

CREATE INDEX USING RUM

RUM index and its application to FTS

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- Why built-in FTS in database
- Full text search in PostgreSQL
- Some FTS problems
- New features:
 - CREATE INDEX ... USING RUM
 - Phrase search
 - Inverse FTS
 - FTS+Timestamp
 - Dictionaries as extensions
 - Dictionaries in shared memory
 - Tsvector editing functions

What is a Full Text Search ?

- Full text search
 - Find documents, which match a query
 - Sort them in some order (optionally)
- Typical Search
 - Find documents with **all words** from query
 - Return them sorted by relevance

Why FTS in Databases ?

- Feed database content to external search engines
 - They are fast !

BUT

- They can't index all documents - could be totally virtual
- They don't have access to attributes - no complex queries
- They have to be maintained — headache for DBA
- Sometimes they need to be certified
- They don't provide instant search (need time to download new data and reindex)
- They don't provide consistency — search results can be already deleted from database

FTS in Databases

- **FTS requirements**
 - **Full integration with database engine**
 - Transactions
 - Concurrent access
 - Recovery
 - Online index
 - Configurability (parser, dictionary...)
 - Scalability

(TEXT op TEXT, op - ~, ~*, LIKE, ILIKE)

- No linguistic support
 - What is a word ?
 - What to index ?
 - Word «normalization» ?
 - Stop-words (noise-words)
- No ranking - all documents are equally similar to query
- Slow, documents should be seq. scanned
- 9.3+ index support of ~* (pg_trgm)

```
select * from man_lines where man_line ~* '(:  
(?:p(?:ostgres(?:ql)?|g?sql)|sql)) (?:(:(?:mak|us)e|do|is))';
```

One of (postgresql,sql,postgres,pgsql,psql) space One of (do,is,use,make)

FTS in PostgreSQL

- OpenFTS — 2000, Pg as a storage
- GiST index — 2000, thanks Rambler
- Tsearch — 2001, contrib:no ranking
- Tsearch2 — 2003, contrib:config
- GIN — 2006, thanks, JFG Networks
- FTS — 2006, in-core, thanks, EnterpriseDB
- FTS(ms) — 2012, some patches committed
- 2016 — Postgres Professional

- **tsvector** – data type for document optimized for search
 - Sorted array of lexems
 - Positional information
 - Structural information (importance)
- **tsquery** – textual data type for query with boolean operators & | ! ()
- **Full text search operator @@:** tsvector @@ tsquery
- Operators @>, <@ for tsquery
- **Functions:** to_tsvector, to_tsquery, plainto_tsquery, ts_lexize, ts_debug, ts_stat, ts_rewrite, ts_headline, ts_rank, ts_rank_cd, setweight,
- **Indexes:** GiST, GIN

What is the benefit ?

Document processed only once when inserting into a table, no overhead in search

- Document parsed into tokens using pluggable parser
- Tokens converted to lexems using pluggable dictionaries
- Words positions with labels (importance) are stored and can be used for ranking
- Stop-words ignored

- Query processed at search time
 - Parsed into tokens
 - Tokens converted to lexems using pluggable dictionaries
 - Tokens may have labels (weights)
 - Stop-words removed from query
 - It's possible to restrict search area
 - 'fat:ab & rats & ! (cats | mice) '
 - Prefix search is supported
 - 'fa*:ab & rats & ! (cats | mice) '
 - Query can be rewritten «on-the-go»

FTS summary

- FTS in PostgreSQL is a flexible search engine, but it is more than a complete solution
- It is a «collection of bricks» you can build your search engine with
 - Custom parser
 - Custom dictionaries
 - Use tsvector as a custom storage
 - + All power of SQL (FTS+Spatial+Temporal)
- For example, instead of textual documents consider chemical formulas or genome string

Some FTS problems: #1

156676 Wikipedia articles:

- Search is fast, ranking is slow.

```
SELECT docid, ts_rank(text_vector, to_tsquery('english', 'title')) AS rank
FROM ti2
WHERE text_vector @@ to_tsquery('english', 'title')
ORDER BY rank DESC
LIMIT 3;
```

```
Limit (actual time=476.106..476.107 rows=3 loops=1)
```

```
  Buffers: shared hit=149804 read=87416
```

```
    -> Sort (actual time=476.104..476.104 rows=3 loops=1)
```

```
      Sort Key: (ts_rank(text_vector, '''titl'''::tsquery)) DESC
```

```
      Sort Method: top-N heapsort  Memory: 25kB
```

```
      Buffers: shared hit=149804 read=87416
```

```
        -> Bitmap Heap Scan on ti2 (actual time=6.894..469.215 rows=47855 loops=1)
```

```
          Recheck Cond: (text_vector @@ '''titl'''::tsquery)
```

```
          Heap Blocks: exact=4913
```

```
          Buffers: shared hit=149804 read=87416
```

```
            -> Bitmap Index Scan on ti2_index (actual time=6.117..6.117 rows=47855 loops=1)
```

```
              Index Cond: (text_vector @@ '''titl'''::tsquery)
```

```
              Buffers: shared hit=1 read=12
```

```
Planning time: 0.255 ms
```

```
Execution time: 476.171 ms
```

```
(15 rows)
```

**HEAP IS SLOW
470 ms !**

Some FTS problems: #2

- No phrase search
 - “A & B” is equivalent to “B & A»
There are only 92 posts with person 'Tom Good',
but FTS finds 34039 posts
- Combination of FTS + regular expression works, but slow
and can be used only for simple queries.

Some FTS problems: #3

- Combine FTS with ordering by timestamp

```
SELECT sent, subject from pglist
WHERE fts @@ to_tsquery('english', 'tom & lane')
ORDER BY abs(sent - '2000-01-01'::timestamp) ASC LIMIT 5;
```

```
Limit (actual time=545.560..545.560 rows=5 loops=1)
-> Sort (actual time=545.559..545.559 rows=5 loops=1)
    Sort Key: (CASE WHEN ((sent - '2000-01-01 00:00:00'::timestamp without time zone) < '00:00:00'::interval) THEN (-
(sent - '2000-01-01 00:00:00'::timestamp without time zone)) ELSE (sent - '2000-01-01 00:00:00'::timestamp without time zone)
END)
    Sort Method: top-N heapsort  Memory: 25kB
-> Bitmap Heap Scan on pglist (actual time=87.545..507.897 rows=222813 loops=1)
    Recheck Cond: (fts @@ '''tom'' & ''lane''::tsquery)
    Heap Blocks: exact=105992
-> Bitmap Index Scan on pglist_gin_idx (actual time=57.932..57.932 rows=222813 loops=1)
    Index Cond: (fts @@ '''tom'' & ''lane''::tsquery)

Planning time: 0.376 ms
Execution time: 545.744 ms
```

sent			subject	
-----+-----			-----	
1999-12-31	13:52:55		Re: [HACKERS]	LIKE fixed(?) for non-ASCII collation orders
2000-01-01	11:33:10		Re: [HACKERS]	dubious improvement in new psql
1999-12-31	10:42:53		Re: [HACKERS]	LIKE fixed(?) for non-ASCII collation orders
2000-01-01	13:49:11		Re: [HACKERS]	dubious improvement in new psql
1999-12-31	09:58:53		Re: [HACKERS]	LIKE fixed(?) for non-ASCII collation orders
(5 rows)				

