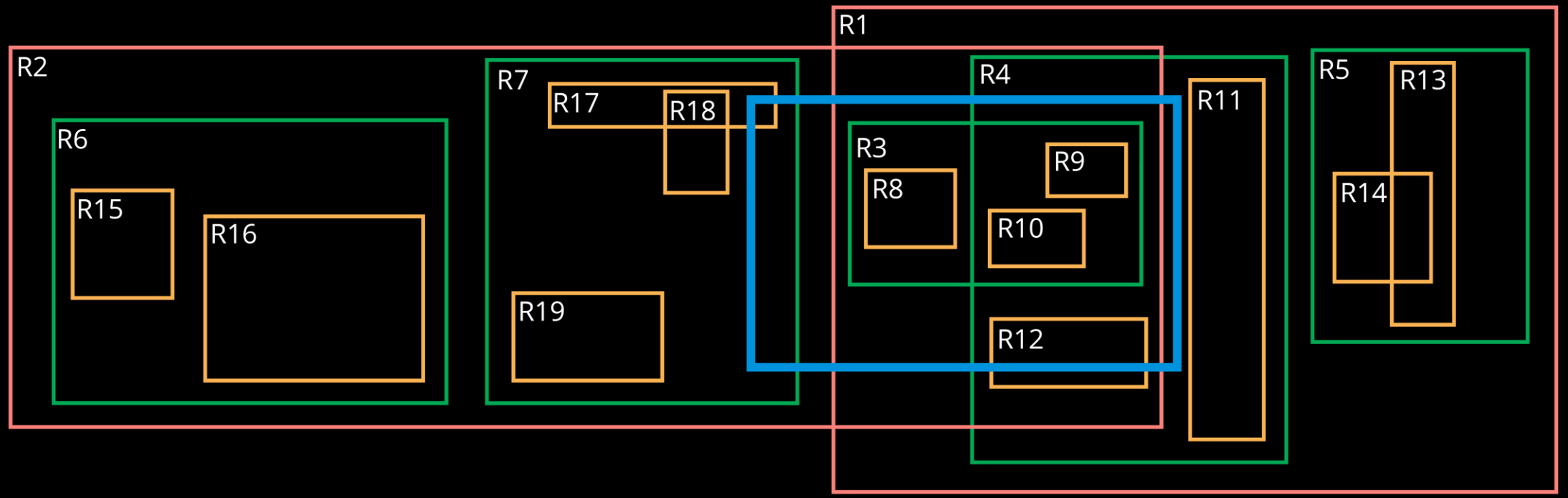
R17 R18 R19

R-tree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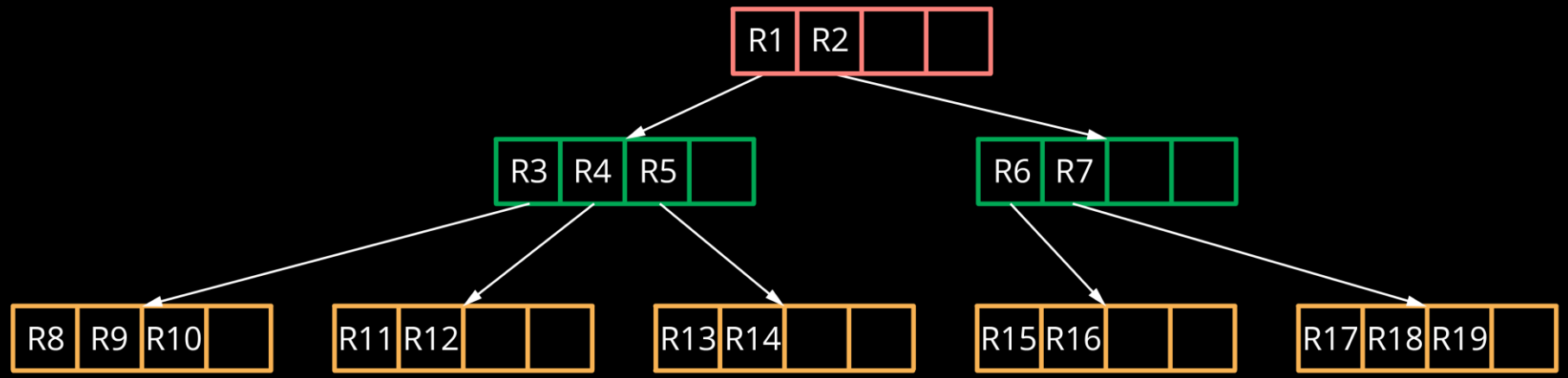
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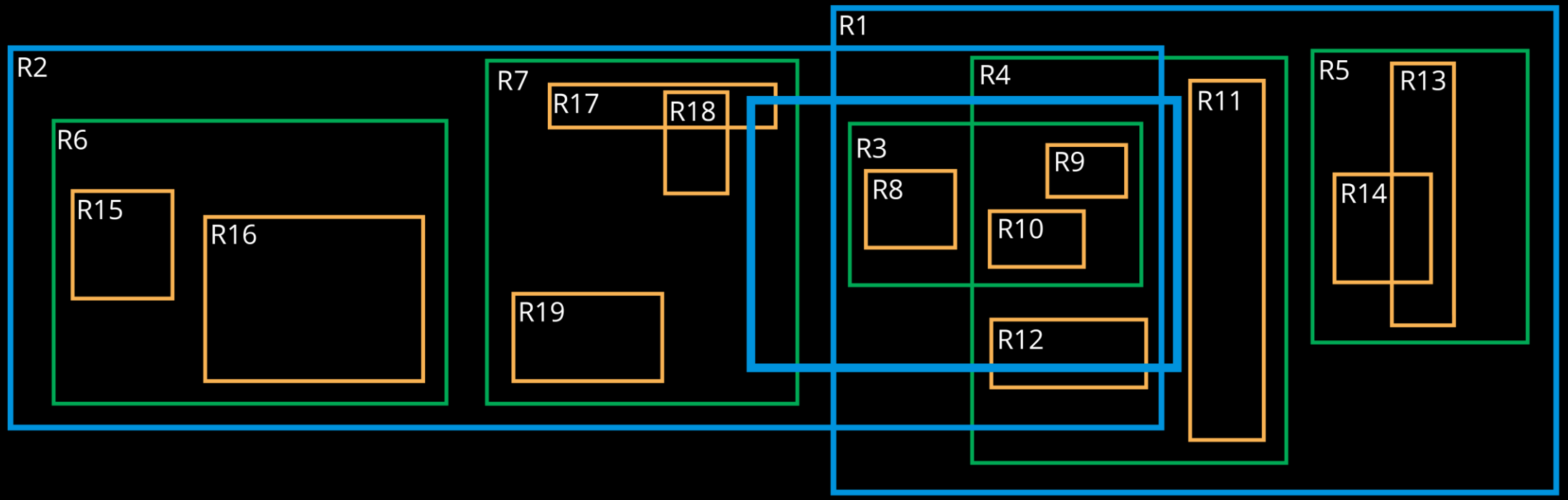
R-tree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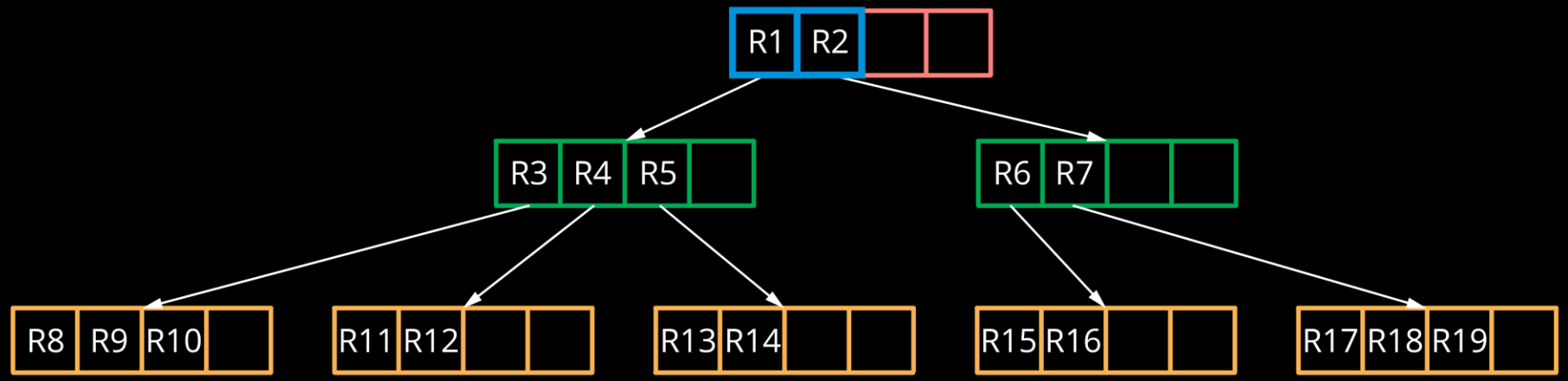
