Accelerating Local Search With PostgreSQL 9.1

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Local Search?

- Not necessarily location based on places
- “How close are two entities to one another?”
- “What are the closest entities to me?”
- “What are my nearest neighbors?”

Nearest Neighbor Overview

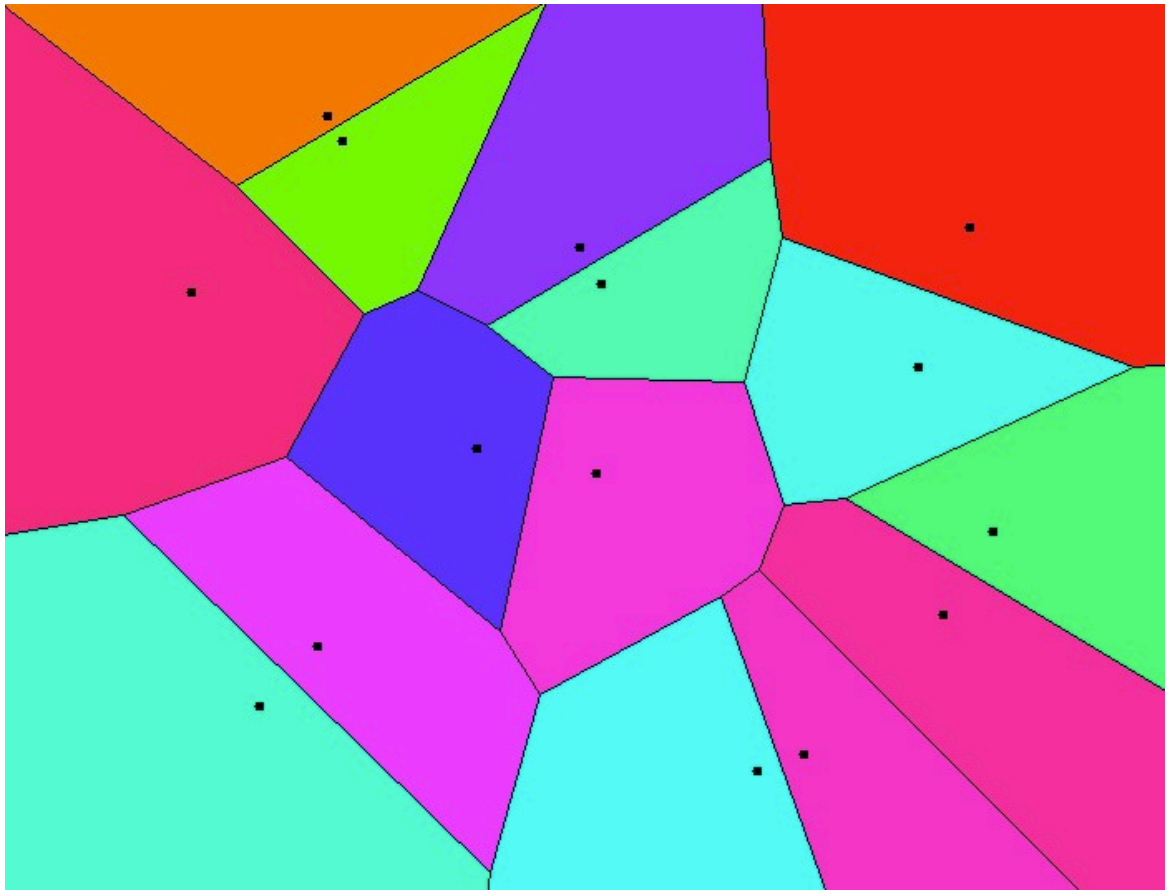
- Want to know "how similar" objects are relative to each other
  - What are the top "k" choices near me?
- Need to define a "metric" for similarity
  - "distance"

K-Nearest Neighbor

- Given a collection of *n* objects
- When trying to classify an unknown object
  - compute the distance between all known objects
  - find the *k* ($k \geq 1$) closest objects to the unknown object
  - classify the object based on class of *k* closest objects

- When k=1, then unknown object is given same classification as object it is closest to

K=1 Example



Voronoi Diagram of order 1 can be used to make k=1 NN queries

Just a bit more theory…

- Voronoi diagrams of order-1 are created in *O(n log n)* time
  - Looks similar to…? :-)
- Queried in *O(1)* time
- Therefore:
  - Pay the time penalty to ***build*** the index
  - Query against index quickly

Applications

- Geolocation + Optimizing Positioning
- Classification
- Similarity
- Recommendation systems
- Content-based image retrieval
- etc.