Time: 568.357 ms

Inverted Index in PostgreSQL

Report Index

ENTRY
TREE

A

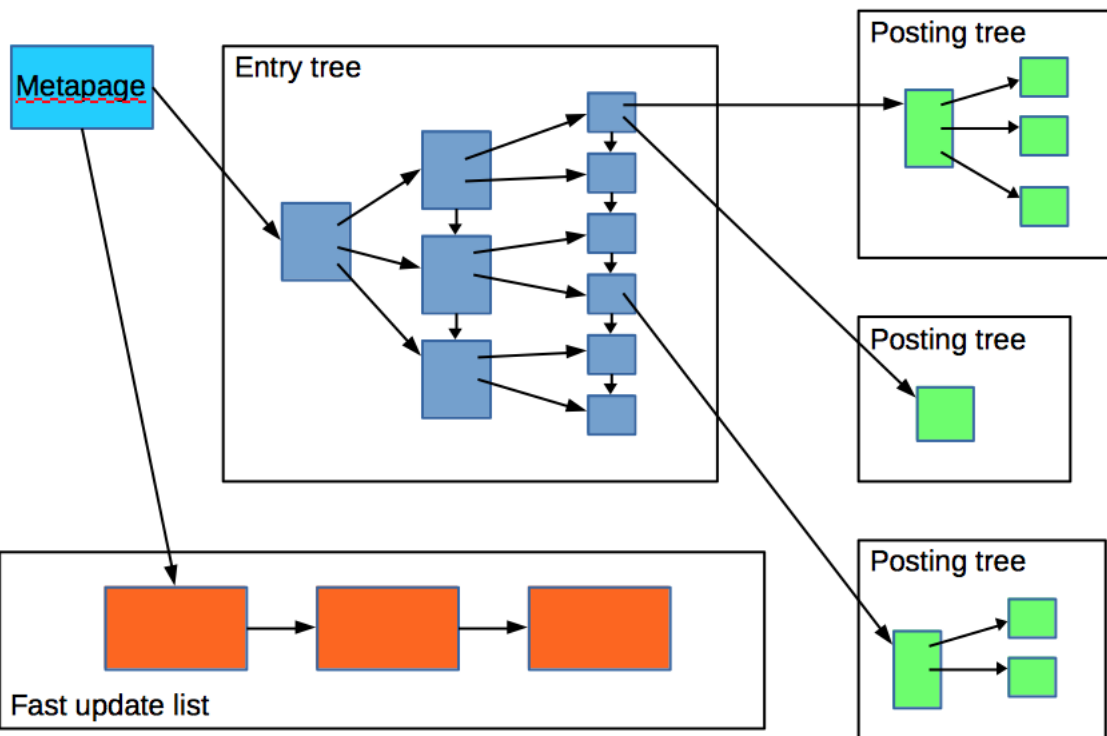
abrasives, 27
 acceleration measurement, 58
 accelerometers, 5, 10, 25, 28, 30, 36, 58, 59, 61, 73, 74
 actuators, 4, 37, 46, 49
 adaptive Kalman filters, 60, 61
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Posting tree

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 Couette flow, 21
 creep, 17
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B

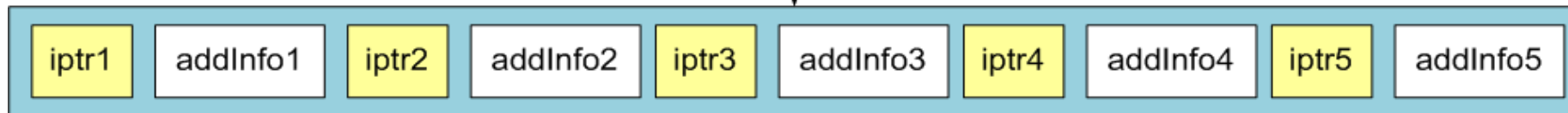
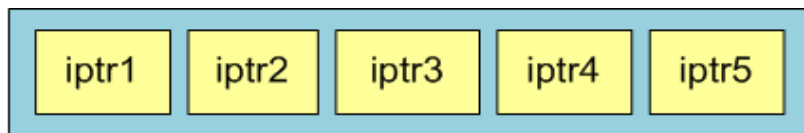
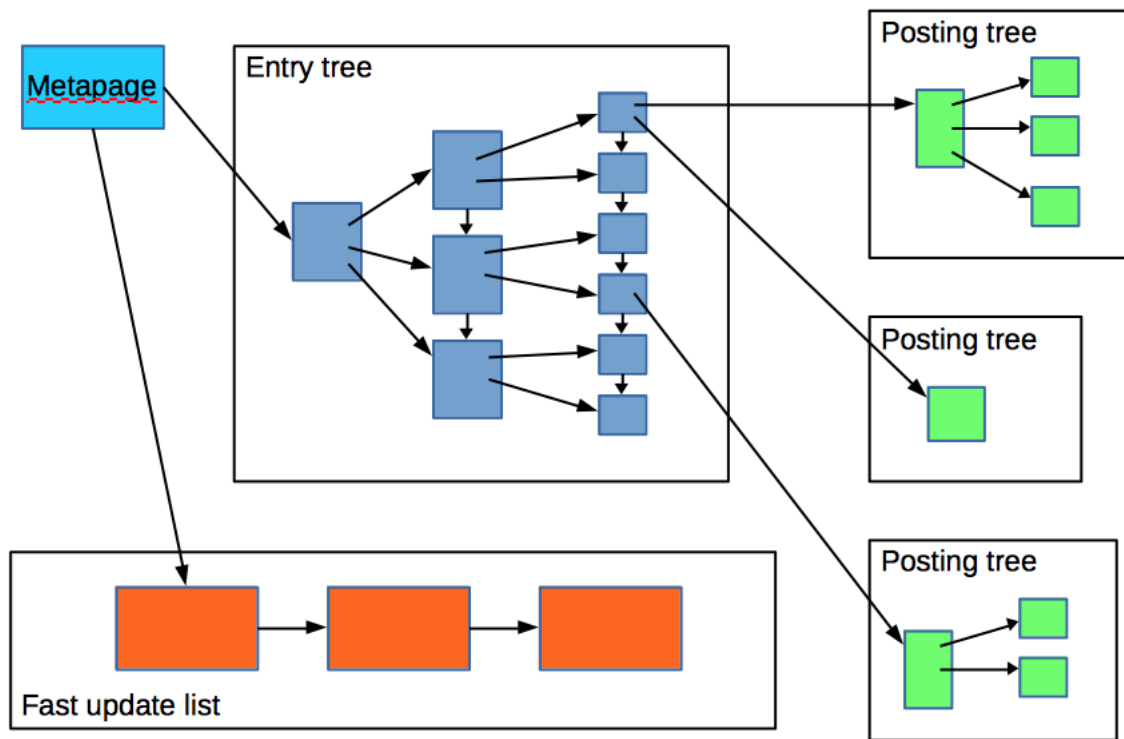
backward wave oscillators, 45