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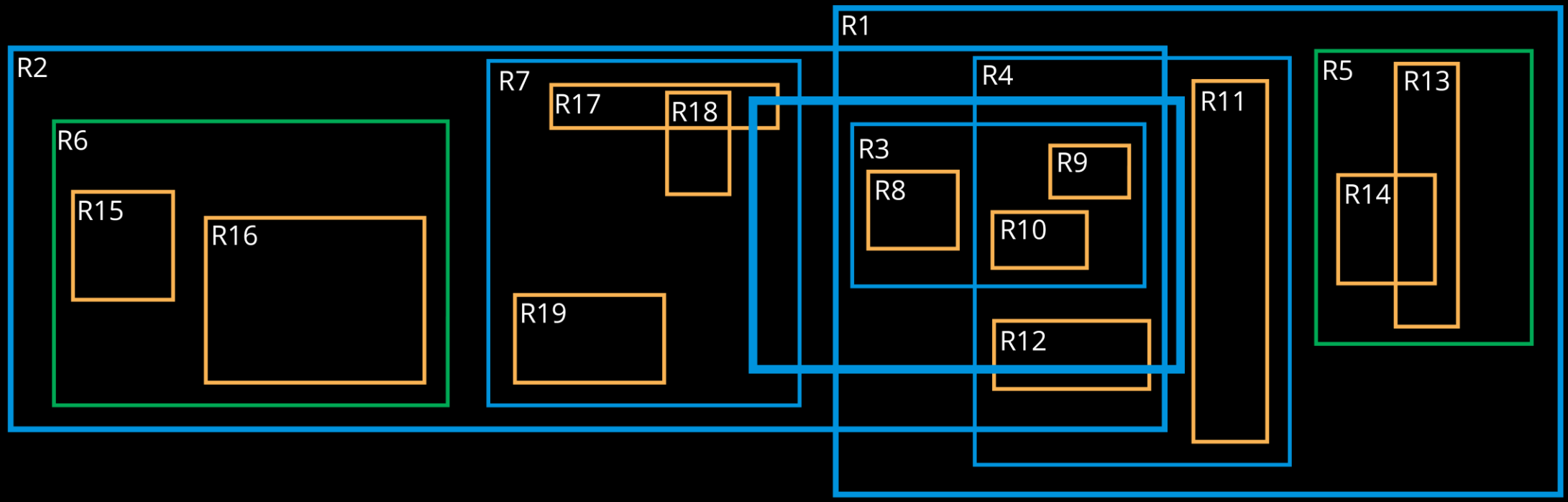
R-tree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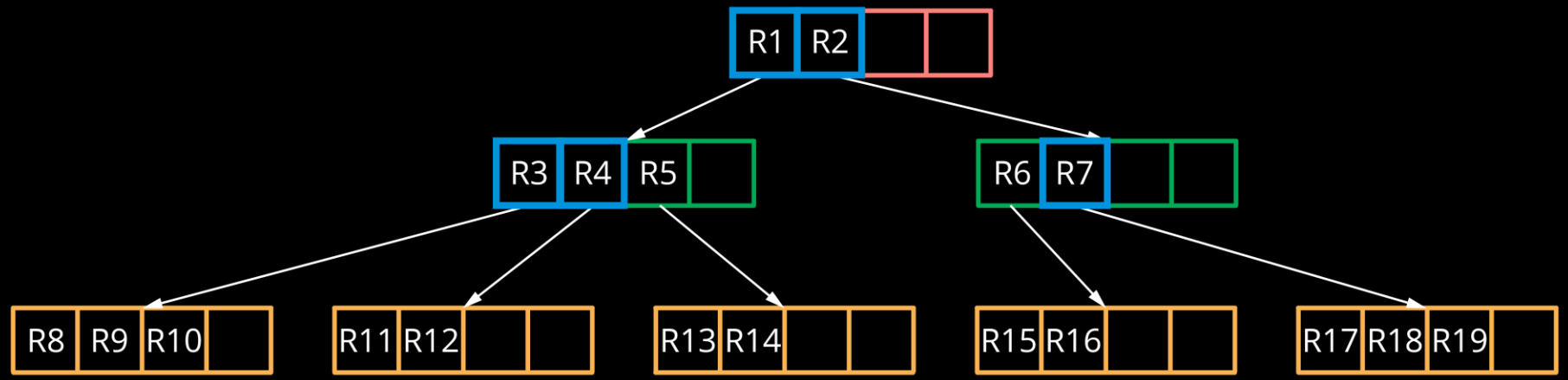
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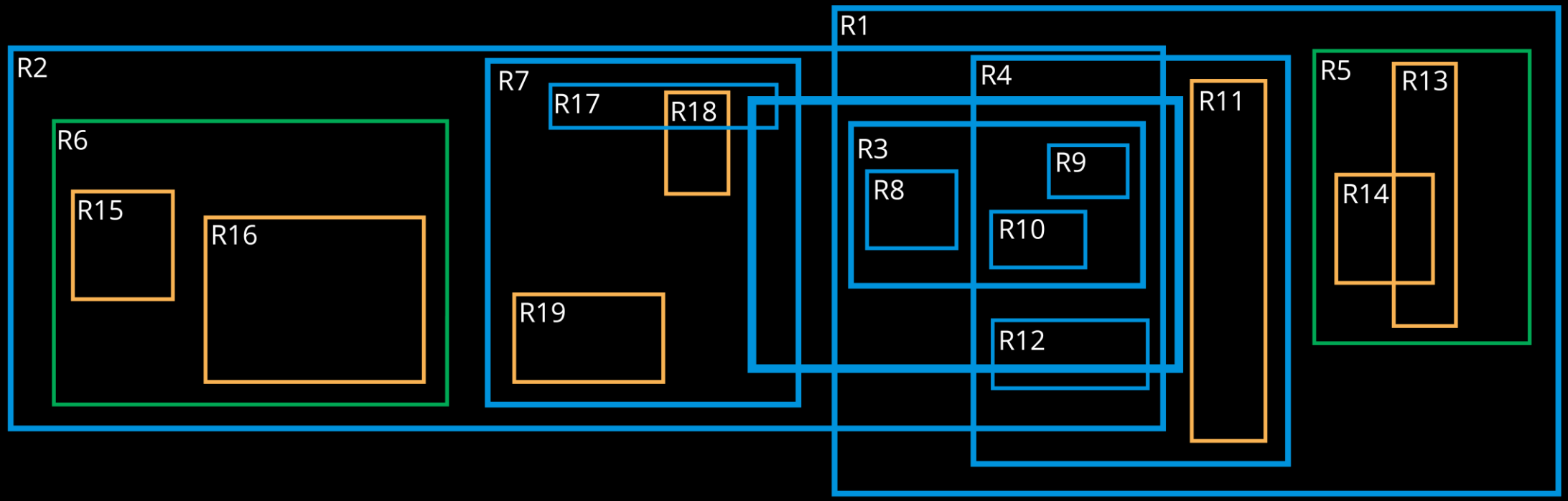
R-tree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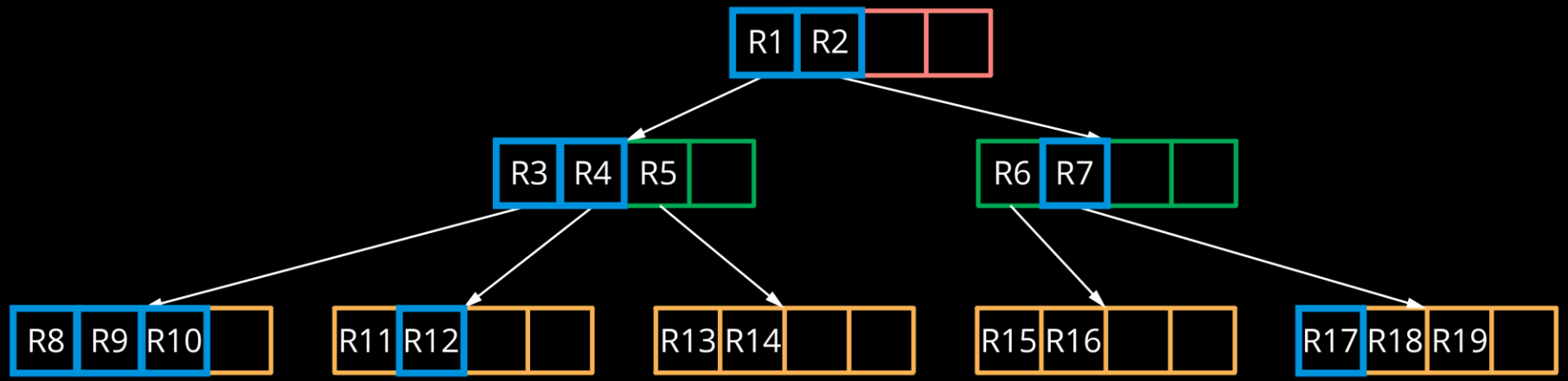
