FlyMine

An integrated database for *Drosophila* and *Anopheles* genomics

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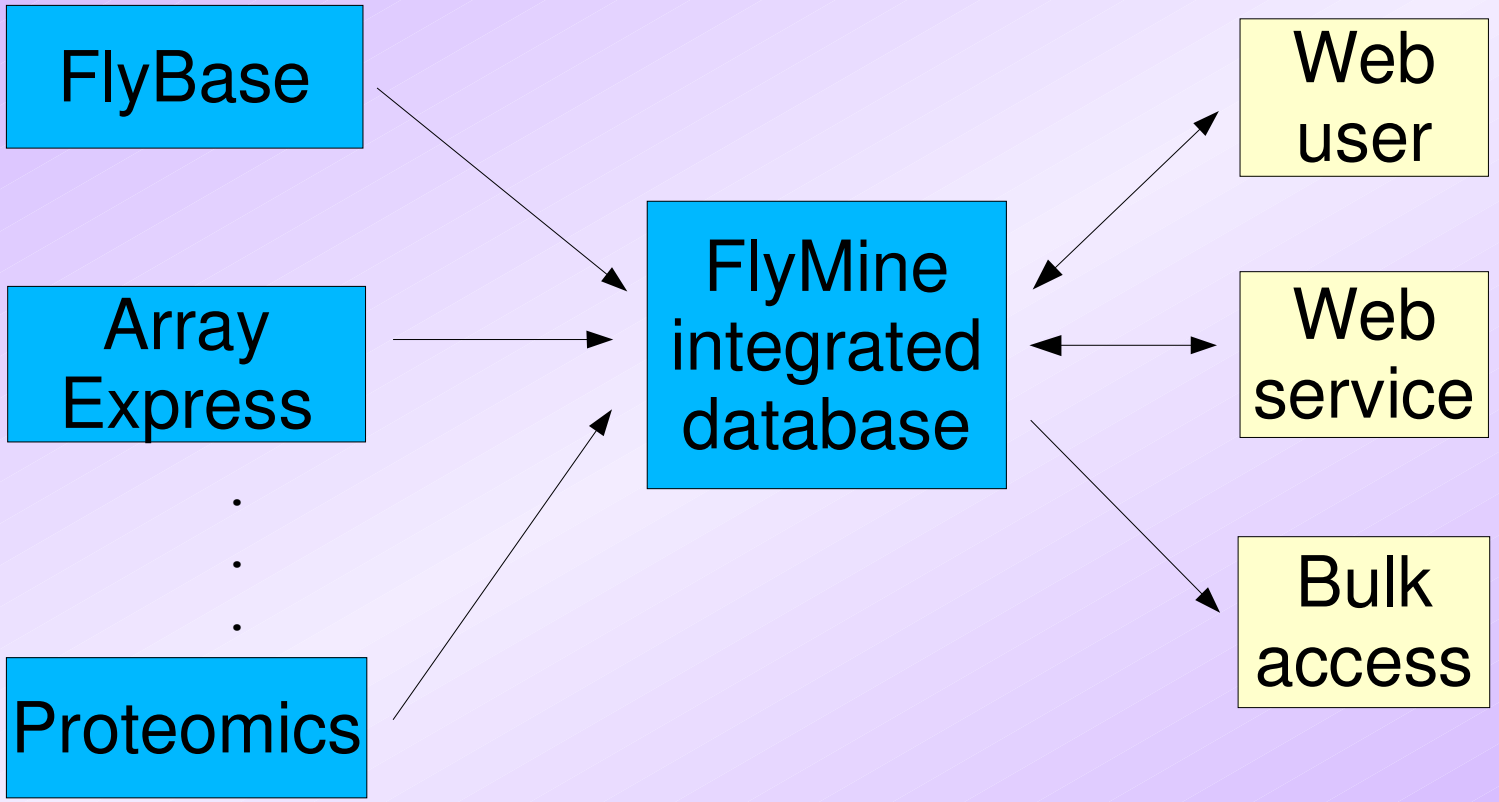
24th June 2003

Why yet another database?