Improving GIN

- Improve GIN index
 - Store additional information in posting tree, for example, lexemes positions or timestamps
 - Use this information to order results

Improving GIN



9.6 opens «Pandora box»

Create access methods as extension ! Let's call it RUM



CREATE INDEX ... USING RUM

- Use positions to calculate rank and order results
- Introduce distance operator `tsvector <=> tsquery`

```
CREATE INDEX ti2_rum_fts_idx ON ti2 USING rum(text_vector rum_tsvector_ops);
```

```
SELECT docid, ts_rank(text_vector, to_tsquery('english', 'title')) AS rank
FROM ti2
WHERE text_vector @@ to_tsquery('english', 'title')
ORDER BY
text_vector <=> plainto_tsquery('english','title') LIMIT 3;
```

QUERY PLAN

```
L Limit (actual time=54.676..54.735 rows=3 loops=1)
```

```
  Buffers: shared hit=355
```

```
    -> Index Scan using ti2_rum_fts_idx on ti2 (actual time=54.675..54.733 rows=3 loops=1)
```

```
      Index Cond: (text_vector @@ '''titl'''::tsquery)
```

```
      Order By: (text_vector <=> '''titl'''::tsquery)
```

```
      Buffers: shared hit=355
```

```
Planning time: 0.225 ms
```

```
Execution time: 54.775 ms vs 476 ms !
```

```
(8 rows)
```

CREATE INDEX ... USING RUM

- Top-10 (out of 222813) postings with «Tom Lane»
 - GIN index — 1374.772 ms

```
SELECT subject, ts_rank(fts,plainto_tsquery('english', 'tom lane')) AS rank
FROM pglist WHERE fts @@ plainto_tsquery('english', 'tom lane')
ORDER BY rank DESC LIMIT 10;
```

QUERY PLAN

```
-----
Limit (actual time=1374.277..1374.278 rows=10 loops=1)
  -> Sort (actual time=1374.276..1374.276 rows=10 loops=1)
        Sort Key: (ts_rank(fts, '''tom'' & ''lane''::tsquery)) DESC
        Sort Method: top-N heapsort  Memory: 25kB
        -> Bitmap Heap Scan on pglist (actual time=98.413..1330.994 rows=222813 loops=1)
              Recheck Cond: (fts @@ '''tom'' & ''lane''::tsquery)
              Heap Blocks: exact=105992
              -> Bitmap Index Scan on pglist_gin_idx (actual time=65.712..65.712
rows=222813 loops=1)
                    Index Cond: (fts @@ '''tom'' & ''lane''::tsquery)

Planning time: 0.287 ms
Execution time: 1374.772 ms
(11 rows)
```

CREATE INDEX ... USING RUM

- Top-10 (out of 222813) postings with «Tom Lane»
 - RUM index — 216 ms vs 1374 ms !!!

```
create index pglist_rum_fts_idx on pglist using rum(fts rum_tsvector_ops);
```

```
SELECT subject FROM pglist WHERE fts @@ plainto_tsquery('tom lane')  
ORDER BY fts <=> plainto_tsquery('tom lane') LIMIT 10;
```

```
QUERY PLAN
```

```
-----  
Limit (actual time=215.115..215.185 rows=10 loops=1)
```

```
  -> Index Scan using pglist_rum_fts_idx on pglist (actual time=215.113..215.183 rows=10 loops=1)
```

```
        Index Cond: (fts @@ plainto_tsquery('tom lane'::text))
```

```
        Order By: (fts <=> plainto_tsquery('tom lane'::text))
```

```
Planning time: 0.264 ms
```

```
Execution time: 215.833 ms
```

```
(6 rows)
```


CREATE INDEX ... USING RUM

- RUM uses new ranking function (ts_score) — combination of ts_rank and ts_rank_cd
 - ts_rank doesn't support logical operators
 - ts_rank_cd works poorly with OR queries

```
SELECT ts_rank(fts,plainto_tsquery('english', 'tom lane')) AS rank,
       ts_rank_cd (fts,plainto_tsquery('english', 'tom lane')) AS rank_cd ,
       fts <=> plainto_tsquery('english', 'tom lane') as score, subject
FROM pglist WHERE fts @@ plainto_tsquery('english', 'tom lane')
ORDER BY fts <=> plainto_tsquery('english', 'tom lane') LIMIT 10;
```

rank	rank_cd	score	subject
0.999637	2.02857	0.487904	Re: ATTN: Tom Lane
0.999224	1.97143	0.492074	Re: Bug #866 related problem (ATTN Tom Lane)
0.99798	1.97143	0.492074	Tom Lane
0.996653	1.57143	0.523388	happy birthday Tom Lane ...
0.999697	2.18825	0.570404	For Tom Lane
0.999638	2.12208	0.571455	Re: Favorite Tom Lane quotes
0.999188	1.68571	0.593533	Re: disallow LOCK on a view - the Tom Lane remix
0.999188	1.68571	0.593533	Re: disallow LOCK on a view - the Tom Lane remix
0.999188	1.68571	0.593533	Re: disallow LOCK on a view - the Tom Lane remix
0.999188	1.68571	0.593533	Re: [HACKERS] disallow LOCK on a view - the Tom Lane remix

