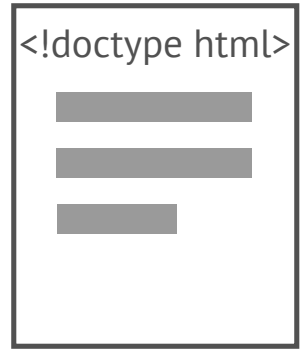
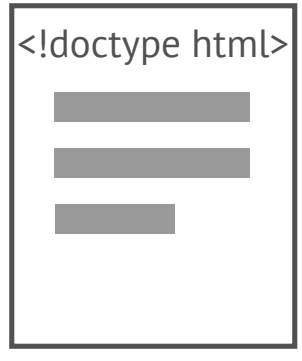
Data-Oriented Django Drei

Adam Johnson


t3.nano

5Gbps burst network capacity


<!doctype html>



1MiB would be big

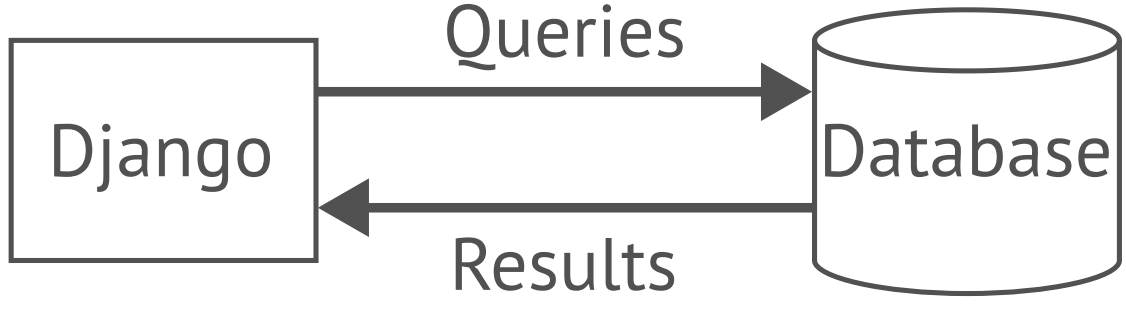
1MiB / 5Gbps =

1MiB / 5Gbps = **1.7ms**

1MiB / 5Gbps = **1.7ms**

So why is 100ms a “great” server response time?

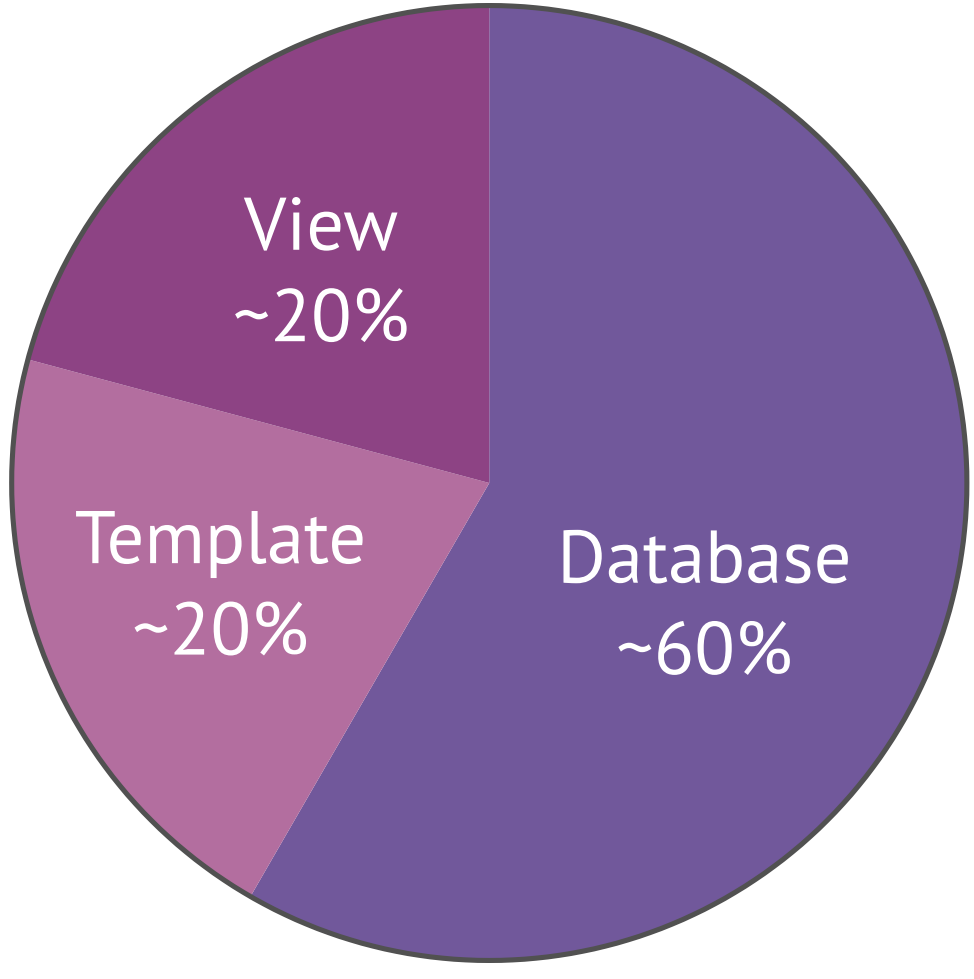

Browser
Requests
HTML
Django
Queries
Results
Database

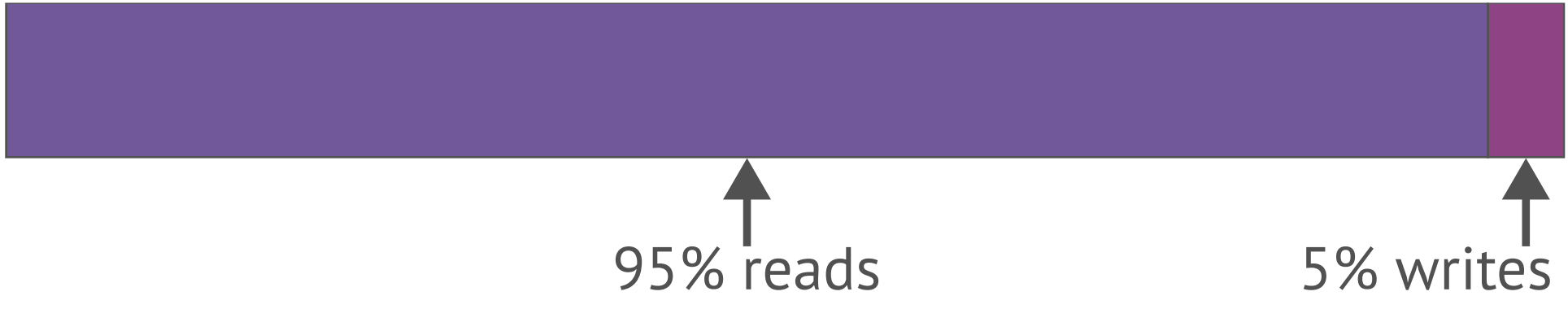

Queries
Django
Database
Results

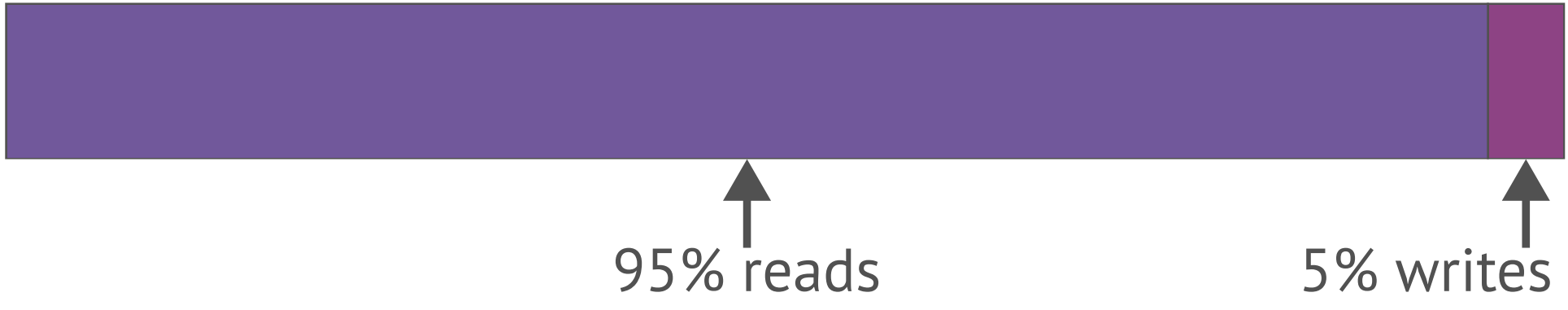
Measure

Profile production with an APM tool:

- **Sentry**
- **Scout APM**
- **django-debug-toolbar**


View
~20%
Template
~20%
Database
~60%


95% reads
5% writes



We gotta optimize the reads!

Model

```
from django.db import models

class Engine(models.Model):
    name = models.TextField()
    colour = models.TextField()
```

Table

id	name	colour
1	Thomas	blue
6	Percy	green
78	Kana	purple

...

Table

ctid	id	name	colour
75	1	Thomas	blue
11	6	Percy	green
20	78	Kana	purple

...

```
Engine.objects.filter(name='Kana')
```

```
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```

```
SELECT * FROM example_engine
WHERE name = 'Kana'
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ctid	id	name	colour	matched?
75	1	Thomas	blue	
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...