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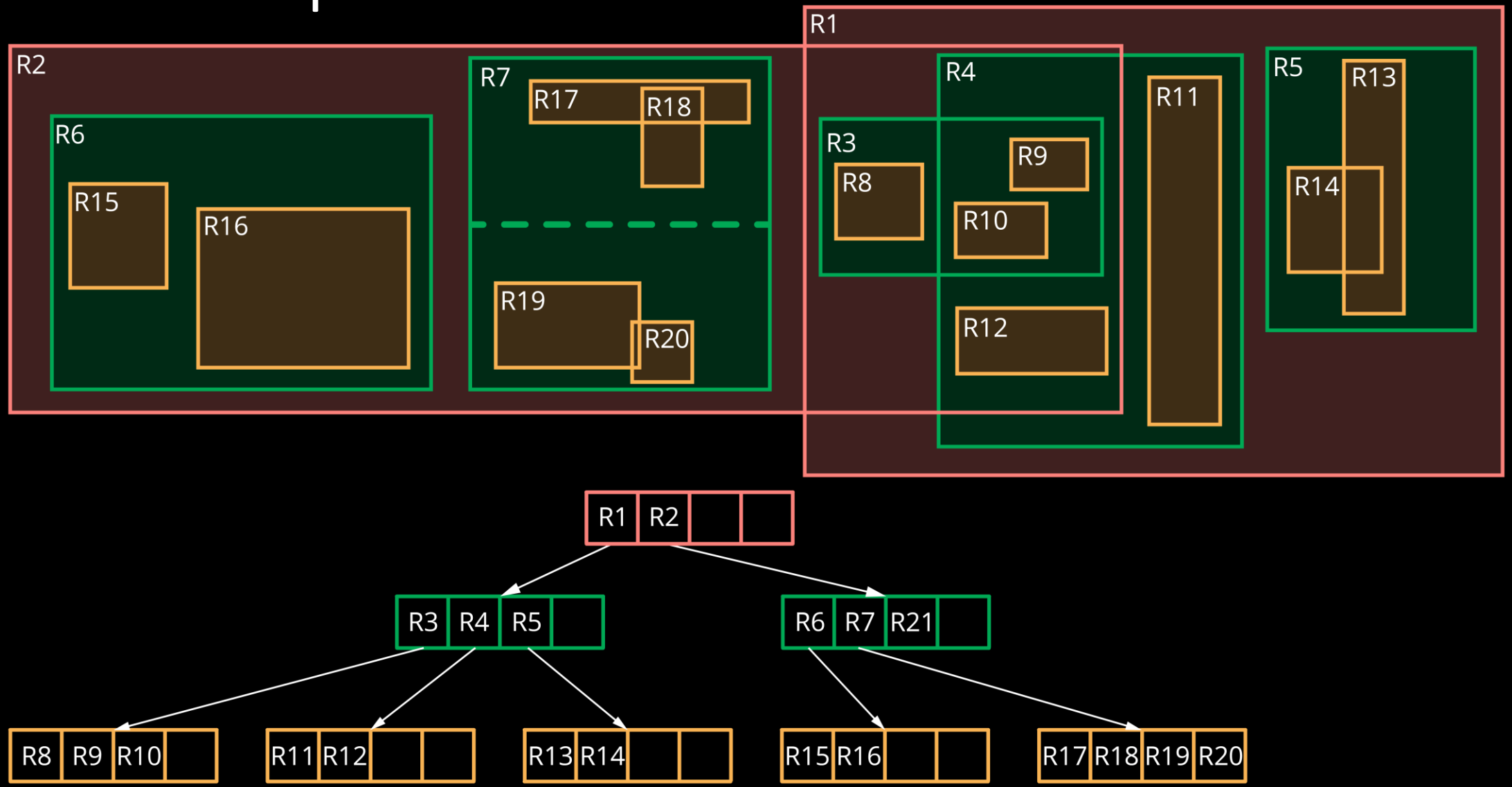
R-tree: split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R13
R14
R1 R2
R3 R4 R5
R6 R7 R21
R8 R9 R10
R11 R12
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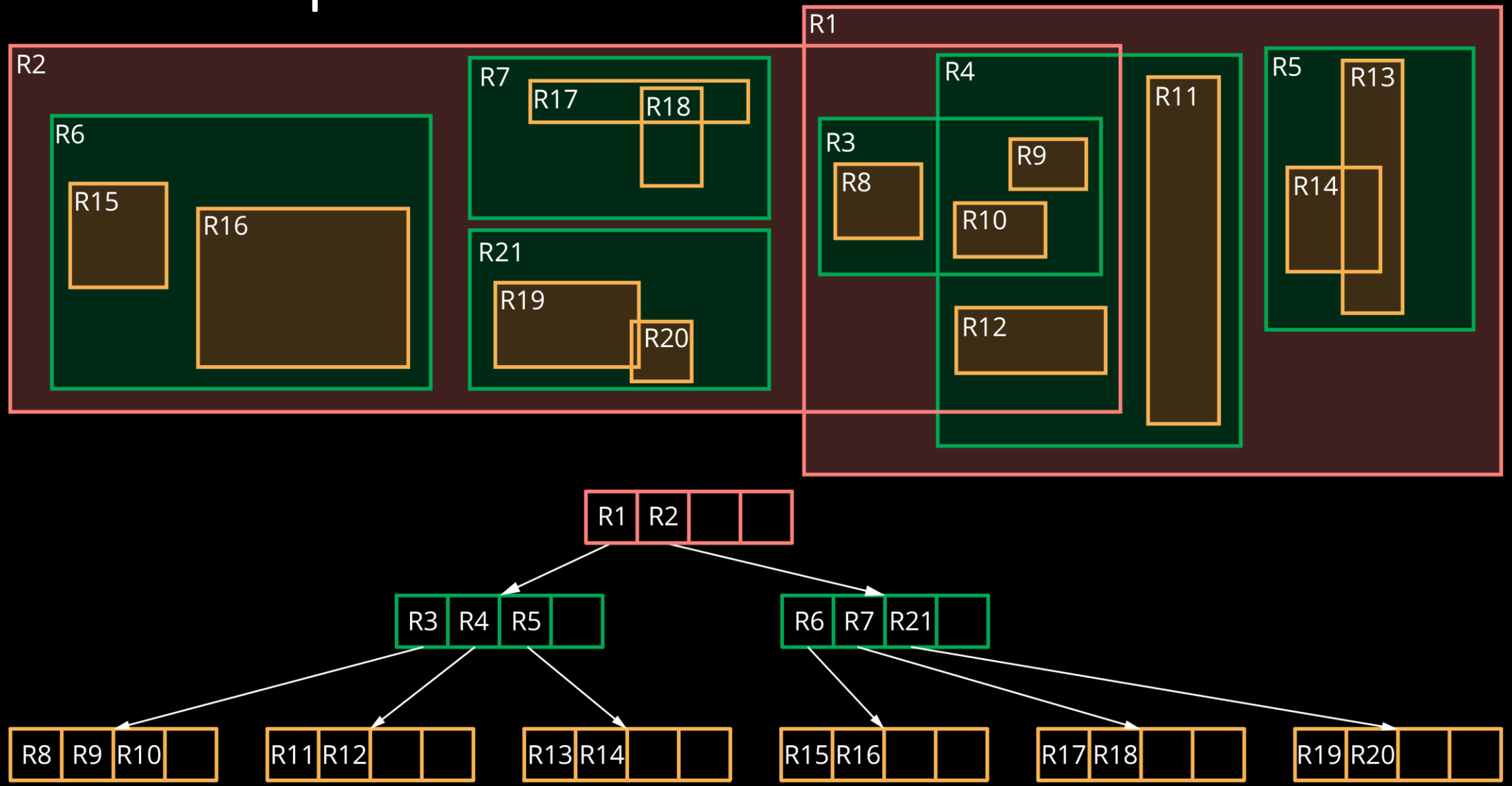
R15 R16
R17 R18 R19 R20