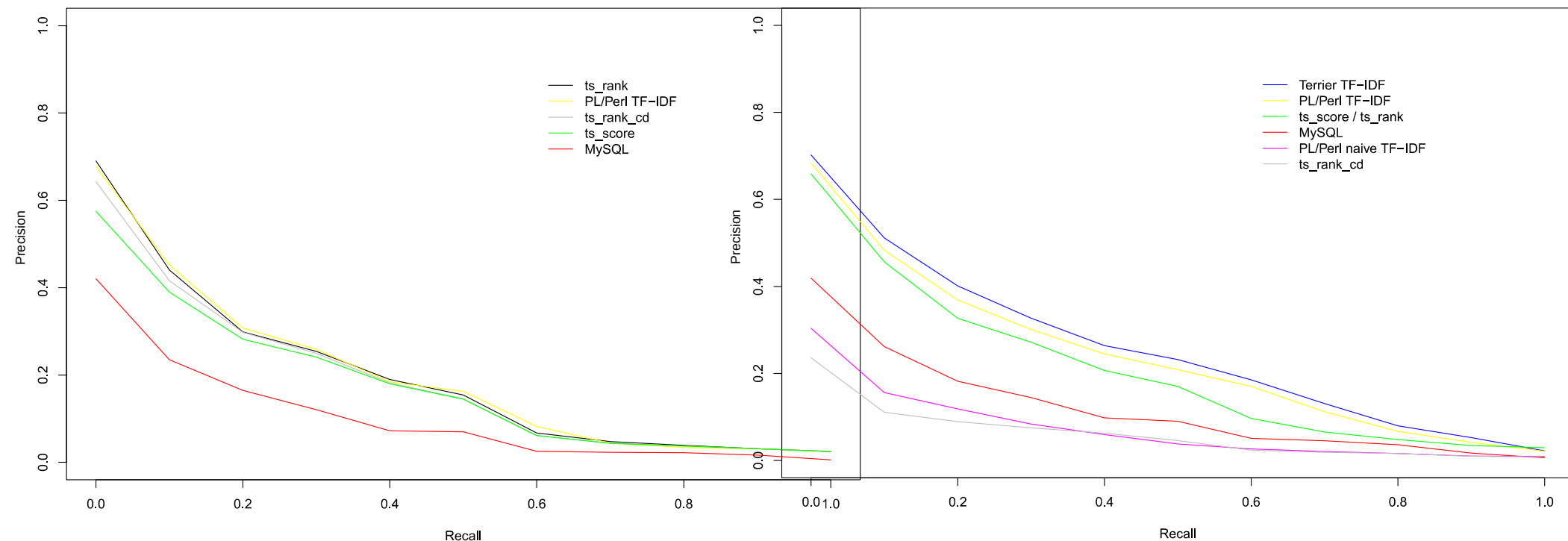
(10 rows)

- RUM uses new ranking function (ts_score) — combination of ts_rank and ts_rank_cd

Precision-Recall (NIST TREC, AD-HOC coll.)

AND queries

OR queries



Phrase Search (8 years old!)

- Queries 'A & B'::tsquery and 'B & A'::tsquery produce the same result
- Phrase search - preserve order of words in a query

Results for queries 'A & B' and 'B & A' should be different !

- Introduce new FOLLOWED BY ($\leftarrow\rightarrow$) operator:
 - Guarantee an order of operands
 - Distance between operands

$$a \leftarrow n b == a \& b \& (\exists i,j : \text{pos}(b)i - \text{pos}(a)j = n)$$

Phrase search - definition

- FOLLOWED BY operator returns:
 - false
 - true and array of positions of the **right** operand, which satisfy distance condition
- FOLLOWED BY operator requires positions

```
select 'a b c'::tsvector @@ 'a <-> b'::tsquery; – false, there no positions  
?column?
```

```
-----
```

```
f
```

```
(1 row)
```

```
select 'a:1 b:2 c'::tsvector @@ 'a <-> b'::tsquery;  
?column?
```

```
-----
```

```
t
```

```
(1 row)
```

Phrase search - properties

- 'A <-> B' = 'A<1>B'
- 'A <0> B' matches the word with two different forms (infinitives)

```
=# SELECT ts_lexize('ispell','bookings');  
      ts_lexize  
-----  
      {booking,book}  
to_tsvector('bookings') @@ 'booking <0> book'::tsquery
```

- Precedence of tsquery operators - '!' <-> & |'
Use parenthesis to control nesting in tsquery

```
select 'a & b <-> c'::tsquery;
      tsquery
```

```
-----
'a' & 'b' <-> 'c'
```

```
select 'b <-> c & a'::tsquery;
      tsquery
```

```
-----
'b' <-> 'c' & 'a'
```

```
select 'b <-> (c & a)'::tsquery;
      tsquery
```

```
-----
'b' <-> 'c' & 'b' <-> 'a'
```

Phrase search - example

- `TSQUERY phraseto_tsquery([CFG,] TEXT)`
Stop words are taken into account.

```
select phraseto_tsquery('PostgreSQL can be extended by the user in many ways');
           phraseto_tsquery
```

```
-----
'postgresql' <3> 'extend' <3> 'user' <2> 'mani' <-> 'way'
(1 row)
```

- It's possible to combine `tsquery`'s

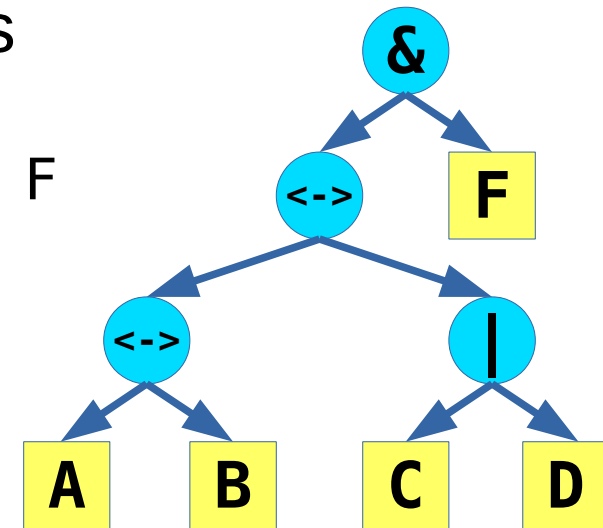
```
select phraseto_tsquery('PostgreSQL can be extended by the user in many ways') ||
       to_tsquery('oho<->ho & ik');
           ?column?
```

```
-----
'postgresql' <3> 'extend' <3> 'user' <2> 'mani' <-> 'way' | 'oho' <-> 'ho' & 'ik'
(1 row)
```