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SELECT * FROM example_engine
WHERE name = 'Kana'
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ctid	id	name	colour	matched?
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SELECT * FROM example_engine
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```

ctid	id	name	colour	matched?
75	1	Thomas	blue	❌
11	6	Percy	green	❌
20	78	Kana	purple	✅

...

Sequential scan

Sequential scan

O(n)

Sequential scan

O(n)

Fast for small **n**

Sequential scan

O(n)

Fast for small **n**

Slow for medium **n**

O(n)

# rows	~operations
1	1
10	10
100	100
1,000	1,000
10,000	10,000
100,000	100,000
1,000,000	1,000,000

Tables are a leaky abstraction

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Promise: describe your data, DB figures out storage

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Reality: horrendous performance without indexes

Tables are a leaky abstraction

Promise: describe your data, DB figures out storage

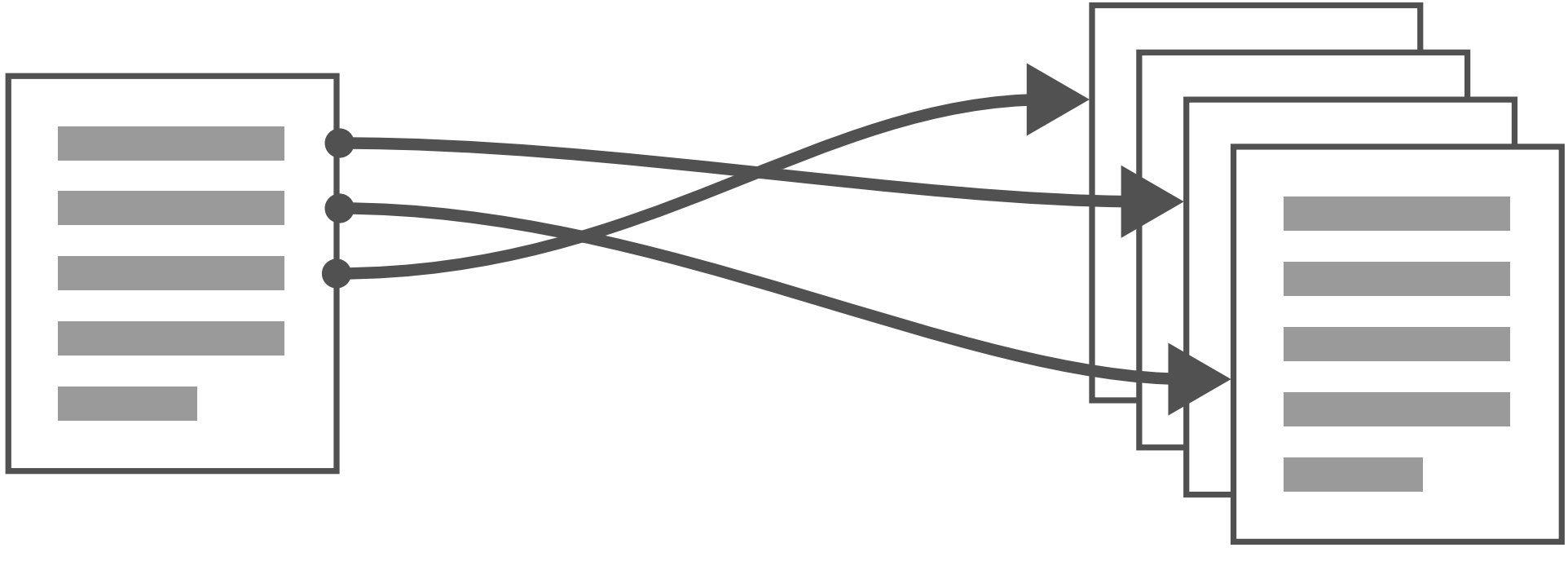
Reality: horrendous performance without indexes

Indexes make the world go round

Indexes

Index

Content



Indexes

Like a `dict` of values to row IDs

```
index_on_name = {
    "Kana": [20],
    "Percy": [11],
    "Thomas": [75],
}
```

Add an index

```
from django.db import models

class Engine(models.Model):
    name = models.TextField()
    colour = models.TextField()
```

Add an index

```
from django.db import models

class Engine(models.Model):
    name = models.TextField()
    colour = models.TextField()

    class Meta:
        indexes = [
            models.Index("name"),
        ]
```

Migration

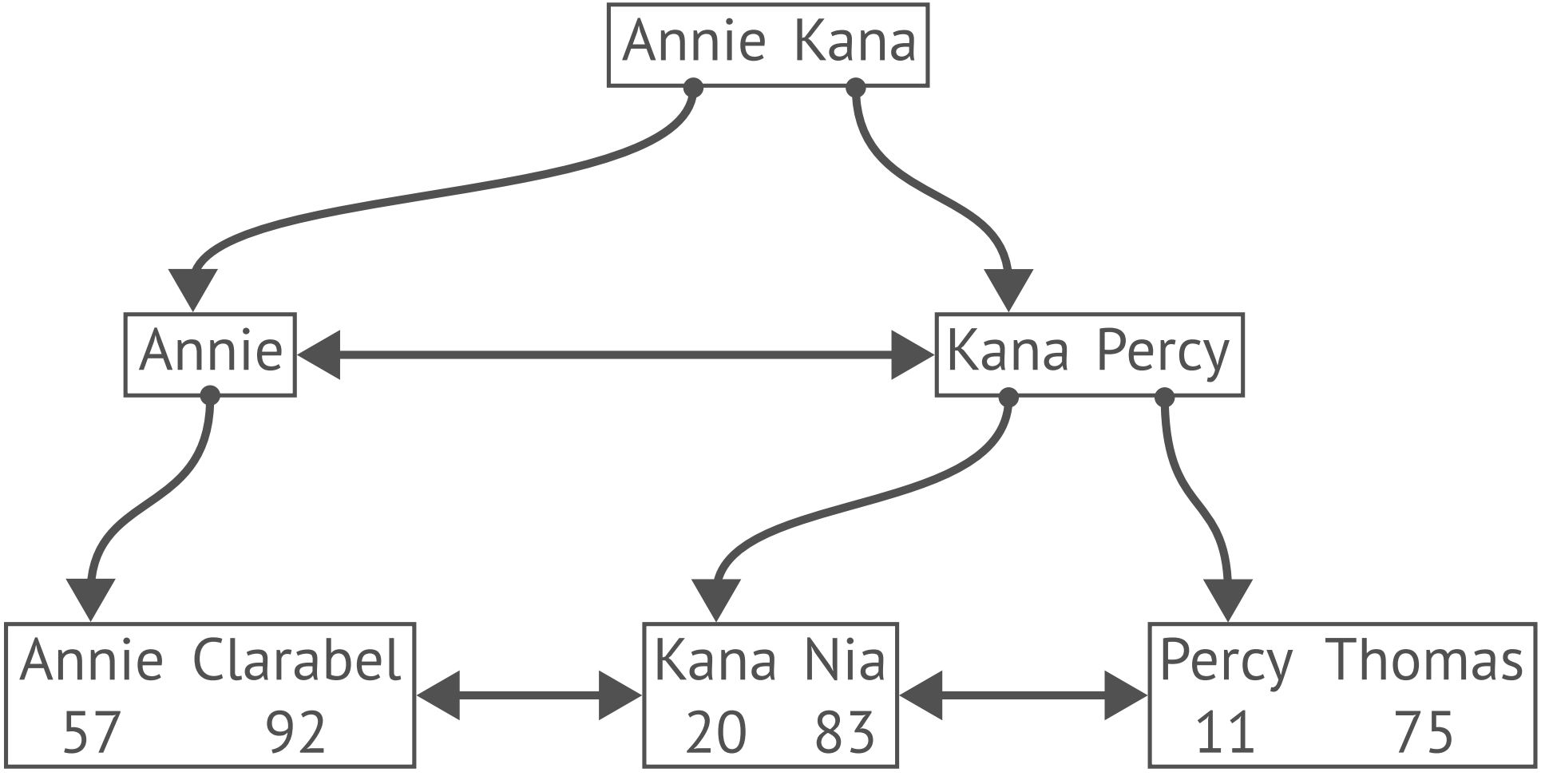
```
migrations.AddIndex(
    model_name="engine",
    index=models.Index(
        "name",
        name="example_engine_name",
    ),
)
```

Migration

```
migrations.AddIndex(
    model_name="engine",
    index=models.Index(
        "name",
        name="example_engine_name",
    ),
)
```