- Currently lots of little databases
  - fine for “browsing”, bad for “querying”
- Hard to query across them
- Massive amounts of experimental data (microarray, proteomics) being produced
- Need to tie this information together
- Chado etc. did not exist
  - FlyMine has broader scope

Outline

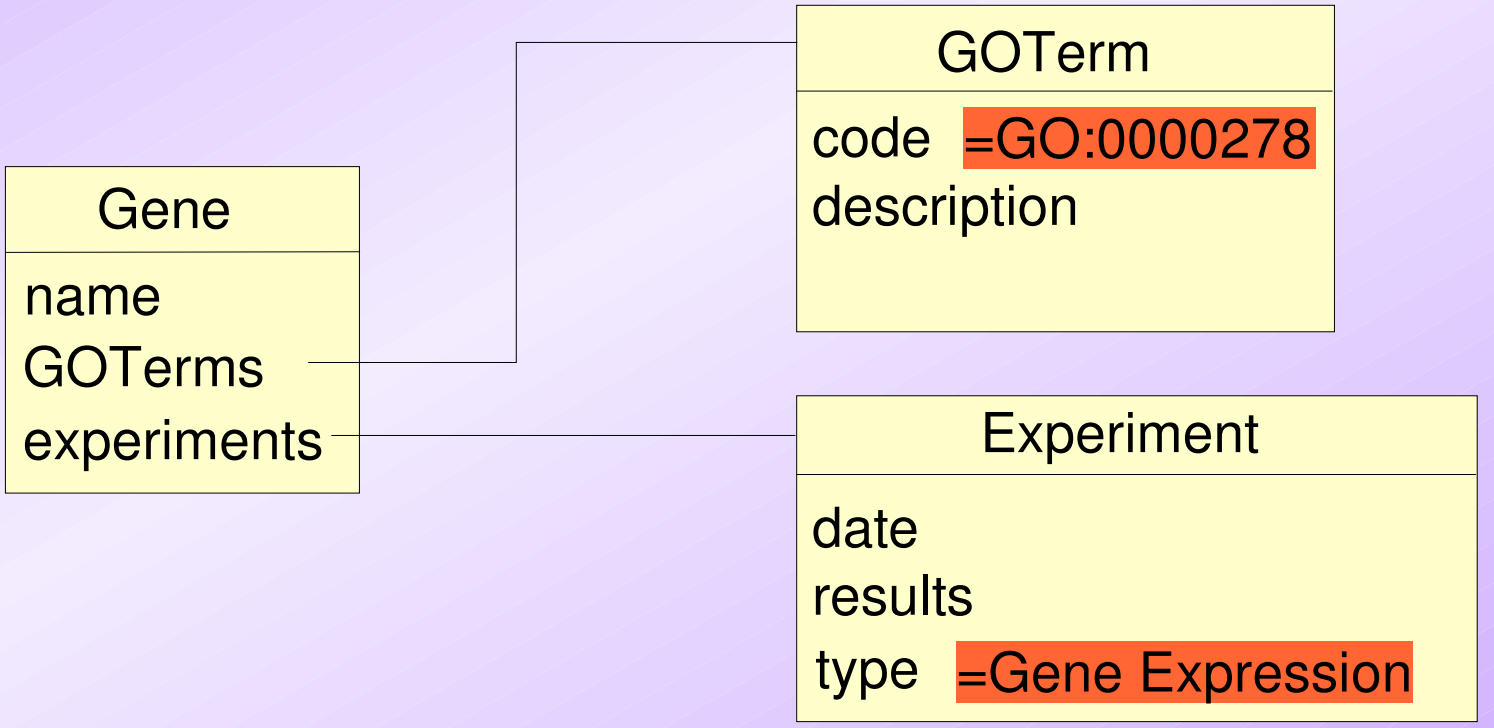

FlyBase
Array Express
Proteomics
FlyMine integrated database
Web user
Web service
Bulk access

Aims

- Integrate data from multiple sources
- Allow arbitrary queries from users
- Queries based on objects, not SQL
- Multiple query interfaces (Java, OQL, graphical, etc)
- Different classes of user (web-based, SOAP)
- Open source!