Phrase search - internals

- Phrase search has overhead, since it requires access and operations on posting lists

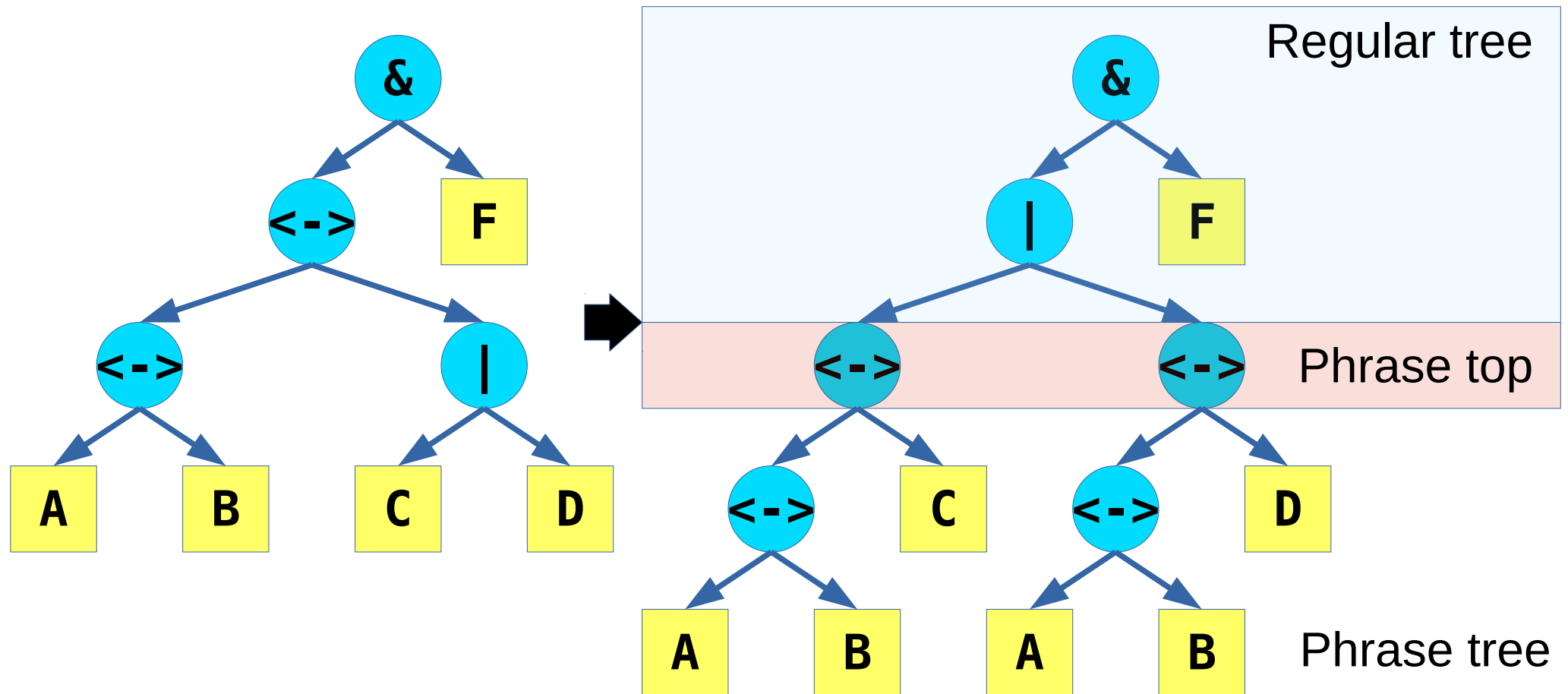
$((A \leftrightarrow B) \leftrightarrow (C \mid D)) \& F$



- We want to avoid slowdown FTS operators (& |), which do not need positions.
- Rewrite query, so any $\leftrightarrow$ operators pushed down in query tree and call phrase executor for the top $\leftrightarrow$ operator.

Phrase search - transformation

$((A \leftrightarrow B) \leftrightarrow (C \mid D)) \& F$



$('A' \leftrightarrow 'B' \leftrightarrow 'C' \mid 'A' \leftrightarrow 'B' \leftrightarrow 'D') \& 'F'$

Phrase search - push down

$a <-> (b \& c) \Rightarrow a <-> b \ \& \ a <-> c$

$(a \& b) <-> c \Rightarrow a <-> c \ \& \ b <-> c$

$a <-> (b \mid c) \Rightarrow a <-> b \ \mid \ a <-> c$

$(a \mid b) <-> c \Rightarrow a <-> c \ \mid \ b <-> c$

$a <-> !b \Rightarrow a \ \& \ !(a <-> b)$

there is no position of A followed by B

$!a <-> b \Rightarrow !(a <-> b) \ \& \ b$

there is no position of B preceded by A

Phrase search - transformation

```
# select '( A | B ) <-> ( D | C )'::tsquery;  
          tsquery
```

```
-----  
'A' <-> 'D' | 'B' <-> 'D' | 'A' <-> 'C' | 'B' <-> 'C'
```

```
# select 'A <-> ( B & ( C | ! D ) )'::tsquery;  
          tsquery
```

```
-----  
'A' <-> 'B' & ( 'A' <-> 'C' | 'A' & !( 'A' <-> 'D' ) )
```

Phrase search - Examples

- 1.1 mln postings (postgres mailing lists)

```
select count(*) from pglist where fts @@ to_tsquery('english', 'tom <-> lane');
count
```

```
-----
222777
(1 row)
```

Sequential Scan: 2.6 s <-> vs 2.2 s &+regexp

```
select count(*) from pglist where fts @@ to_tsquery('english', 'tom <-> lane');
QUERY PLAN
```

```
-----
Aggregate (actual time=2576.989..2576.989 rows=1 loops=1)
  -> Seq Scan on pglist (actual time=0.310..2552.800 rows=222777 loops=1)
        Filter: (fts @@ '''tom''' <-> '''lane'''::tsquery)
        Rows Removed by Filter: 790993
Planning time: 0.310 ms
Execution time: 2577.019 ms
(6 rows)
```

- 1.1 mln postings (postgres mailing lists)

```
select count(*) from pglist where fts @@ to_tsquery('english', 'tom <-> lane');
count
```

```
-----
222777
(1 row)
```