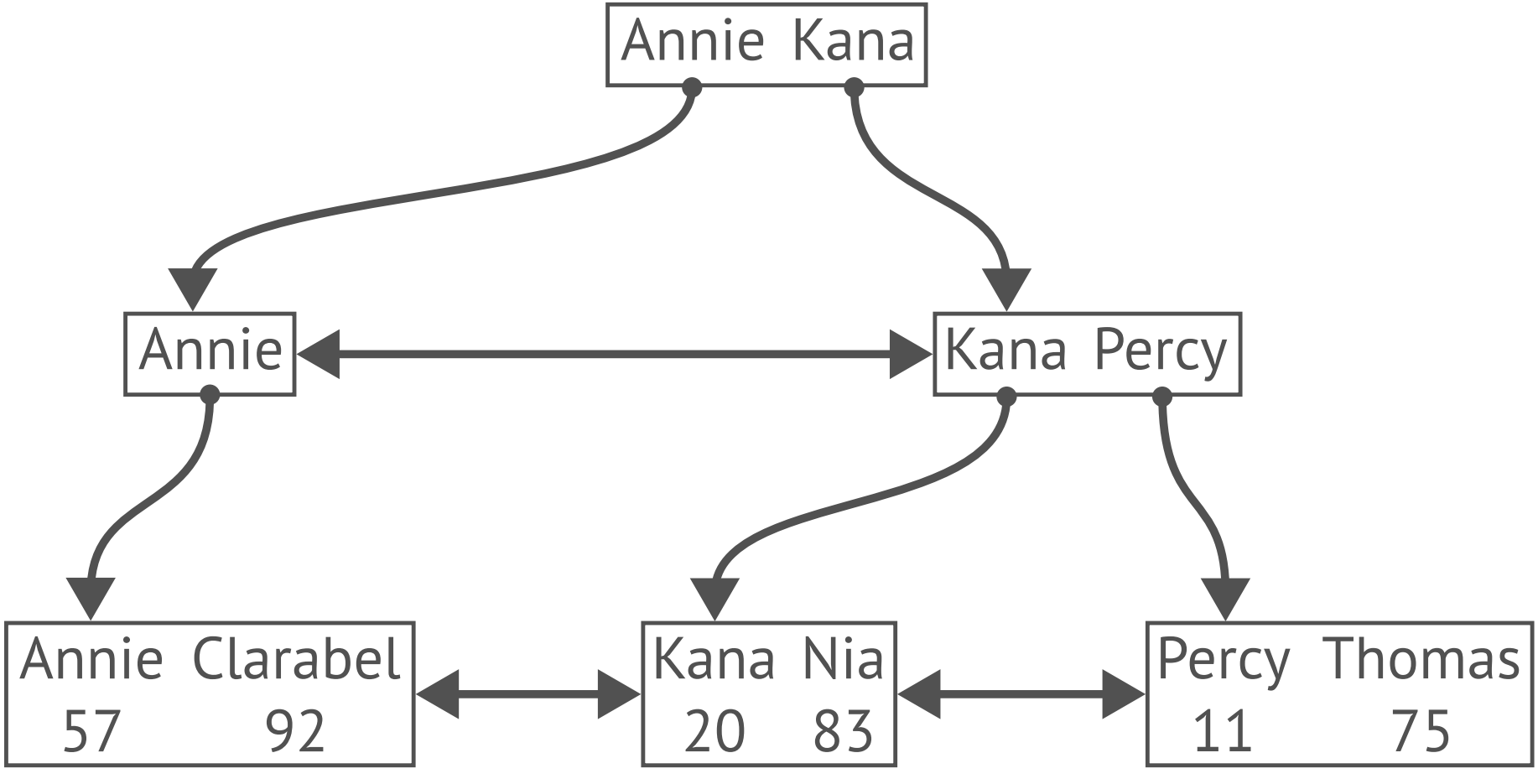
```
CREATE INDEX example_engine_name
ON example_engine (name);
```

B+ tree index


Annie Kana
Annie
Kana Percy
Annie Clarabel
57 92
Kana Nia
20 83
Percy Thomas
11 75

```
SELECT * FROM example_engine
WHERE name = 'Kana'
```

```
SELECT * FROM example_engine
WHERE name = 'Kana'
```



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SELECT * FROM example_engine
WHERE name = 'Kana'
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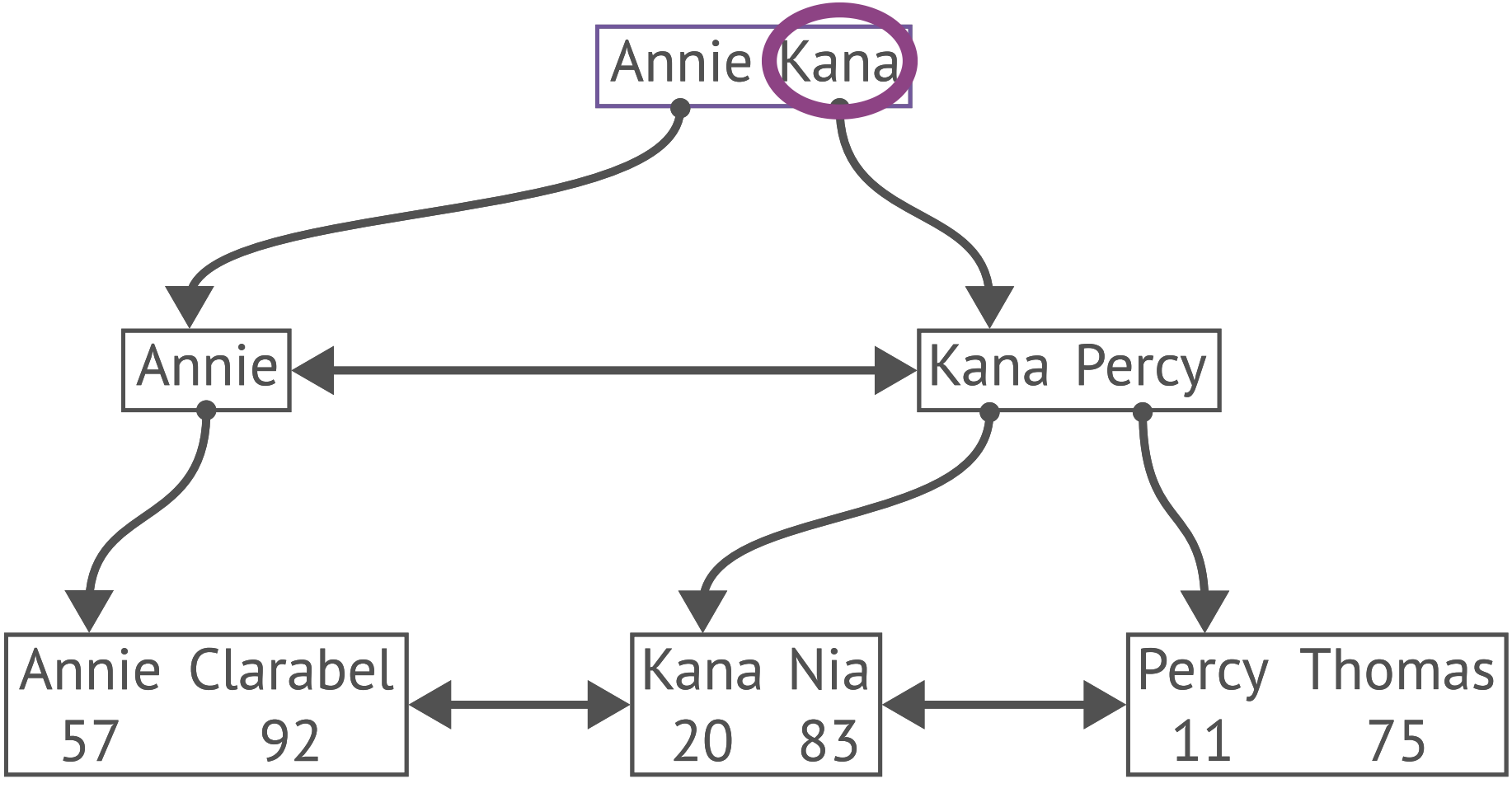