R-tree: split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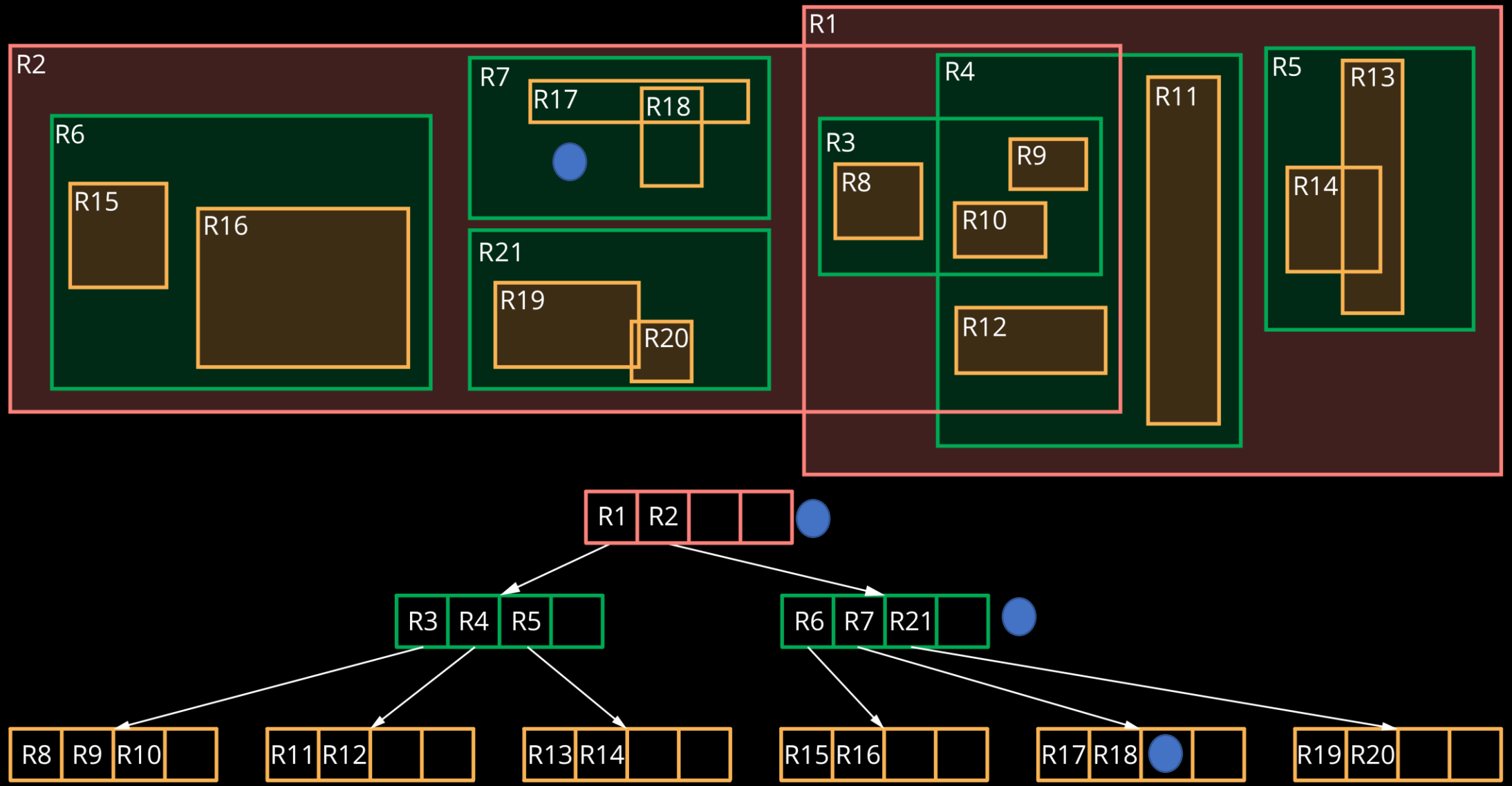
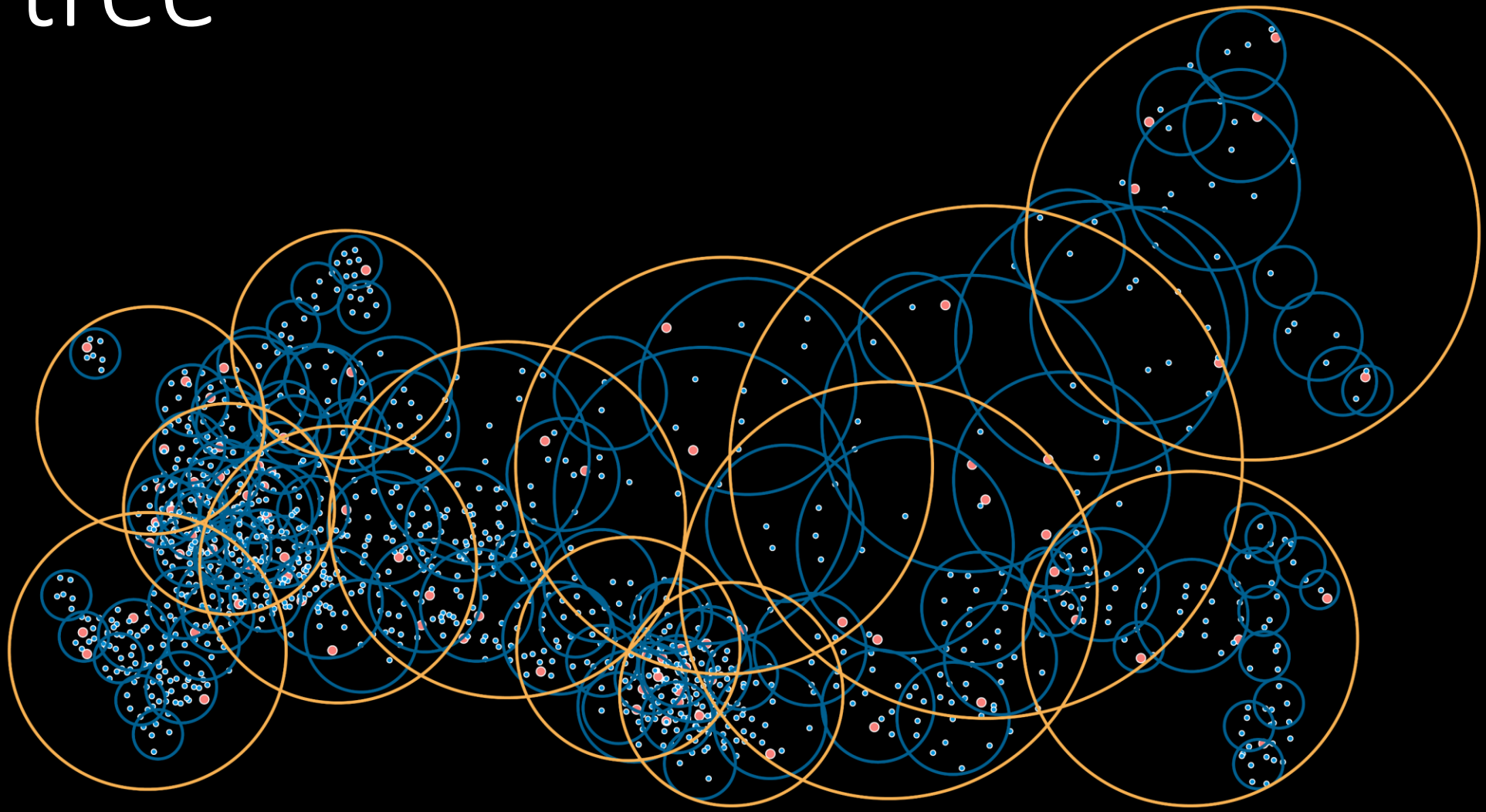
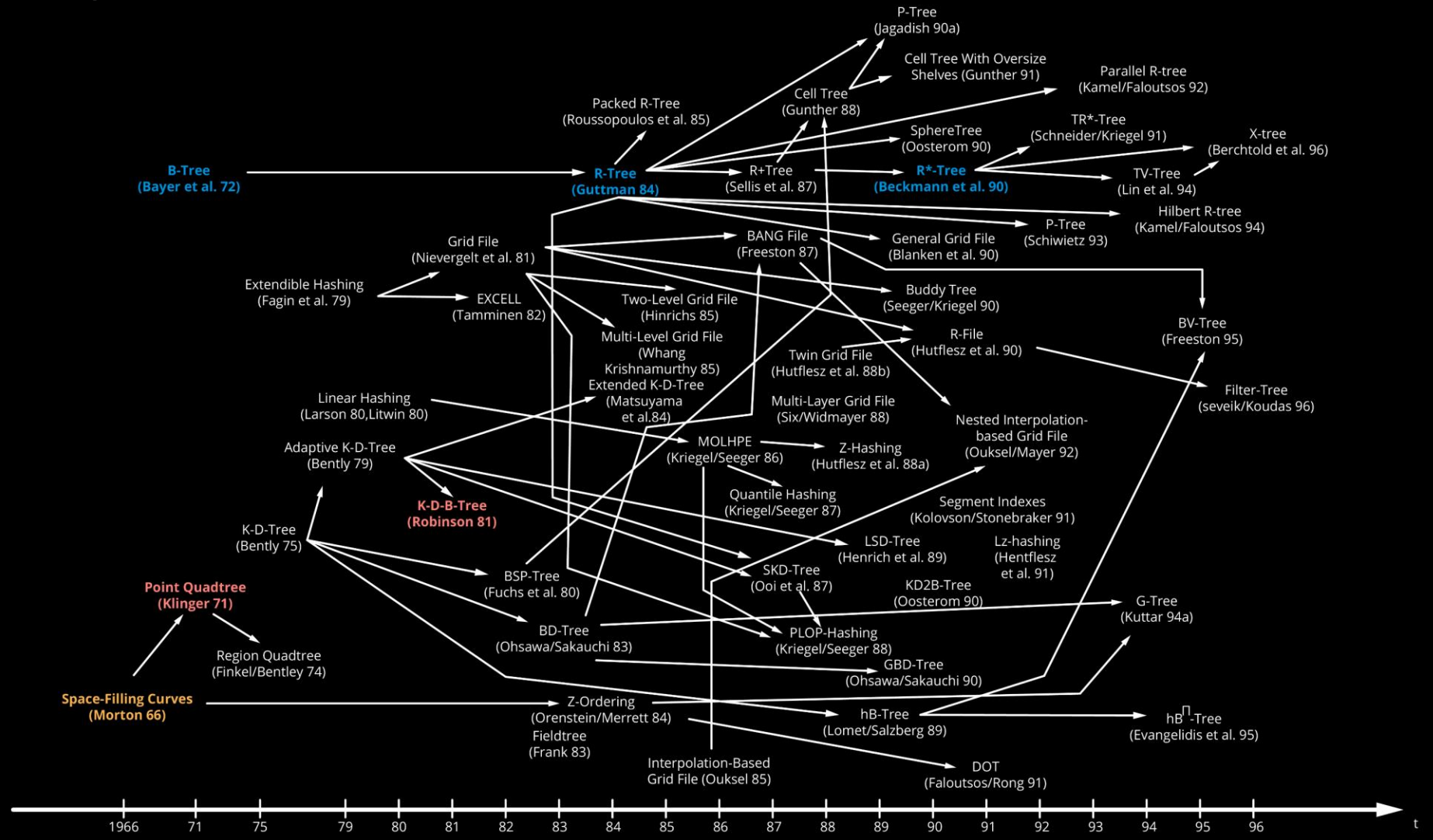
R-tree: choose subtree