So what about PostgreSQL?

- As of PostgreSQL 9.0
  - supports geometric types and distances
    - Points, circles, lines, boxes, polygons
    - Distance operator: <->
  - pg_trgm – supplied module for determining text similarity
    - similarity("abc", "ade") computes similarity score
    - <-> defines distance (opposite if similarity), not defined (in 9.0)

PostgreSQL 9.1: KNN-GiST

- Let n = size of a table
- Can index data that provides a “<->” (distance) operator
  - Geometric
  - pg_trgm
- “k” = LIMIT clause
- Known inefficiencies when k=n and n is small

Example: pg_trgm

- Data:
  - List of 1,000,000 names – 700,000 unique
  - n = 1,000,000
- Indexes:
  - CREATE INDEX names_name_idx ON names (name)
  - CREATE INDEX trgm_idx ON names USING gist (name gist_trgm_ops)
- k=10
- Displaying query plan / execution time after 10 runs

pg_trgm: 9.0

```
EXPLAIN ANALYZE
  SELECT name, similarity(name, 'jon') AS sim
  FROM names
  WHERE name % 'jon'
  ORDER BY sim DESC
  LIMIT 10;
```

pg_trgm: 9.0

Limit (cost=2724.95..2724.98 rows=10 width=14) (actual time=192.793..192.794 rows=10 loops=1)

-> Sort (cost=2724.95..2727.45 rows=1000 width=14) (actual time=192.790..192.791 rows=10 loops=1)

Sort Key: (similarity(name, 'jon'::text))

Sort Method: top-N heapsort Memory: 25kB

-> Bitmap Heap Scan on names (cost=56.47..2703.34 rows=1000 width=14) (actual time=188.836..192.499 rows=865 loops=1)

Recheck Cond: (name % 'jon'::text)

-> Bitmap Index Scan on trgm_idx (cost=0.00..56.22 rows=1000 width=0) (actual time=188.652..188.652 rows=865 loops=1)

Index Cond: (name % 'jon'::text)

Total runtime: **192.881 ms**

pg_trgm: 9.1

```
EXPLAIN ANALYZE
  SELECT name, similarity(name, 'jon') AS sim
  FROM names
  WHERE name % 'jon'
  ORDER BY sim DESC
  LIMIT 10;
```

pg_trgm 9.1

```
Limit  (cost=2720.91..2720.93 rows=10 width=14) (actual
    time=202.022..202.023 rows=10 loops=1)
  ->  Sort  (cost=2720.91..2723.41 rows=1000 width=14) (actual
    time=202.020..202.021 rows=10 loops=1)
        Sort Key: (similarity(name, 'jon'::text))
        Sort Method: top-N heapsort  Memory: 25kB
        ->  Bitmap Heap Scan on names  (cost=52.43..2699.30 rows=1000
    width=14) (actual time=198.324..201.719 rows=865 loops=1)
              Recheck Cond: (name % 'jon'::text)
              ->  Bitmap Index Scan on names_trgm_idx  (cost=0.00..52.18
    rows=1000 width=0) (actual time=198.156..198.156 rows=865
    loops=1)
                    Index Cond: (name % 'jon'::text)
Total runtime: 202.113 ms
```

Comparable?

- Seems to be similar
  - Need to do more research why – anyone?
- However, 9.1 offers improvements for LIKE/ ILIKE search with pg_trgm

LIKE/ILIKE

```
EXPLAIN ANALYZE
  SELECT name
  FROM names
  WHERE name LIKE '%ata%n';
```

LIKE/ILIKE pg_trgm: 9.0 vs 9.1

Seq Scan on names
(cost=0.00..18717.00 rows=99 width=14) (actual time=0.339..205.659 rows=665 loops=1)

Filter: (name ~~ '%ata%n'::text)

Total runtime: 205.743 ms

Bitmap Heap Scan on names
(cost=9.45..369.20 rows=99 width=14) (actual time=122.494..125.967 rows=665 loops=1)

Recheck Cond: (name ~~ '%ata%n'::text)

-> **Bitmap Index Scan on names_trgm_idx**
(cost=0.00..9.42 rows=99 width=0) (actual time=121.972..121.972 rows=3551 loops=1)

Index Cond: (name ~~ '%ata%n'::text)

Total runtime: 126.065 ms

Geometry

- Data:
  - 2,000,000 points, from (0,0) -> (10000, 10000)
- Index:
  - CREATE INDEX geoloc_coord_idx ON geoloc USING gist (coord);