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WHERE name = 'Kana'
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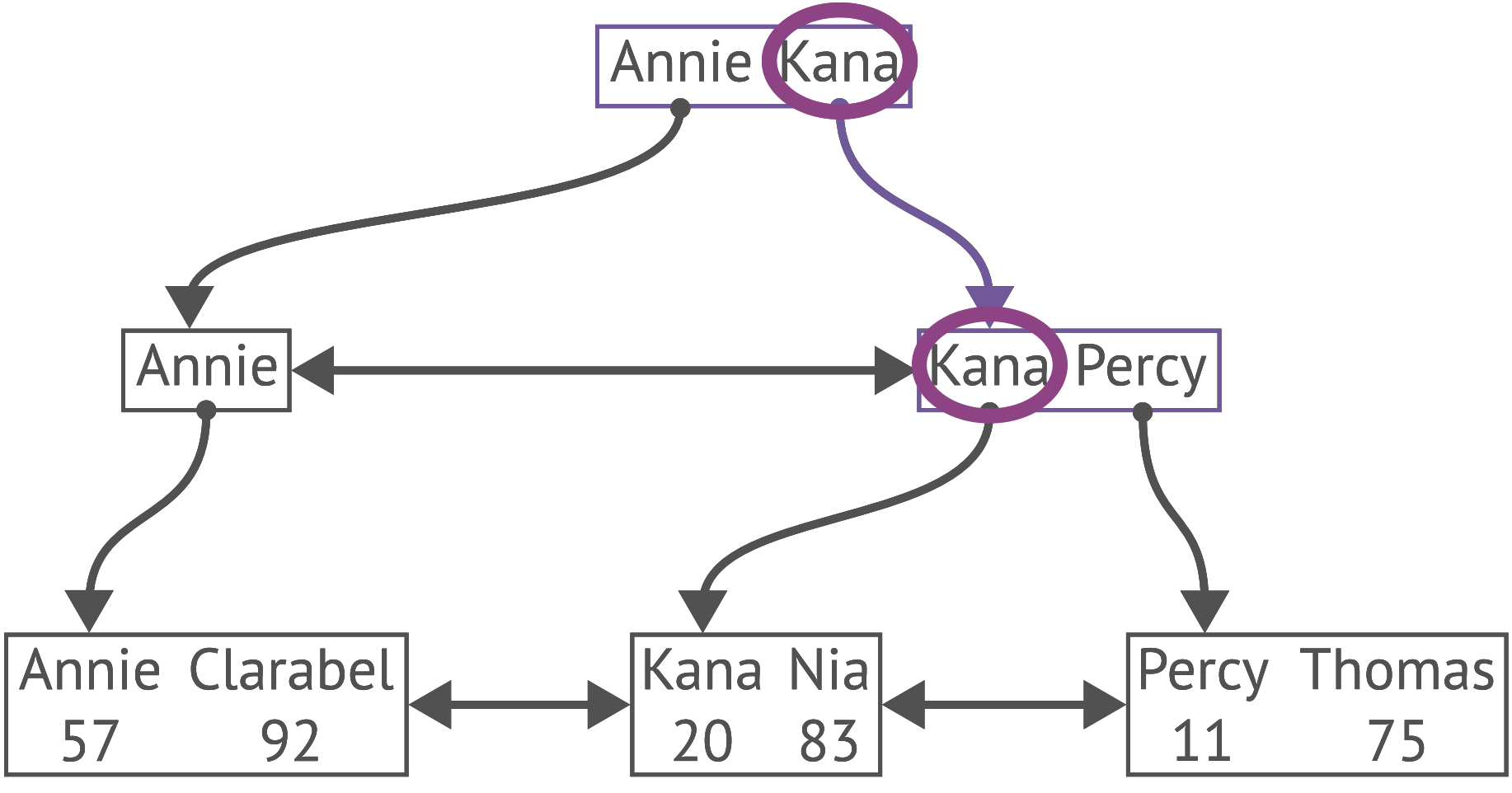
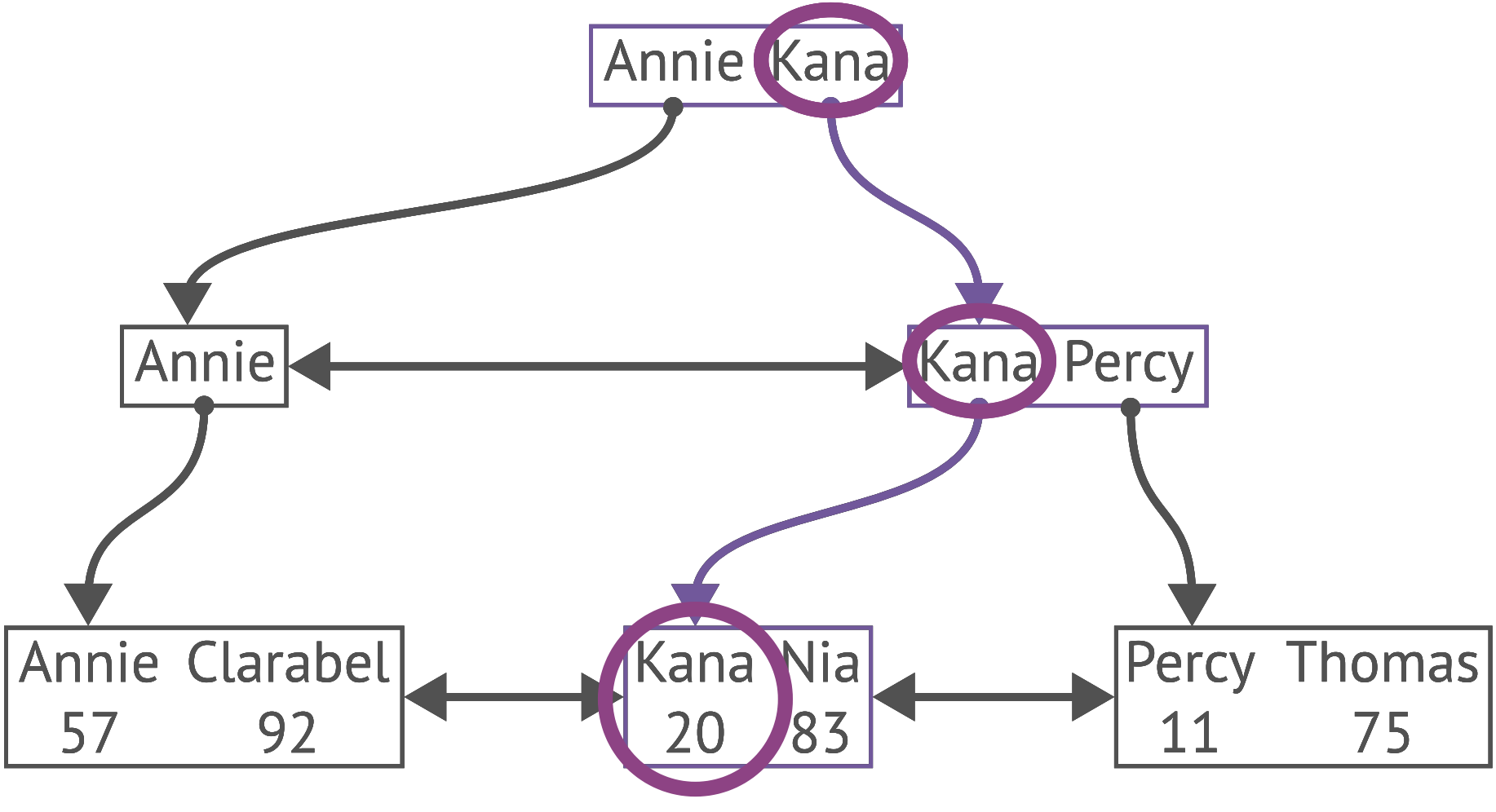


```
SELECT * FROM example_engine
WHERE name = 'Kana'
```



B+ tree search

B+ tree search

O(log n)

B+ tree search

O(log n)

Fast for even large **n**

O(log n)

# rows	~operations
1	1
10	2.3
100	4.6
1,000	6.9
10,000	9.2
100,000	11.5
1,000,000	13.8

Range scans

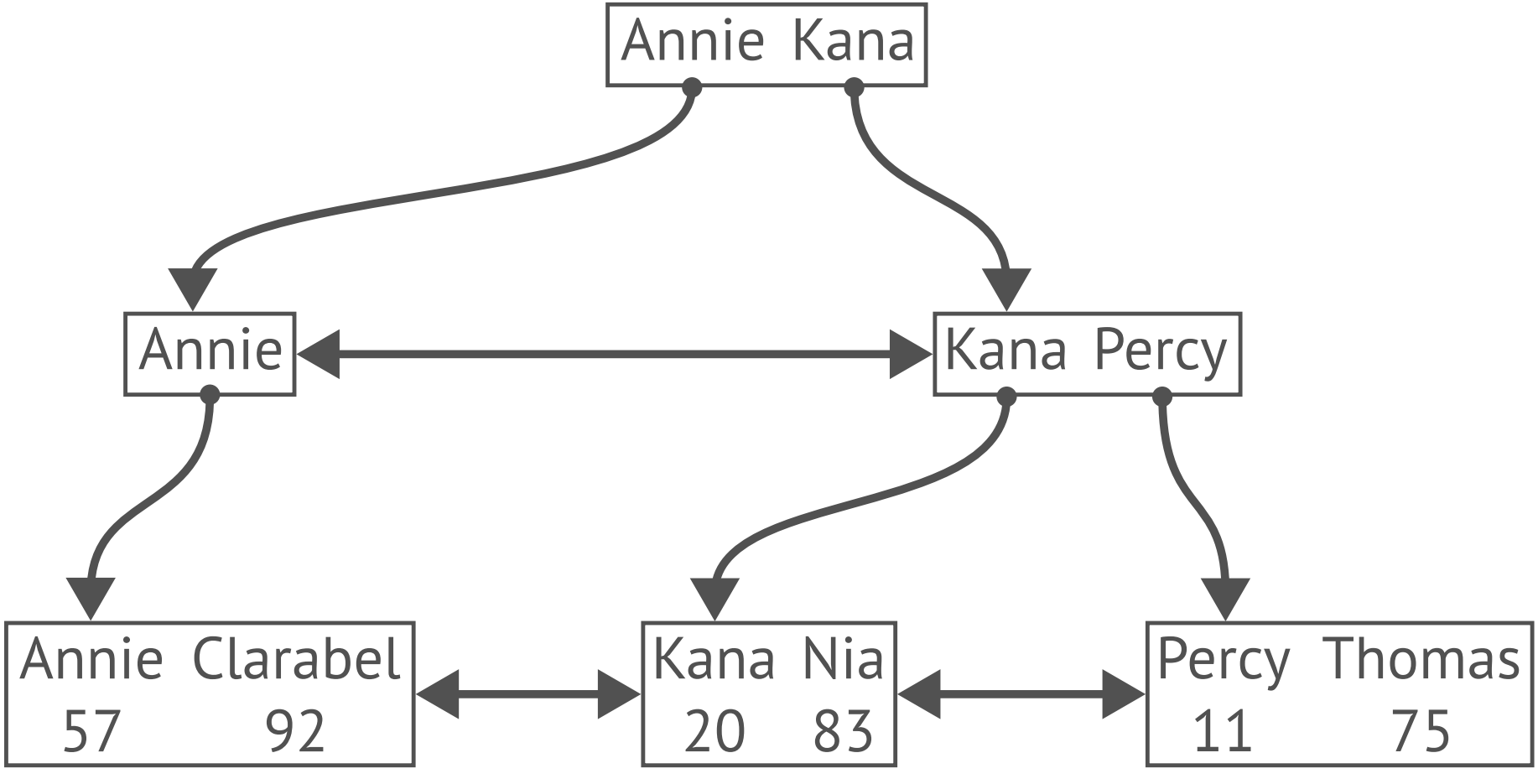
```
Engine.objects.filter(name__gte="Kana")
```