Query interfaces – graphical

"Show gene expression data for genes which have GO term GO:0000278 applied"



Query interfaces – OQL

"Show gene expression data for genes which have GO term GO:0000278 applied"

```
SELECT gene, exp
FROM Gene AS gene, GOTerm AS term,
     Experiment AS exp
WHERE gene.GOTerms CONTAINS term
AND term.code = "GO:0000278"
AND gene.experiments CONTAINS exp
AND exp.type = "Gene Expression"
```

Query interfaces – Java

"Show gene expression data for genes which have GO term GO:0000278 applied"

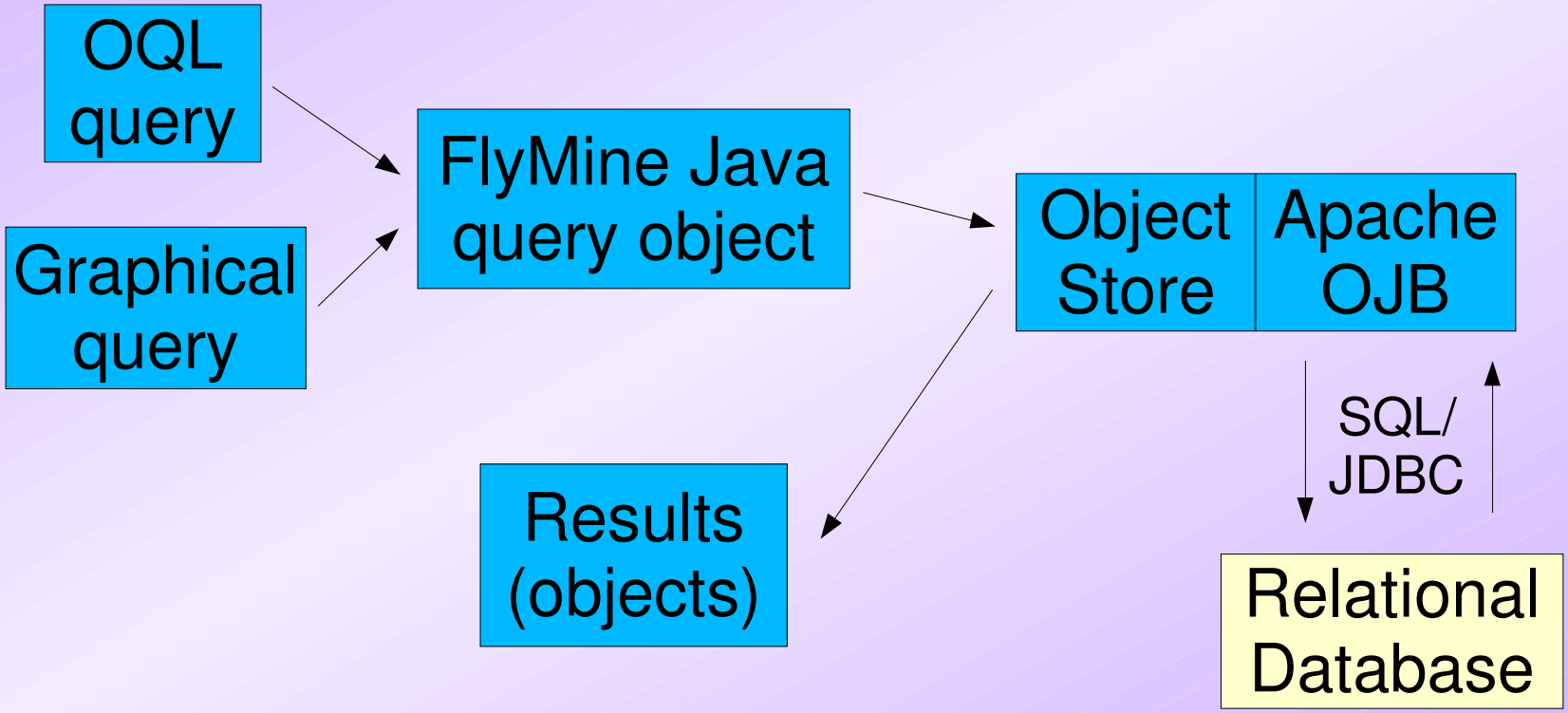
```
Query q = new Query();
QueryClass qcGene = new QueryClass(Gene.class);
QueryClass qcTerm = new QueryClass(GOTerm.class);
QueryField qfGeneTerm = new QueryField(qcGene, "GOTerms")
ConstraintSet cs = new ConstraintSet();
Constraint con1 = new ContainsConstraint(qfGeneTerm,
                  ContainsConstraint.CONTAINS, qcTerm);
cs.add(con1);
.
.
q.setConstraint(cs);
```