M-tree

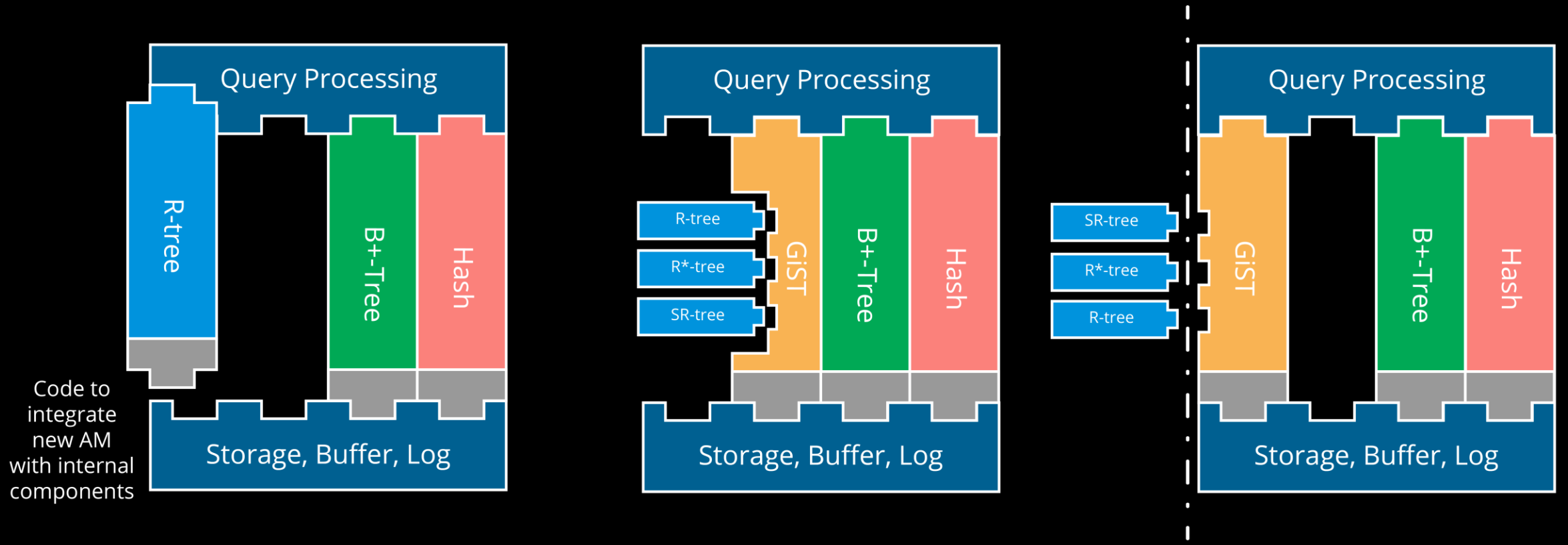


History of multidimensional access methods

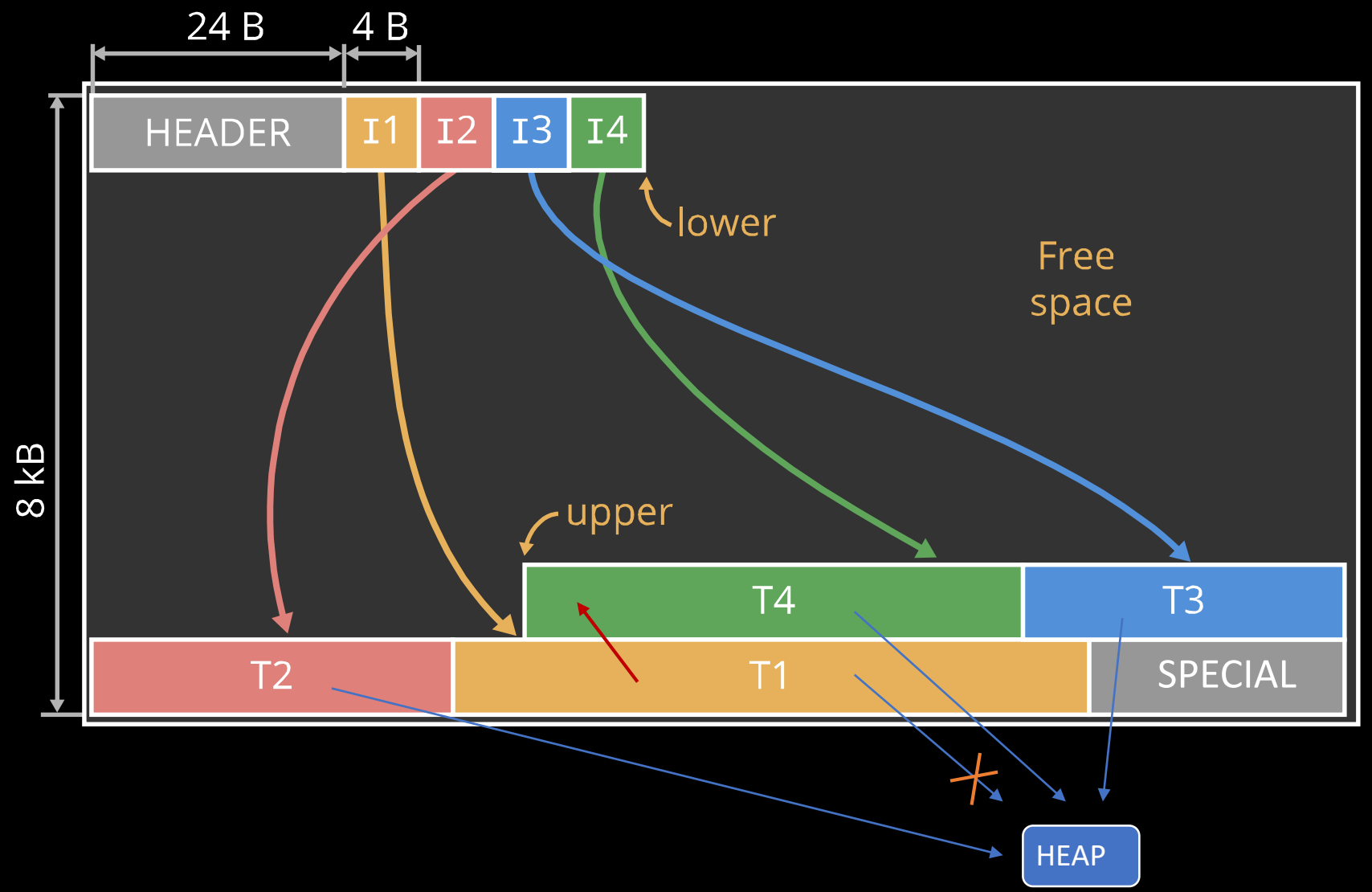


Based on work of O. Gunther and V. Gaede

Generalized index search trees



Intra-page indexing: skiptuple approach



Theoretically optimal fan-out

In a tree with fan-out *f* query returning exactly 1 row has to touch every tuple in a node, but in optimal tree path from root to leaf will take exactly 1 page on each level, so key-compares count *K* is equal to tree height *h* multiplied by *f*.

$$K = f \cdot h = [f \cdot \log_f N],$$

which is optimal with $f \rightarrow e \approx 3$.

Without loss of generality this holds for cache lines count instead of key compares.

As we saw above this does not work for *f = 2.* Probably, due to differences of constraints (experiment involved more than one row returned by aggregate query)

Performance improvement estimation