Range scans

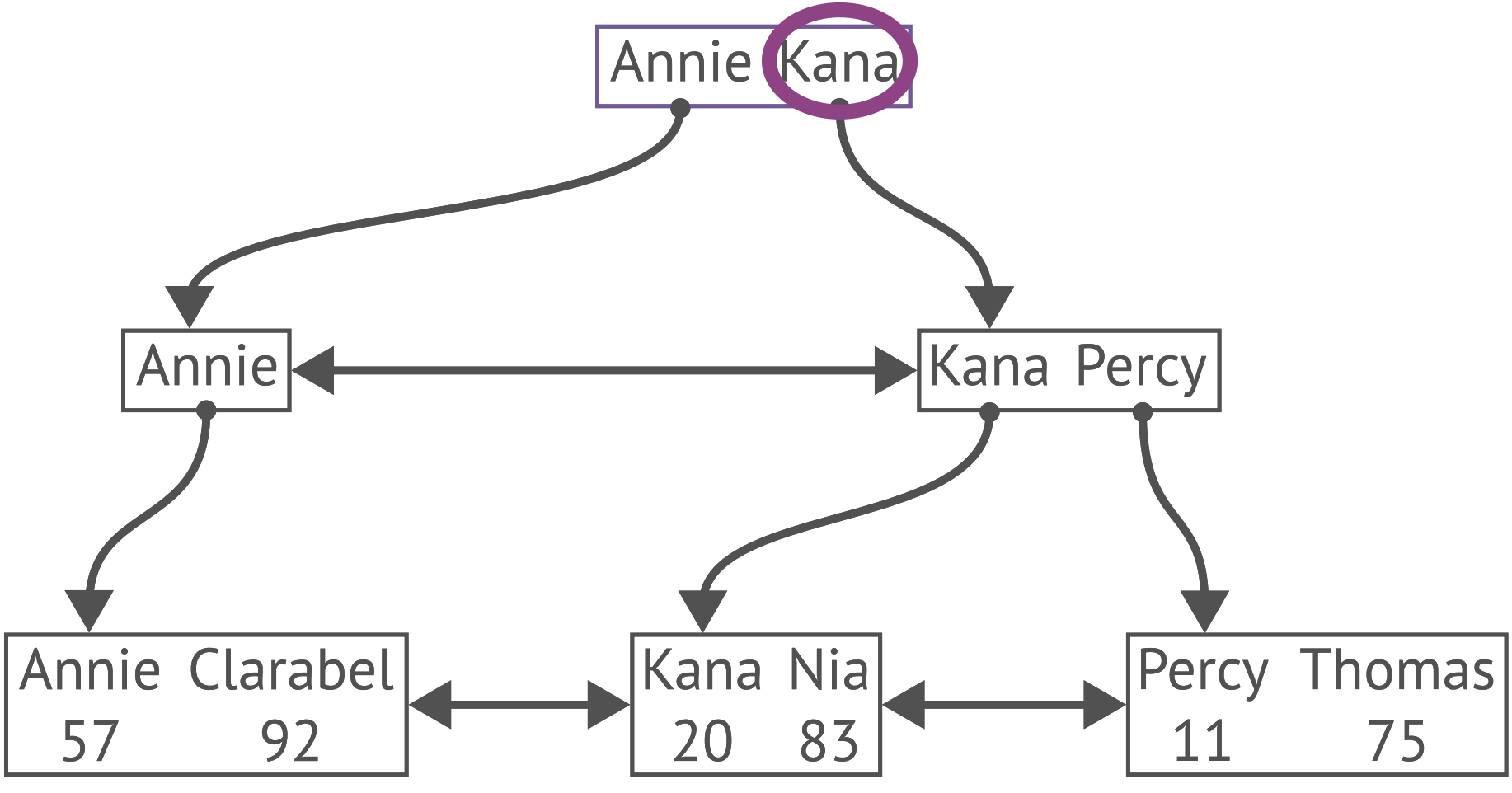
```
Engine.objects.filter(name__gte="Kana")
```

```
SELECT * FROM example_engine
WHERE name >= 'Kana'
```

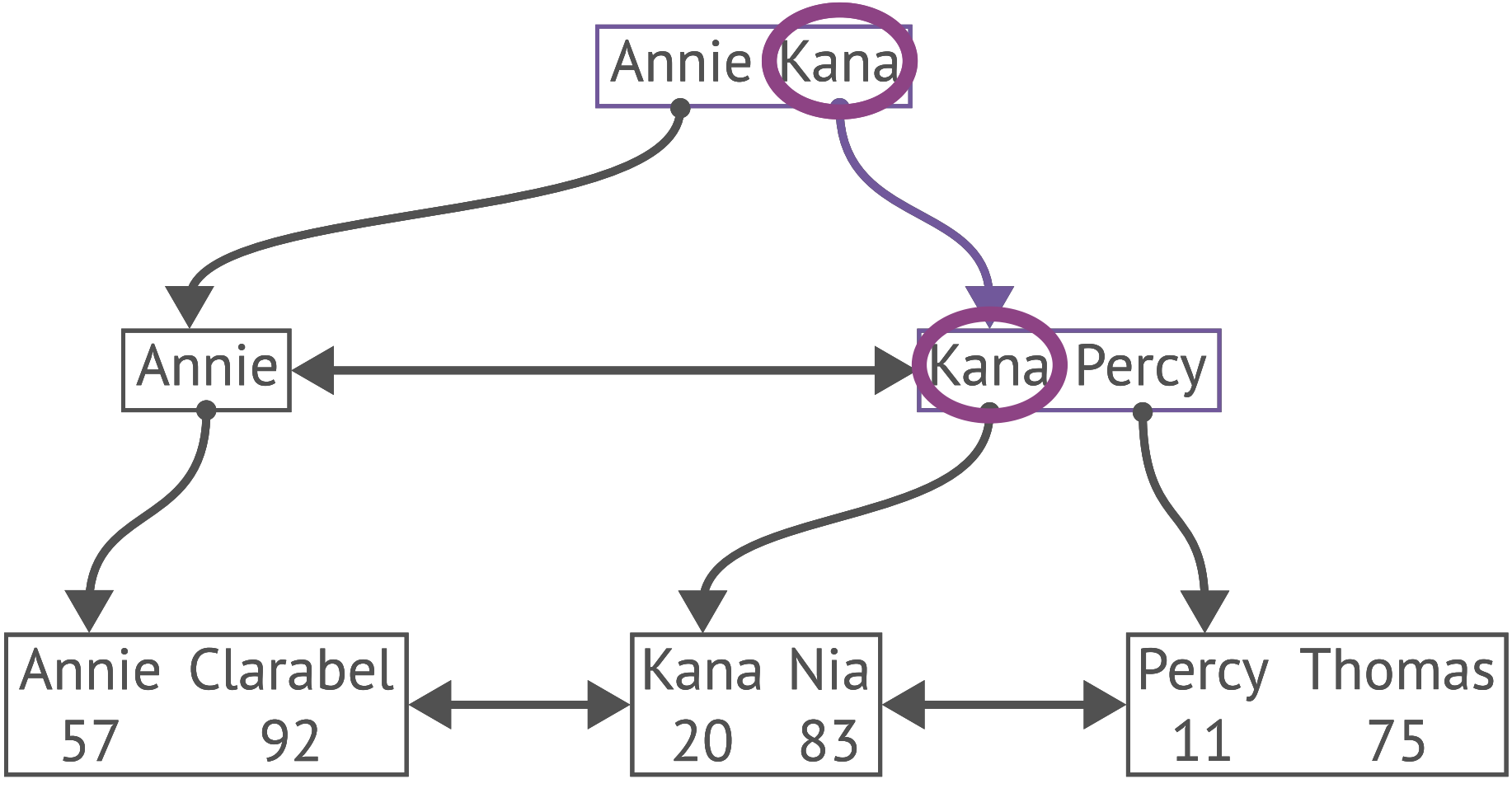
```
SELECT * FROM example_engine
WHERE name >= 'Kana'
```



```
SELECT * FROM example_engine
WHERE name >= 'Kana'
```



```
SELECT * FROM example_engine
WHERE name >= 'Kana'
```