Geometry

```
EXPLAIN ANALYZE
  SELECT *, coord <-> point(500,500)
  FROM geoloc
  ORDER BY coord <-> point(500,500)
  LIMIT 10;
```

Geometry: 9.0 vs 9.1

Limit (cost=80958.28..80958.31 rows=10 width=20) (actual time=1035.313..1035.316 rows=10 loops=1)

-> **Sort** (cost=80958.28..85958.28 rows=2000000 width=20) (actual time=1035.312..1035.314 rows=10 loops=1)

Sort Key: ((coord <-> '(500,500)'::point))

Sort Method: top-N heapsort Memory: 25kB

-> **Seq Scan** on geoloc (cost=0.00..37739.00 rows=2000000 width=20) (actual time=0.029..569.501 rows=2000000 loops=1)

Total runtime: 1035.349 ms

Limit (cost=0.00..0.81 rows=10 width=20) (actual time=0.576..1.255 rows=10 loops=1)

-> **Index Scan using geoloc_coord_idx on geoloc** (cost=0.00..162068.96 rows=2000000 width=20) (actual time=0.575..1.251 rows=10 loops=1)

Order By: (coord <-> '(500,500)'::point)

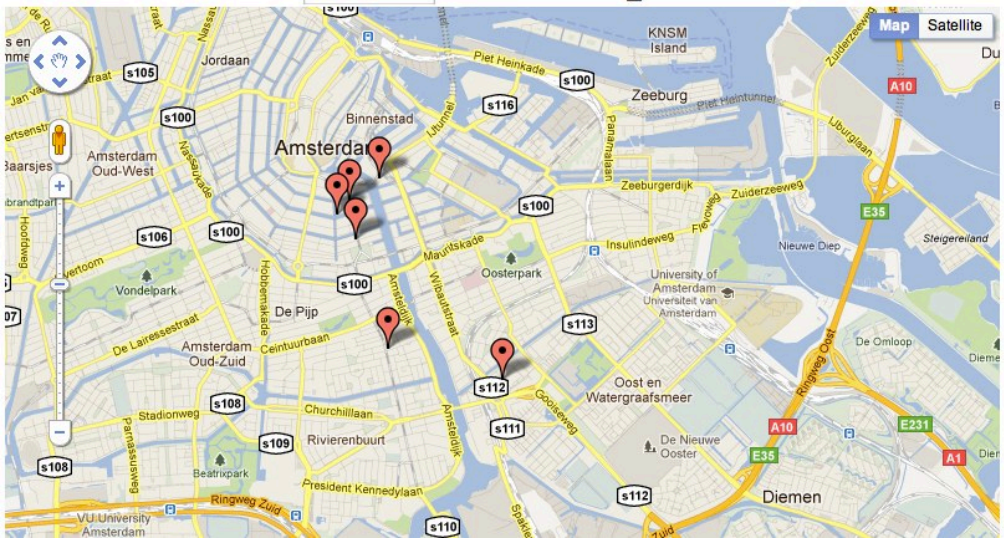
Total runtime: 1.391 ms

Application Examples

- Proximity map search – fast!

KNN - Amsterdam Edition

Find me the 5 closest places for coffee.



Drawbacks

- Performance benefits are limited when:
  - LIMIT is close to size of data set and data set is large
  - Data set is small
- Time to build index
  - High transaction table

Conclusions

- GiST: “Generalized Search Tree” – index is there, up to developers to define access methods of data types
  - e.g. yields KNN-GiST
- Different types of applications can be built – performance enhancements
- Next steps?

My Wish List

- Further geometric-type support in Postgres
  - N-dimensional points
  - '=' operator for point type
  - (PostGIS still champion of complex geometric + geographic data types)
- Define "distance" over multicolumns with different types?
  - SELECT (a.name, a.geocode) <-> (b.name, b.geocode) FROM x a, x b;

References

- Oleg Bartunov – "Efficient K-nearest neighbour search in PostgreSQL" (http://www.sai.msu.su/~megera/postgres/talks/pgday-2010.pdf)

- Oleg Bartunov and Teodor Sigaev for work on KNN-GiST and notes on pg_trgm (http://developer.postgresql.org/pgdocs/postgres/pgtrgm.html)

- Hubert "depesz" Lubaczewski – patterned benchmarks off of his work - http://www.depesz.com/index.php/2010/12/11/waiting-for-9-1-knngist/

Contact

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- Feedback Please!
  - http://2011.pgconf.eu/feedback