(rough upper bound)

- On a page with $n \approx 243$ entries optimal regrouping for $f = 3$ will construct intra-page tree with 4 levels.
- One-row-query traversal will take 15 key compares instead of 243
- Overall tree height will be 57% higher due to reduced 1.5 times page capacity
- One-row-query performance will be better 243/15/1.57 = 10 times

- But in practice I only could gain 10%, as for now.

Tuples were reordered with updates

- Before update

- After update of T3

IndexTupleOverwrite patch

- https://commitfest.postgresql.org/10/661/
- Test:

```
insert into dataTable(c)
    select cube(array[x/100,y/100,z/100])
      from generate_series(1,1e2,1) x,
           generate_series(1,1e2,1) y,
           generate_series(1,1e2,1) z;
```

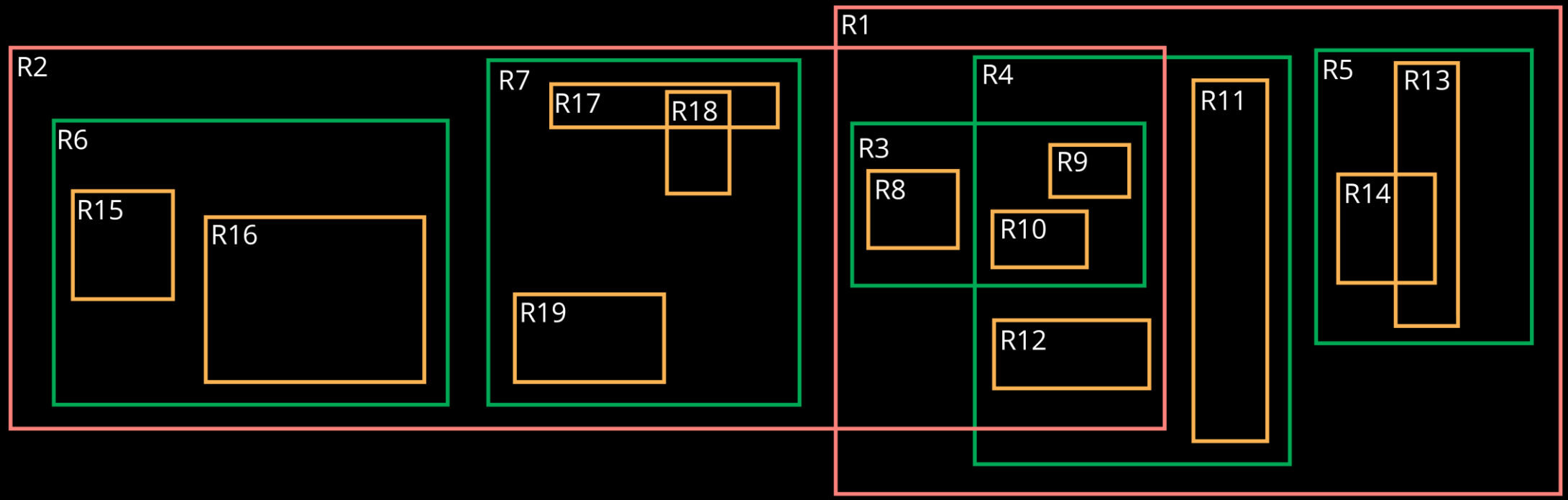
- Results: up to 2 times faster, 3 times smaller index

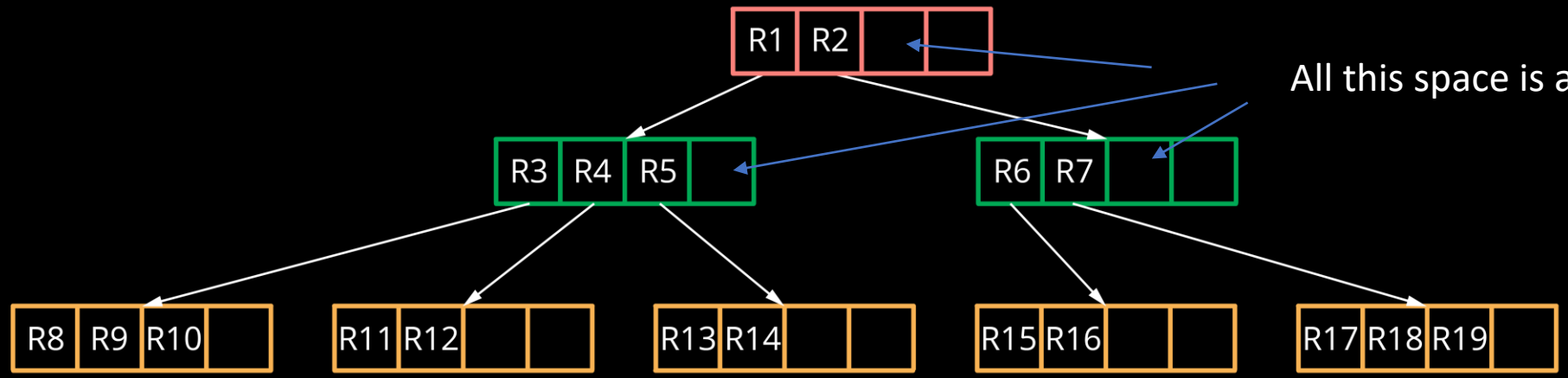
Only on ordered data!