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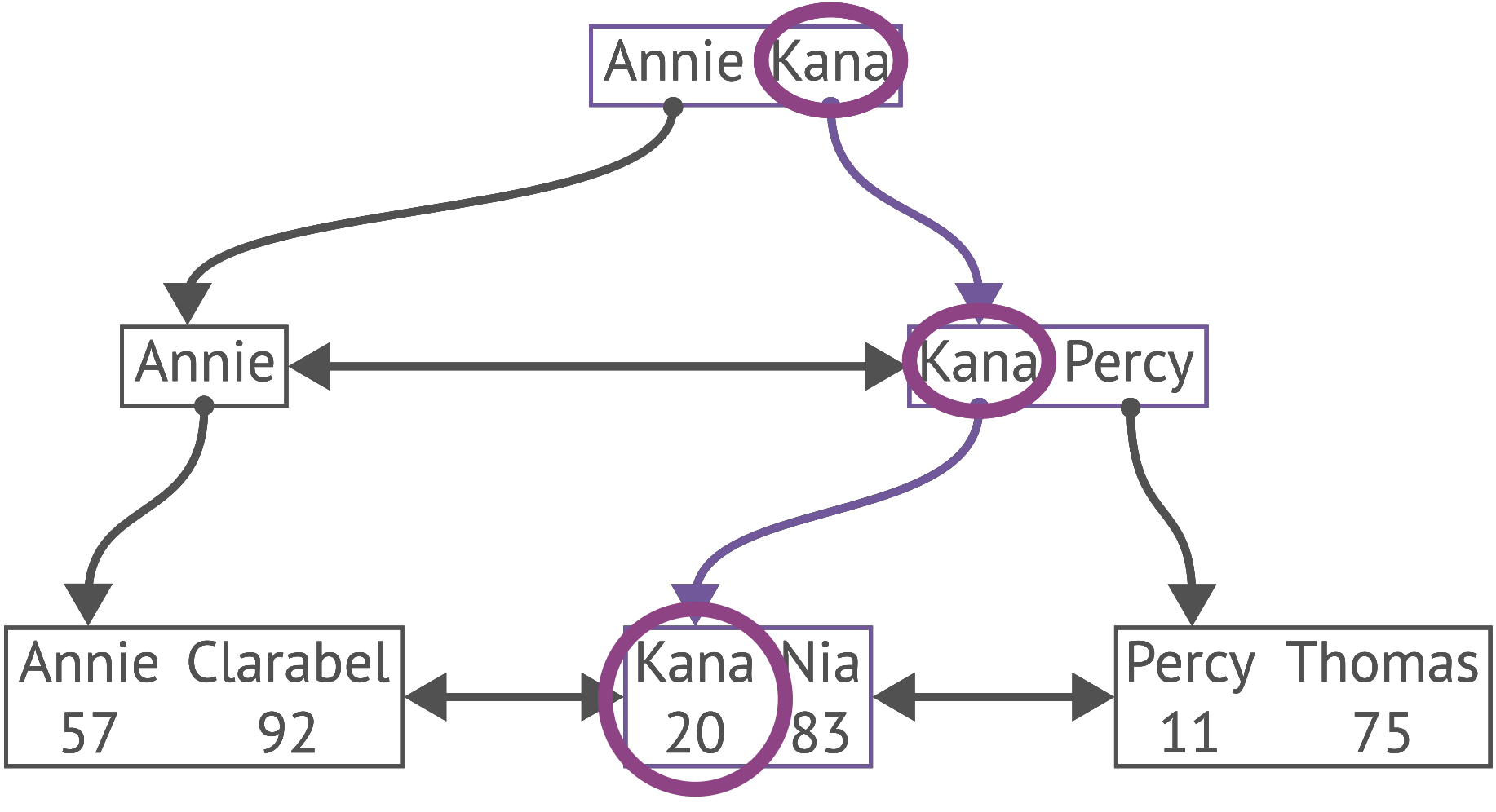
SELECT * FROM example_engine
WHERE name >= 'Kana'
```



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SELECT * FROM example_engine
WHERE name >= 'Kana'
```
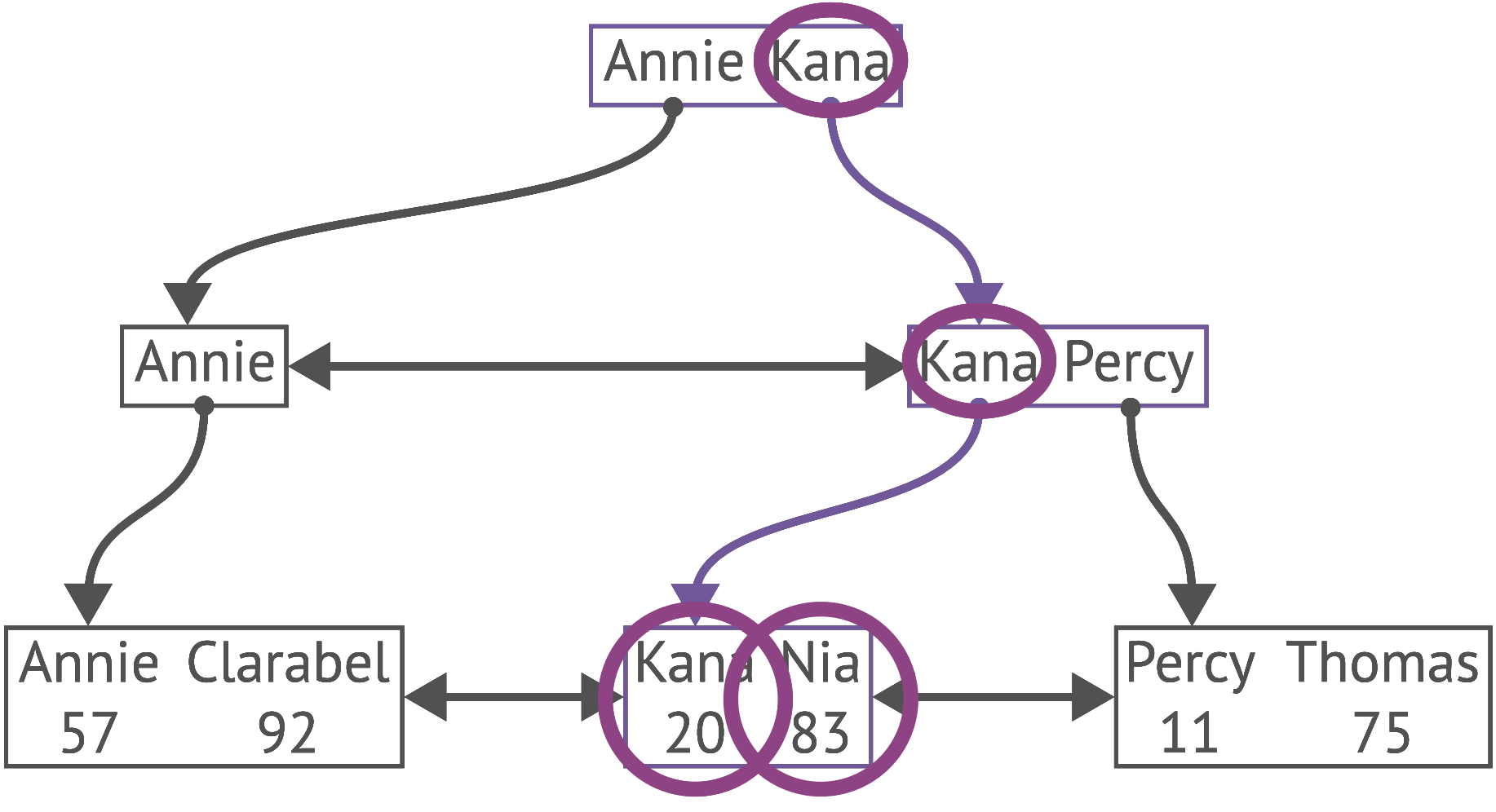
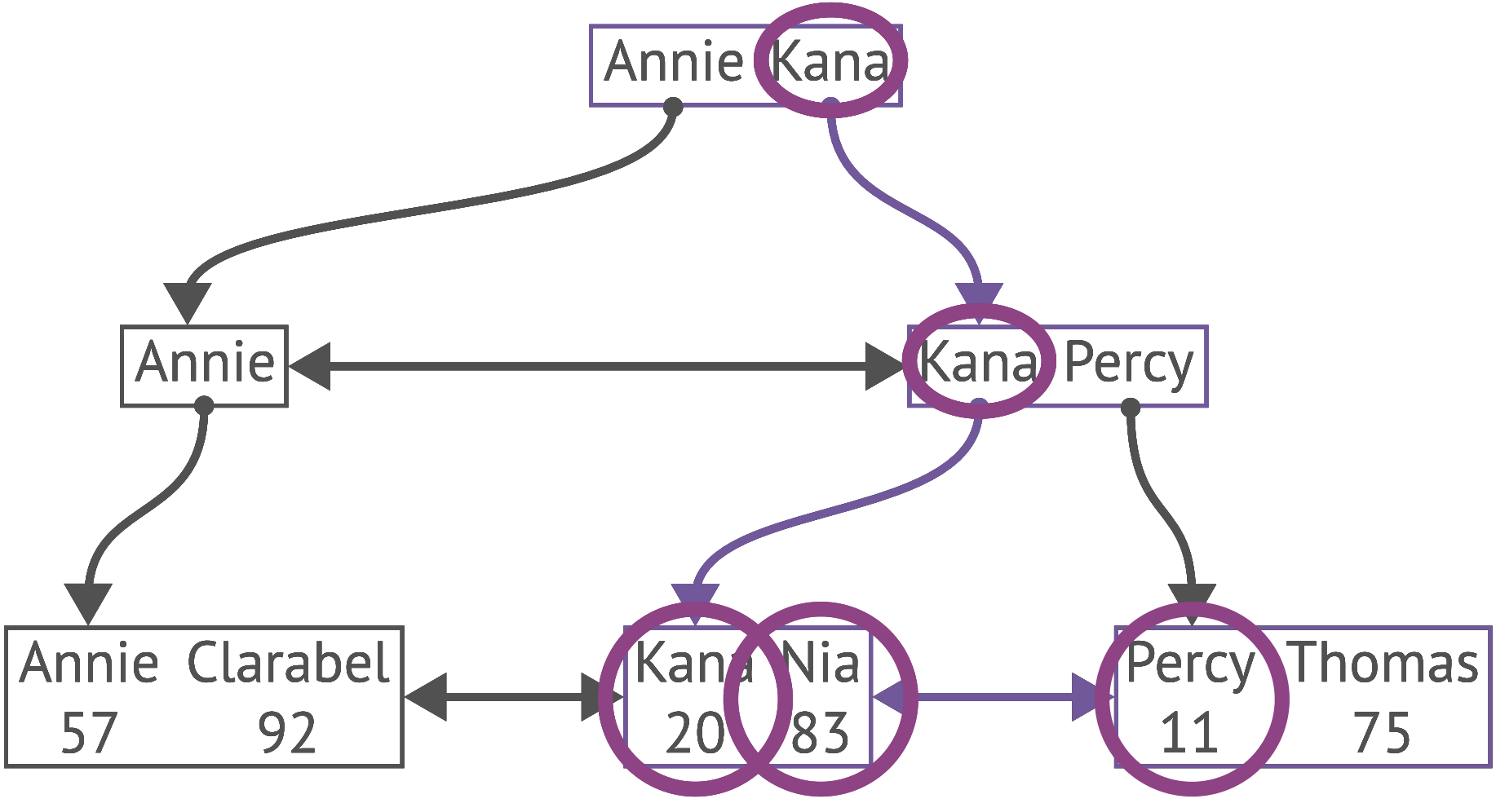
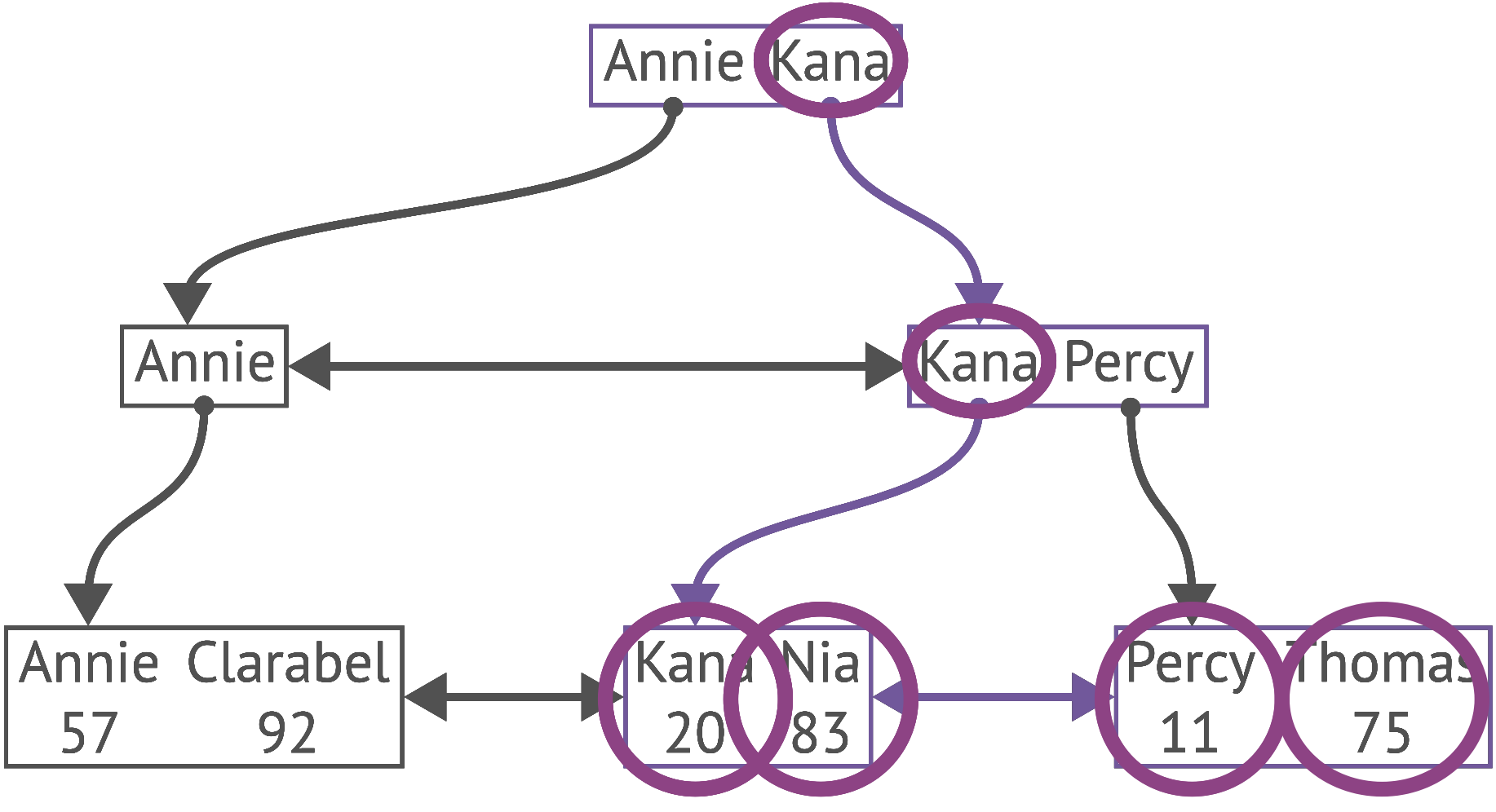



```
SELECT * FROM example_engine
WHERE name >= 'Kana'
```



```
SELECT * FROM example_engine
WHERE name >= 'Kana'
```