Object databases

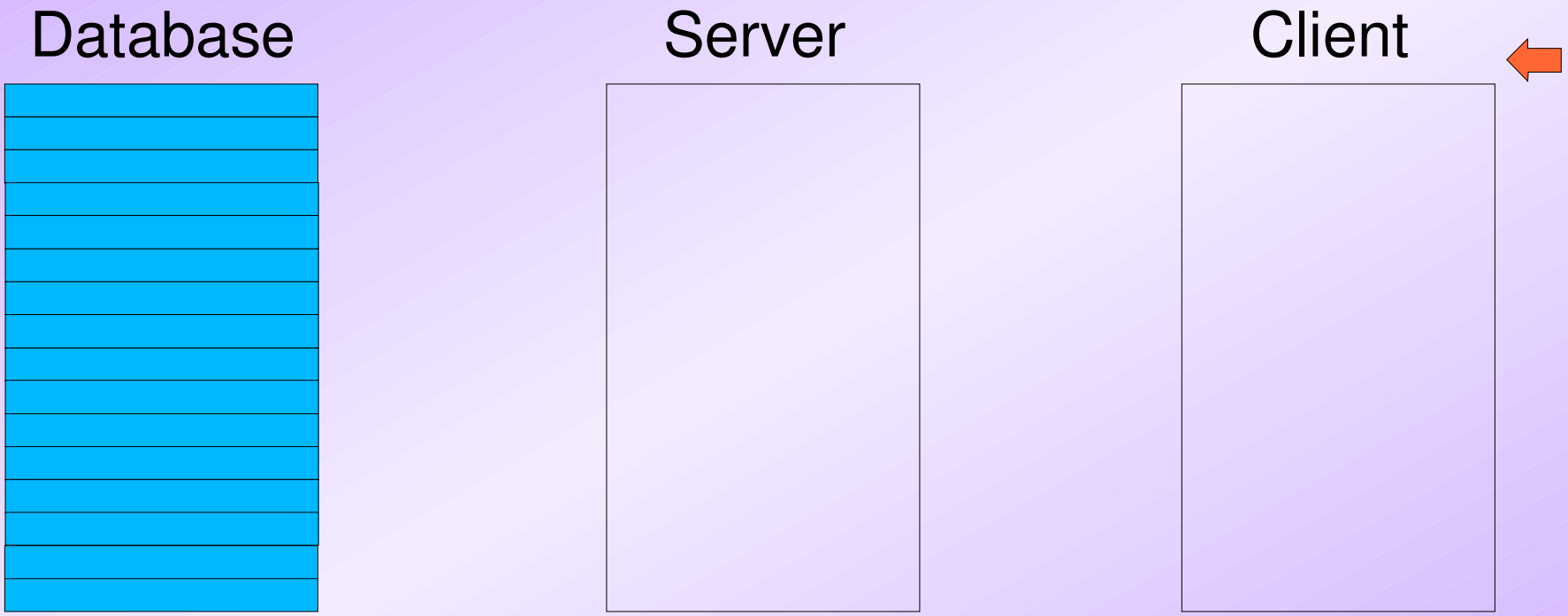
- Open-source solutions include
  - Apache OJB
  - Hibernate
  - Castor
  - various object databases
- Commercial
  - various JDO vendors