Randomized data insertions speed improvement is around 10%-15%

Randomized data insertions already was on this speeds, it is ordered data that was slow

Fractal tree for GiST





All this space is a buffer!

Fractal tree for GiST

On 1 million of insertions classic GiST is 8% faster

On 3M performance is equal

On 30M lazy GiST if 12% faster

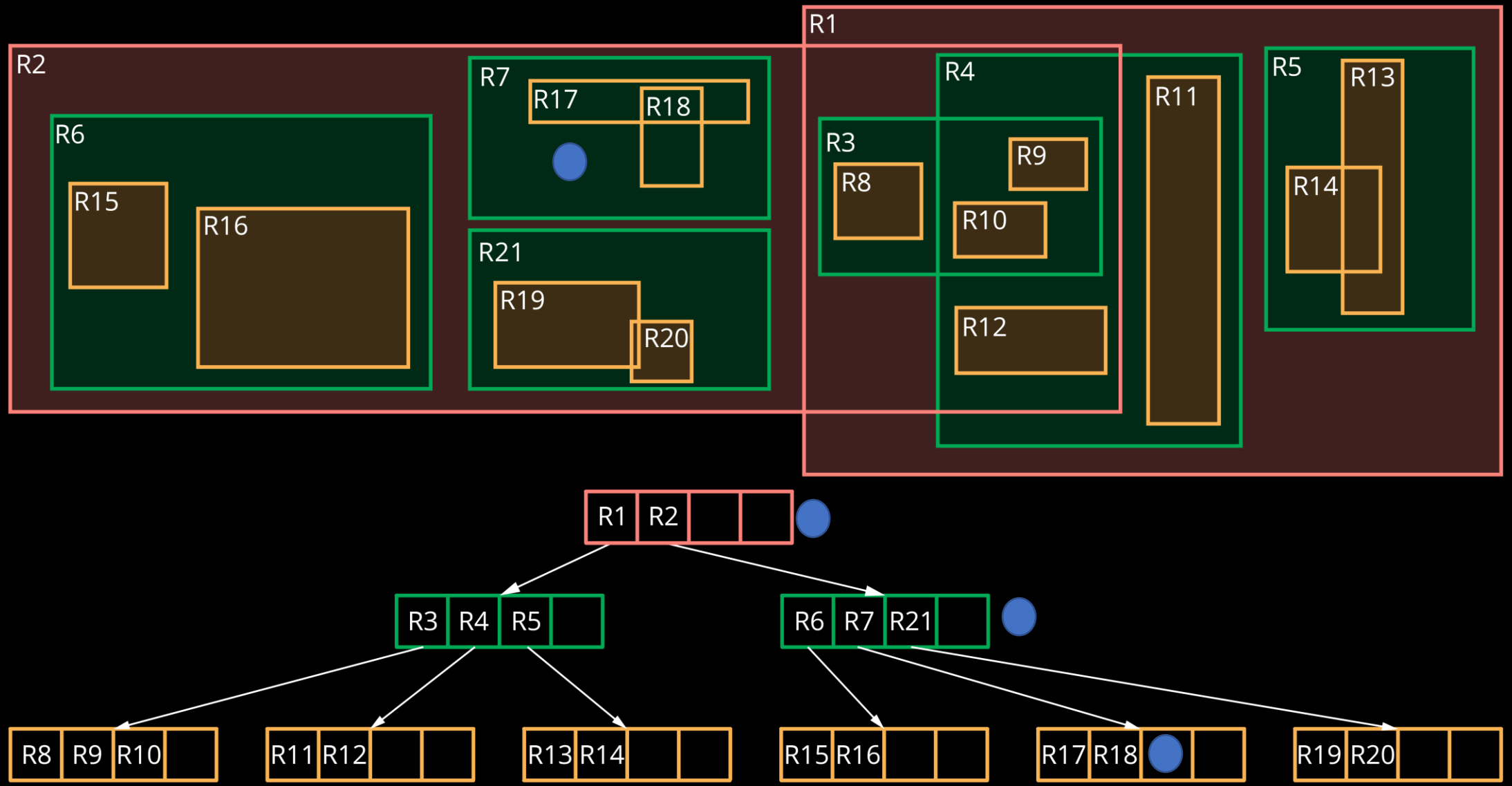
On my machine with SSD disks,

With HDDs IO is more important and number may change in favor of fractal tree

More details and patch:

https://www.postgresql.org/message-id/CAJEAwVE_8VDTV1Utfe1CmbVRCvVPtvHZnSKFdMf0rB5mELSLeA%40mail.gmail.com

R-tree: choose subtree



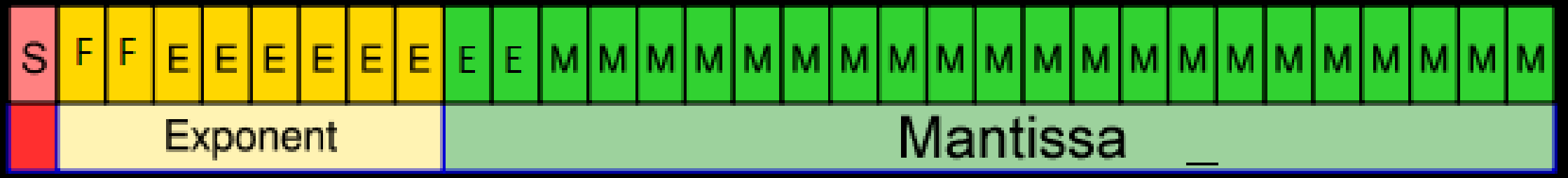
Current penalty function from *cube* extension

```
/*
** The GiST Penalty method for boxes
** As in the R-tree paper, we use change in area as our penalty metric
*/
Datum
g_cube_penalty(PG_FUNCTION_ARGS)
{
        GISTENTRY  *origentry = (GISTENTRY *) PG_GETARG_POINTER(0);
        GISTENTRY  *newentry = (GISTENTRY *) PG_GETARG_POINTER(1);
        float      *result = (float *) PG_GETARG_POINTER(2);
        NDBOX      *ud;
        double          tmp1,
                        tmp2;

        ud = cube_union_v0(DatumGetNDBOX(origentry->key),
                                        DatumGetNDBOX(newentry->key));
        rt_cube_size(ud, &tmp1);
        rt_cube_size(DatumGetNDBOX(origentry->key), &tmp2);
        *result = (float) (tmp1 - tmp2);

        PG_RETURN_FLOAT8(*result);
}
```

Realms

```
/* REALM 0: No extension is required, volume is zero, return edge       */
/* REALM 1: No extension is required, return nonzero volume             */
/* REALM 2: Volume extension is zero, return nonzero edge extension     */
/* REALM 3: Volume extension is nonzero, return it                      */
```