GIN index: 1.1 s <-> vs 0.48 s &, considerable overhead

```
select count(*) from pglist where fts @@ to_tsquery('english', 'tom <-> lane');
QUERY PLAN
```

```
-----
Aggregate (actual time=1074.983..1074.984 rows=1 loops=1)
-> Bitmap Heap Scan on pglist (actual time=84.424..1055.770 rows=222777 loops=1)
    Recheck Cond: (fts @@ '''tom''' <-> '''lane'''::tsquery)
    Rows Removed by Index Recheck: 36
    Heap Blocks: exact=105992
    -> Bitmap Index Scan on pglist_gin_idx (actual time=53.628..53.628 rows=222813
loops=1)
        Index Cond: (fts @@ '''tom''' <-> '''lane'''::tsquery)
Planning time: 0.329 ms
Execution time: 1075.157 ms
(9 rows)
```

Phrase search - Examples

- 1.1 mln postings (postgres mailing lists)

```
select count(*) from pglist where fts @@ to_tsquery('english', 'tom <-> lane');
count
```

```
-----
222777
(1 row)
```

RUM index: 0.5 s <-> vs 0.48 s & : Use positions in addinfo, almost no overhead of phrase operator !

```
select count(*) from pglist where fts @@ to_tsquery('english', tom <-> lane');
QUERY PLAN
```

```
-----
Aggregate (actual time=513.517..513.517 rows=1 loops=1)
-> Bitmap Heap Scan on pglist (actual time=134.109..497.814 rows=221919 loops=1)
    Recheck Cond: (fts @@ to_tsquery('tom <-> lane'::text))
    Heap Blocks: exact=105509
-> Bitmap Index Scan on pglist_rum_fts_idx (actual time=98.746..98.746
rows=221919 loops=1)
    Index Cond: (fts @@ to_tsquery('tom <-> lane'::text))
Planning time: 0.223 ms
Execution time: 515.004 ms
(8 rows)
```

Some FTS problems: #3

- Combine FTS with ordering by timestamp
 - Store timestamps in additional information in timestamp order !

```
create index pglist_fts_ts_order_rum_idx on pglist using rum(fts
rum_tsvector_timestamp_ops, sent) WITH (attach = 'sent', to ='fts',
order_by_attach = 't');
```

```
select sent, subject from pglist
where fts @@ to_tsquery('tom & lane')
order by sent <=> '2000-01-01'::timestamp limit 5;
```

```
-----
L Limit (actual time=84.866..84.870 rows=5 loops=1)
  -> Index Scan using pglist_fts_ts_order_rum_idx on pglist (actual
time=84.865..84.869 rows=5 loops=1)
    Index Cond: (fts @@ to_tsquery('tom & lane'::text))
    Order By: (sent <=> '2000-01-01 00:00:00'::timestamp without
time zone)
    Planning time: 0.162 ms
    Execution time: 85.602 ms vs 645 ms !
(6 rows)
```

Some FTS problems: #3

- Combine FTS with ordering by timestamp
 - Store timestamps in additional information in timestamp order !

```
select sent, subject from pglist
where fts @@ to_tsquery('tom & lane') and sent < '2000-01-01'::timestamp order by sent desc
limit 5;
```

```
explain analyze select sent, subject from pglist
where fts @@ to_tsquery('tom & lane') order by sent <=| '2000-01-01'::timestamp limit 5;
```

Speedup ~ 1x, since 'tom lane' is popular → filter

```
select sent, subject from pglist
where fts @@ to_tsquery('server & crashed') and sent < '2000-01-
01'::timestamp order by sent desc limit 5;
```

```
select sent, subject from pglist
where fts @@ to_tsquery('server & crashed') order by sent <=| '2000-
01-01'::timestamp limit 5;
```

Speedup ~ 10x

Inverse FTS (FQS)

- Find queries, which match given document
- Automatic text classification

```
SELECT * FROM queries;
```

q	tag
'supernova' & 'star'	sn
'black'	color
'big' & 'bang' & 'black' & 'hole'	bang
'spiral' & 'galaxi'	shape
'black' & 'hole'	color

(5 rows)

```
SELECT * FROM queries WHERE
```

```
to_tsvector('black holes never exists before we think about them')  
@@ q;
```

q	tag
'black'	color
'black' & 'hole'	color

(2 rows)

Inverse FTS (FQS)

- RUM index supported – store branches of query tree in addinfo

Find queries for the first message in postgres mailing lists

```
\d pg_query
      Table "public.pg_query"
  Column |      Type      | Modifiers
-----+-----+-----
   q     | tsquery         |
  count  | integer         |
```

Indexes:

```
    "pg_query_rum_idx" rum (q)
```

33818 queries

```
select q from pg_query pgq, pglist where q @@ pglist.fts and pglist.id=1;
      q
```

```
-----
'one' & 'one'
```

```
'postgresql' & 'freebsd'
```

```
(2 rows)
```

Inverse FTS (FQS)

- RUM index supported – store branches of query tree in addinfo

Find queries for the first message in postgres mailing lists

```
create index pg_query_rum_idx on pg_query using rum(q);
select q from pg_query pgq, pglist where q @@ pglist.fts and pglist.id=1;
                                QUERY PLAN
```

```
-----
Nested Loop (actual time=0.719..0.721 rows=2 loops=1)
```

```
  -> Index Scan using pglist_id_idx on pglist
```

```
(actual time=0.013..0.013 rows=1 loops=1)
```

```
    Index Cond: (id = 1)
```

```
  -> Bitmap Heap Scan on pg_query pgq
```

```
(actual time=0.702..0.704 rows=2 loops=1)
```

```
    Recheck Cond: (q @@ pglist.fts)
```

```
    Heap Blocks: exact=2
```

```
  -> Bitmap Index Scan on pg_query_rum_idx
```

```
(actual time=0.699..0.699 rows=2 loops=1)
```

```
    Index Cond: (q @@ pglist.fts)
```

```
Planning time: 0.212 ms
```

```
Execution time: 0.759 ms
```

```
(10 rows)
```

Inverse FTS (FQS)

- RUM index supported – store branches of query tree in addinfo

Monstrous postings

```
select id, t.subject, count(*) as cnt into pglist_q from pg_query,  
(select id, fts, subject from pglist) t where t.fts @@ q  
group by id, subject order by cnt desc limit 1000;
```

```
select * from pglist_q order by cnt desc limit 5;
```

id	subject	cnt
248443	Packages patch	4472
282668	Re: release.sgml, minor pg_autovacuum changes	4184
282512	Re: release.sgml, minor pg_autovacuum changes	4151
282481	release.sgml, minor pg_autovacuum changes	4104
243465	Re: [HACKERS] Re: Release notes	3989