Multi-column indexes

```
from django.db import models

models.Index("name", "colour")
```

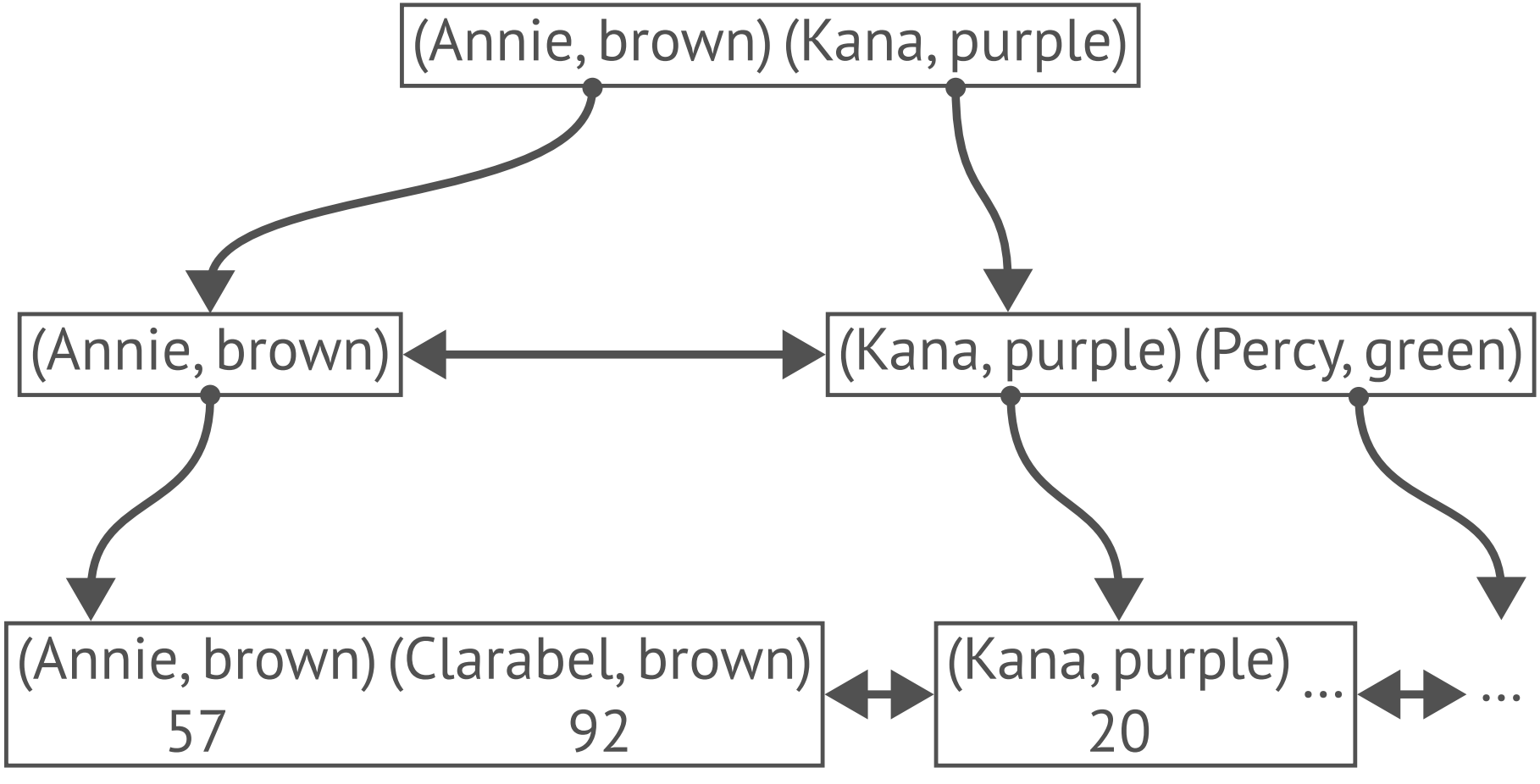
Multi-column indexes

```
from django.db import models

models.Index("name", "colour")
```