2 flag bits inside IEEE 754 float



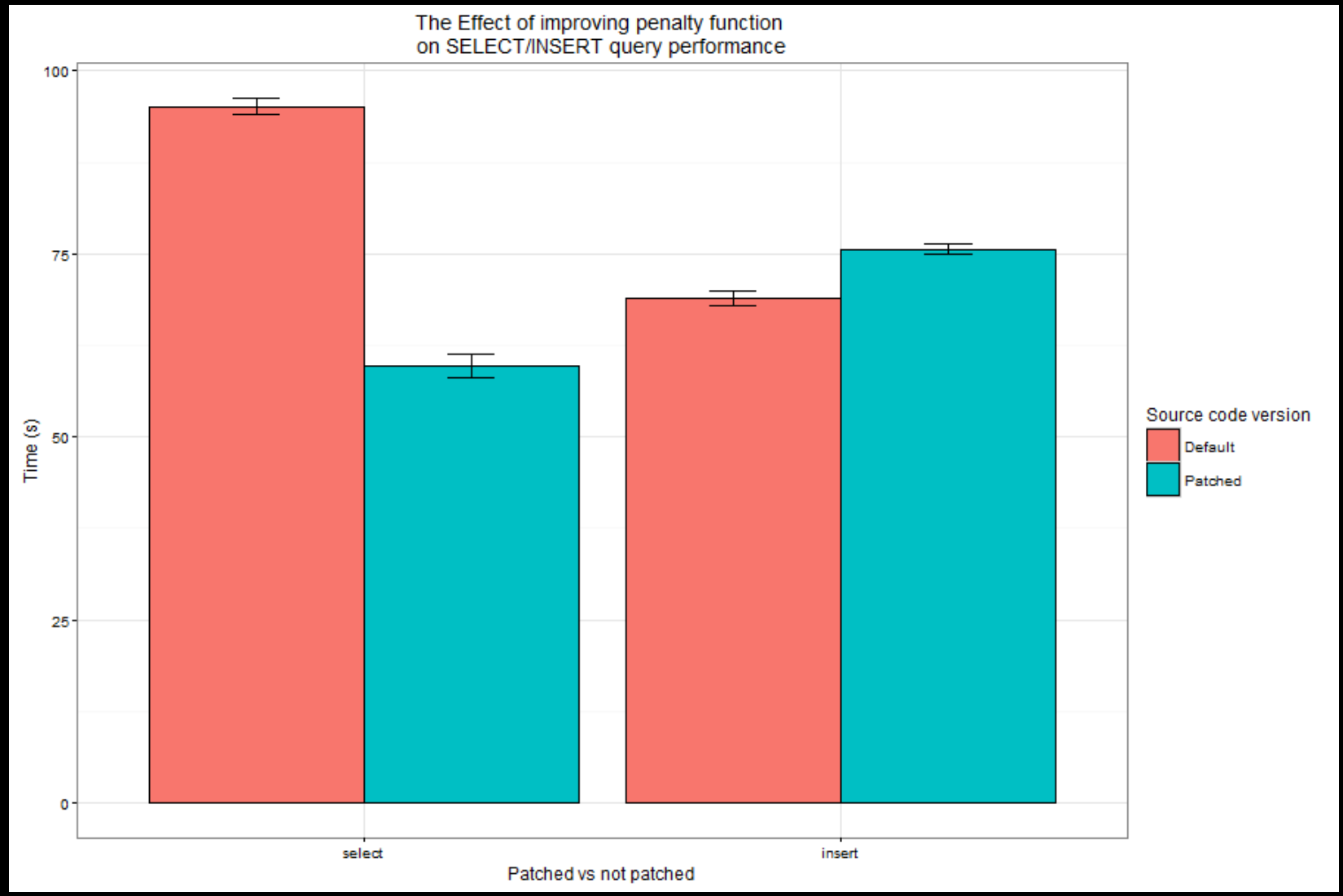
M

M

Packing float: code

```
typedef union { float fp; int i; } U;
float pack_float(const float v, const int r) {
  const U a = { .fp = v };
  const U b = { .i = (a.i >> 2) + r * (INT32_MAX / 4) };
  return b.fp;
}
```

Benchmarking



Cube extension GiST penalty function improvement

- https://commitfest.postgresql.org/10/782/

“Returned with feedback”

Revised R*-tree

- Split algorithm (with small deviations):

https://github.com/x4m/pggistopt/blob/rrsplit_pack/contrib/cube/cube.c#L539

Up to 50% faster small SELECTs for cube extension

- Choose subtree algorithm:

Currently impossible in GiST API

As Norbert Beckman, author of RR*-tree, put it in the discussion: “Overlap optimization is one of the main elements, if not the main query performance tuning element of the RR*-tree. You would fall back to old R-Tree times if that would be left off.”

GiST API: collision check function

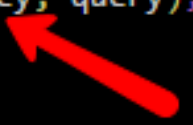
- Collision check currently returns a binary result:

1. Query may be collides with subtree MBR
2. Query do not collides with subtree

- This result may be augmented with a third state: subtree is totally within the query. In this case, GiST scan can scan down subtree without key checks.

GiST API: collision check function

```
bool
g_cube_internal_consistent(NDBOX *key,
                                                NDBOX *query,
                                                StrategyNumber strategy)

{
        bool            retval;

        /*
         * fprintf(stderr, "internal_consistent, %d\n", strategy);
         */
        switch (strategy)
        {
                case RTOverlapStrategyNumber:
                        retval = (bool) cube_overlap_v0(key, query);
                        break;
                case RTSameStrategyNumber:
                case RTContainsStrategyNumber:
                case RTOldContainsStrategyNumber:
                        retval = (bool) cube_contains_v0(key, query);
                        break;
                case RTContainedByStrategyNumber:
                case RTOldContainedByStrategyNumber:
                        retval = (bool) cube_overlap_v0(key, query);
                        break;
                default:
                        retval = FALSE;
        }
        return (retval);
}
```



GiST API advancement

1. Allow choose subtree not via penalty calculation
2. Extend consistency API

GiST API advancement

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Any students here?

GiST API advancement

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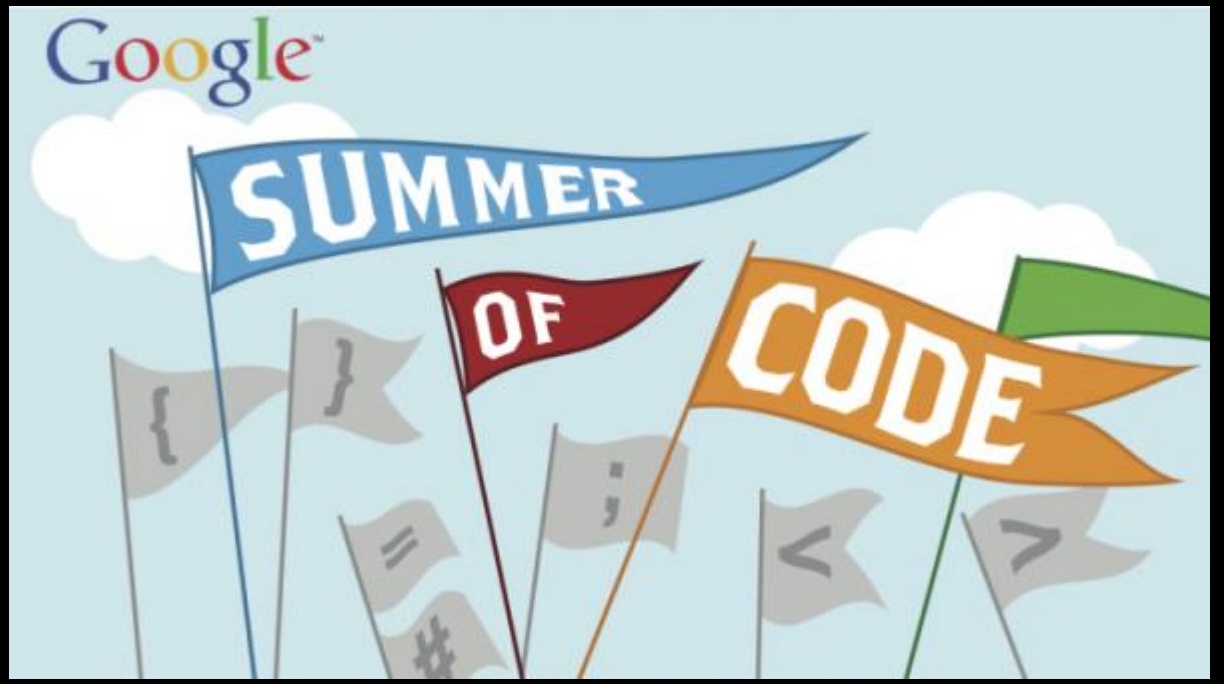
GSoC 2017 applications are open!



Read more on
https://wiki.postgresql.org/wiki/GSoC_2017#GiST_API_advancement

Questions?

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