(5 rows))

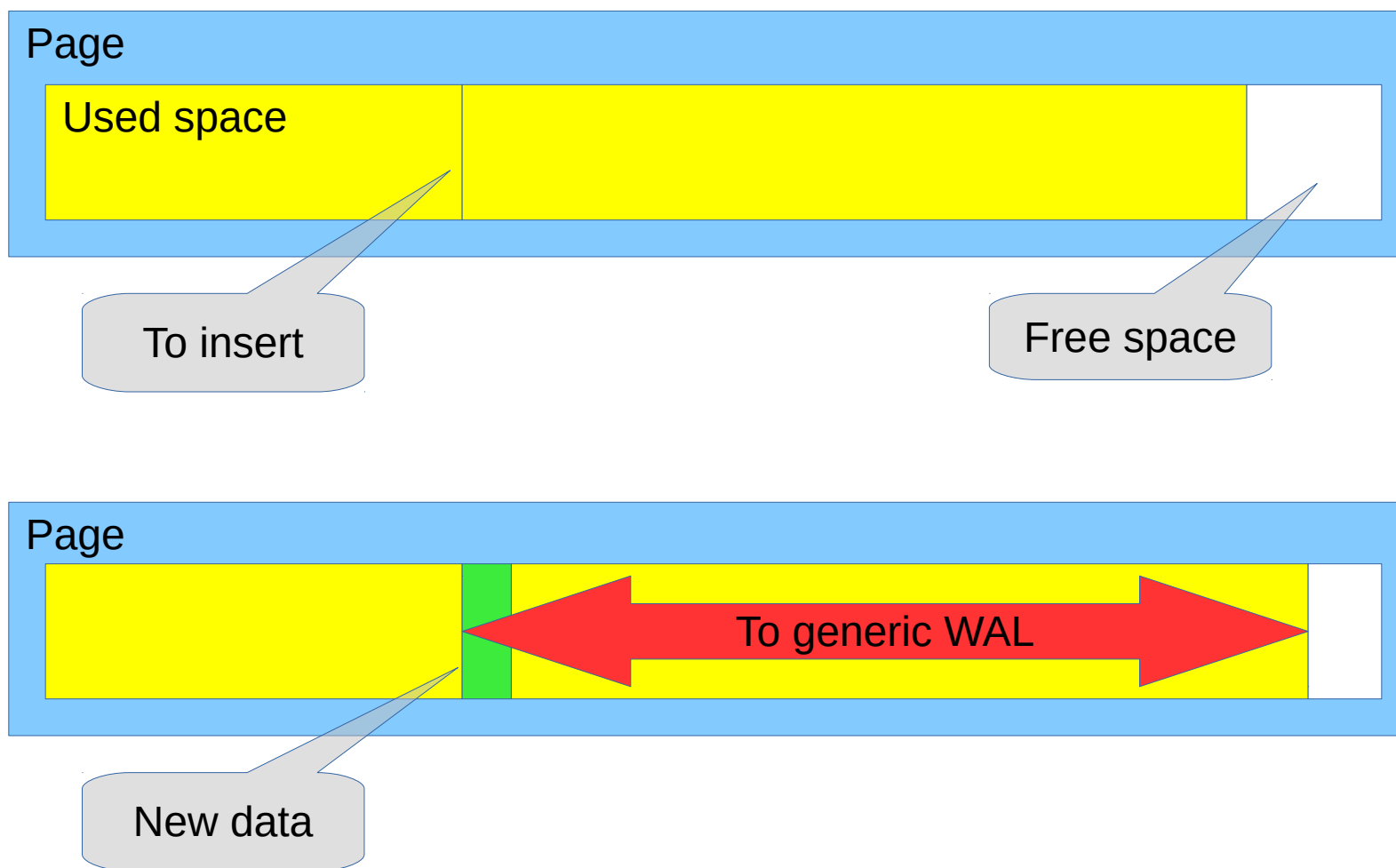
- 6 mln classifies, real fts queries, concurrency 24, duration 1 hour
 - GIN — 258087
 - RUM — 1885698 (7x speedup)
- RUM has no pending list (not implemented) and stores more data.

Insert 1 mln messages:

	table	gin/opt	gin(no fast)	rum/opt	rum_nologged	gist
insert(min)	10	12/10	21	41/34	34	10.5
WAL size		9.5Gb/7.5	24Gb	37/29GB	41MB	3.5GB

- CREATE INDEX

- GENERIC WAL (9.6) generates too big WAL traffic



- CREATE INDEX

- GENERIC WAL(9.6) generates too big WAL traffic.

It currently doesn't supports shift.

rum(fts, ts+order) generates 186 Gb of WAL !

- RUM writes WAL AFTER creating index

	table	gin	rum (fts	rum(fts,ts)	rum(fts,ts+order)
Create time		147 s	201	209	215
Size(mb)	2167/1302	534	980	1531	1921
WAL (Gb)		0.9	0.68	1.1	1.5

- Allow multiple additional info (lexemes positions + timestamp)
- add opclasses for array (similarity and as additional info) and int/float
- improve ranking function to support TF/IDF
- Add support of prefix search
- Improve insert time (pending list ?)
- Improve GENERIC WAL to support shift

Availability:

- 9.6+ only: <https://github.com/postgrespro/rum>



Thanks !

Some FTS problems #4

- Working with dictionaries can be difficult and slow
 - Installing dictionaries can be complicated
 - Dictionaries are loaded into memory for every session (slow first query symptom) and eat memory.

```
time for i in {1..10}; do echo $i; psql postgres -c "select  
ts_lexize('english_hunspell', 'evening')" > /dev/null; done
```

```
1  
2  
3  
4  
5  
6  
7  
8  
9  
10
```

```
real    0m0.656s  
user    0m0.015s  
sys 0m0.031s
```

For russian hunspell dictionary:

```
real 0m3.809s  
user 0m0.015s  
sys 0m0.029s
```

Each session «eats» 20MB !