Like a `dict` of value tuples to row IDs

```
index_on_name_and_colour = {
    ("Kana", "purple"): [20],
    ("Percy", "green"): [11],
    ("Thomas", "blue"): [75],
}
```

```python
from django.db import models

models.Index("name", "colour")
```



Expression indexes

```
from django.db import models
from django.db.models import Lower

models.Index(Lower("name"))
```

Expression indexes

```
from django.db import models
from django.db.models import Lower

models.Index(Lower("name"))
```

Speeds up filtering like:

```
Engine.objects.annotate(
    name_lower=Lower("name")
).filter(
    name_lower="kana"
)
```

Partial indexes

```
from django.db import models

models.Index(
    "name",
    condition=models.Q(colour="purple"),
)
```

Partial indexes

```
from django.db import models

models.Index(
    "name",
    condition=models.Q(colour="purple"),
)
```

Speeds up only queries with `condition`:

```
Engine.objects.filter(colour="purple", name="Kana")
```

Inclusion indexes

```
from django.db import models

models.Index(
    "name",
    include=["colour"]
)
```

Inclusion indexes

```
from django.db import models

models.Index(
    "name",
    include=["colour"]
)
```

Speeds up queries that only use indexed and included columns:

```
Engine.objects.filter(
    name="Kana",
).only("name", "colour")
```

Alternative index data structures

Typically **O(log n)** but smaller

Alternative index data structures

Typically **O(log n)** but smaller

- **GiST** - spatial data, full text search
- **GIN** - full text search, JSON
- **Hash** - dict-like
- **Bloom** - bloom filters
- **HNSW** / **IVFFlat** - embedding vectors (pgvector)

Alternative index data structures

Typically **O(log n)** but smaller

- **GiST** - spatial data, full text search
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- **Hash** - dict-like
- **Bloom** - bloom filters
- **HNSW** / **IVFFlat** - embedding vectors (pgvector)

See `django.contrib.postgres.indexes`

Options combinable

Partial inclusion multi-column expression bloom index, anyone?

Default indexes

- Primary key
- Foreign keys
- Unique constraints

Replace a default index

```
from django.db import models

class Engine(models.Model):
    ...
    home = models.ForeignKey(..., db_index=False)

    class Meta:
        indexes = [
            models.Index("home"),
        ]
```

Indexes are not free

Extra storage

Overhead on writes

So we cannot “index all the things”

Which indexes to add?

Which indexes to add?

Whole system optimization problem

Which indexes to add?

Whole system optimization problem

More of an art than a science

Two approaches

1. **Design** indexes with model and queries
2. **Debug** slow/resource-consuming queries

Design

“I know we will be filtering by `name` a lot, so let’s index it”

Debug

“These are the slowest queries, let’s see if any indexes could help them”

pgMustard

pgMustard

Get the **query plan** with `QuerySet.explain()`:

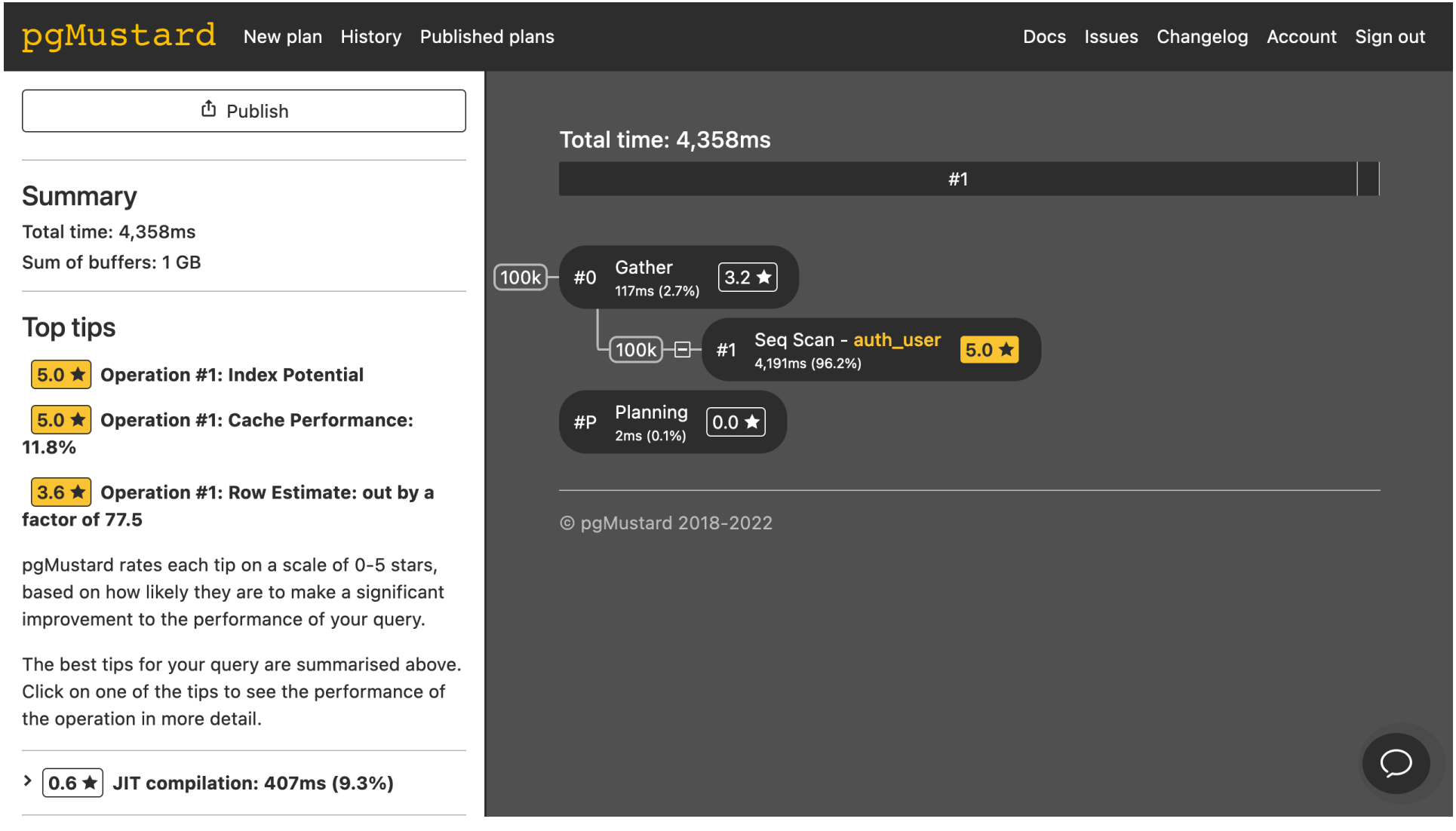
```
Engine.objects.filter(name="kana").explain(
    format="json",
    analyze=True,
    buffers=True,
    verbose=True,
    settings=True,
    wal=True,
)
```

pgMustard

Query plan:


```
[{"Plan": {"Node Type": "Gather", "Parallel Aware":
false, "Startup Cost": 1000.0, "Total Cost":
191384.91, "Plan Rows": 1031, "Plan Width": 72,
"Actual Startup Time": 36.64, "Actual Total Time":
4307.309, "Actual Rows": 100001, "Actual Loops": 1,
...
```

pgMustard


pgMustard
New plan
History
Published plans
Docs
Issues
Changelog
Account
Sign out
Publish
Summary
Total time: 4,358ms
Sum of buffers: 1 GB
Top tips
5.0 ★ Operation #1: Index Potential
5.0 ★ Operation #1: Cache Performance: 11.8%
3.6 ★ Operation #1: Row Estimate: out by a factor of 77.5
pgMustard rates each tip on a scale of 0-5 stars, based on how likely they are to make a significant improvement to the performance of your query.
The best tips for your query are summarised above. Click on one of the tips to see the performance of the operation in more detail.
0.6 ★ JIT compilation: 407ms (9.3%)
Total time: 4,358ms
#1
100k
#0 Gather
117ms (2.7%)
3.2 ★
100k
#1 Seq Scan - auth_user
4,191ms (96.2%)
5.0 ★
#P Planning
2ms (0.1%)
0.0 ★
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Resources

- PlanetScale B-trees post
- use-the-index-luke.com
- Django pgMustard
- Django's indexes documentation
- PostgreSQL docs Chapter 11: Indexes

Thank you! 🤗

- adamj.eu
- github.com/adamchainz/talk-data-oriented-django-drei
- adamj.eu/books
  - Boost Your GitHub DX ***beta***
  - Boost Your Django DX
  - Boost Your Git DX
  - Speed Up Your Django Tests