Dictionaries in shared memory

- Now it's easy (Artur Zakirov, Postgres Professional + Thomas Vondra)

https://github.com/postgrespro/shared_ispell

```
CREATE EXTENSION shared_ispell;
CREATE TEXT SEARCH DICTIONARY english_shared (
    TEMPLATE = shared_ispell,
    DictFile = en_us,
    AffFile = en_us,
    StopWords = english
);
CREATE TEXT SEARCH DICTIONARY russian_shared (
    TEMPLATE = shared_ispell,
    DictFile = ru_ru,
    AffFile = ru_ru,
    StopWords = russian
);
time for i in {1..10}; do echo $i; psql postgres -c "select ts_lexize('russian_shared', 'туши')" > /dev/null; done
1
2
.....
10

real 0m0.170s      real 0m3.809s
user 0m0.015s      user 0m0.015s
sys  0m0.027s      sys  0m0.029s
```

Dictionaries as extensions

- Now it's easy (Artur Zakirov, Postgres Professional)
https://github.com/postgrespro/hunspell_dicts

```
CREATE EXTENSION hunspell_ru_ru; -- creates russian_hunspell dictionary
CREATE EXTENSION hunspell_en_us; -- creates english_hunspell dictionary
CREATE EXTENSION hunspell_nn_no; -- creates norwegian_hunspell dictionary
SELECT ts_lexize('english_hunspell', 'evening');
       ts_lexize
```

```
-----
{evening,even}
(1 row)
```

```
Time: 57.612 ms
SELECT ts_lexize('russian_hunspell', 'туши');
       ts_lexize
```

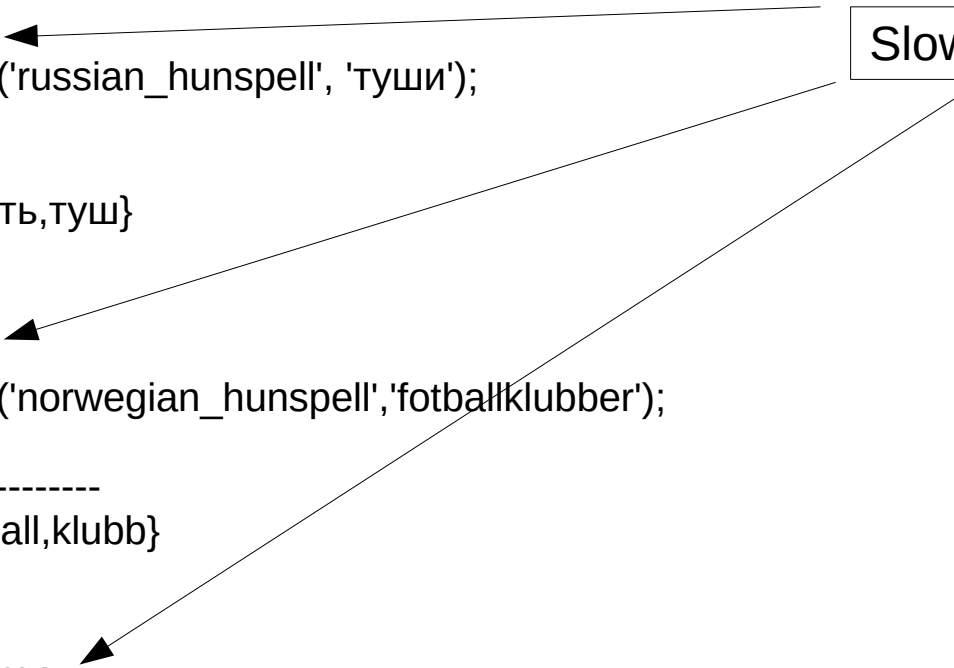
```
-----
{туша,тушь,тушить,туш}
(1 row)
```

```
Time: 382.221 ms
SELECT ts_lexize('norwegian_hunspell', 'fotballklubber');
       ts_lexize
```

```
-----
{fotball,klubb,fot,ball,klubb}
(1 row)
```

```
Time: 323.046 ms
```

Slow first query syndrom

A rectangular box with the text "Slow first query syndrom" has three arrows pointing from its left side to the first three SQL queries. The first arrow points to the first query (English dictionary), the second arrow points to the second query (Russian dictionary), and the third arrow points to the third query (Norwegian dictionary).

Tsvector editing functions

- Stas Kelvich (Postgres Professional)
- `setweight(tsvector, 'char', text[])` - add label to lexemes from `text[]` array

```
select setweight( to_tsvector('english', '20-th anniversary of PostgreSQL'),
'A',    '{postgresql,20}');
           setweight
-----
'20':1A 'anniversari':3 'postgresql':5A 'th':2
(1 row)
```

- `ts_delete(tsvector, text[])` - delete lexemes from tsvector

```
select ts_delete( to_tsvector('english', '20-th anniversary of PostgreSQL'),
'{20,postgresql}'::text[]);
           ts_delete
-----
'anniversari':3 'th':2
(1 row)
```

Tsvector editing functions

- `unnest(tsvector)`

```
select * from unnest( setweight( to_tsvector('english',
'20-th anniversary of PostgreSQL'), 'A',  '{postgresql,20}'));
lexeme      | positions | weights
-----+-----+-----
20          | {1}       | {A}
anniversari | {3}       | {D}
postgresql  | {5}       | {A}
th          | {2}       | {D}
(4 rows)
```

- `tsvector_to_array(tsvector)` — tsvector to text[] array
`array_to_tsvector(text[])`

```
select tsvector_to_array( to_tsvector('english',
'20-th anniversary of PostgreSQL'));
tsvector_to_array
-----
{20,anniversari,postgresql,th}
(1 row)
```

Tsvector editing functions

- `ts_filter(tsvector, text[])` - fetch lexemes with specific label{s}

```
select ts_filter($$('20':2A 'anniversari':4C 'postgresql':1A,6A 'th':3$$)::tsvector,  
'{C}');  
          ts_filter  
-----  
'anniversari':4C  
(1 row)  
  
select ts_filter($$('20':2A 'anniversari':4C 'postgresql':1A,6A 'th':3$$)::tsvector,  
'{C,A}');  
          ts_filter  
-----  
'20':2A 'anniversari':4C 'postgresql':1A,6A  
(1 row)
```

Multilingual support

- New JOIN option for text search configuration mapping

```
CREATE TEXT SEARCH CONFIGURATION multi_conf (COPY=simple);  
ALTER TEXT SEARCH CONFIGURATION multi_conf  
ALTER MAPPING FOR asciiword, asciihword, hword_asciipart, word, hword, hword_part  
WITH german_hunspell (JOIN), english_hunspell;
```

Artur Zakirov, Postgres Professional

https://github.com/select-artur/pg_multilingual