FlyMine ObjectStore

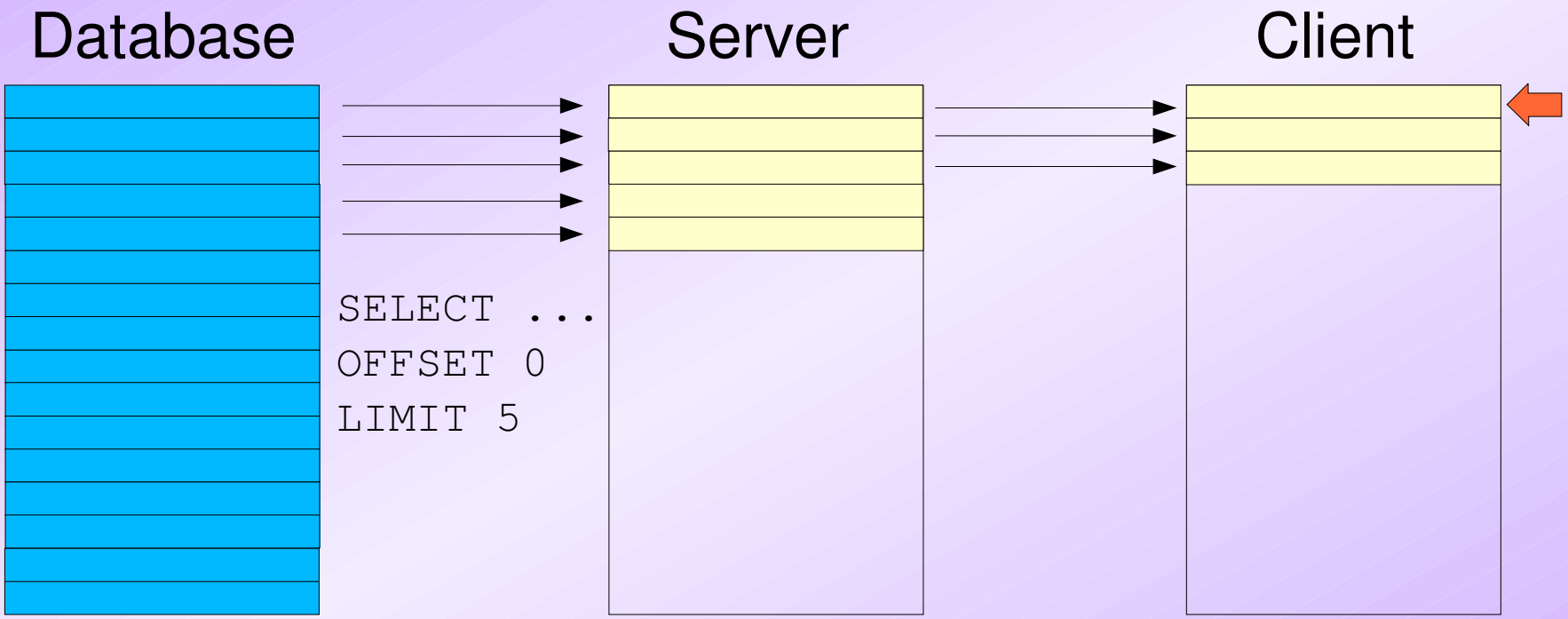
- Based on heavily modified Apache OJB



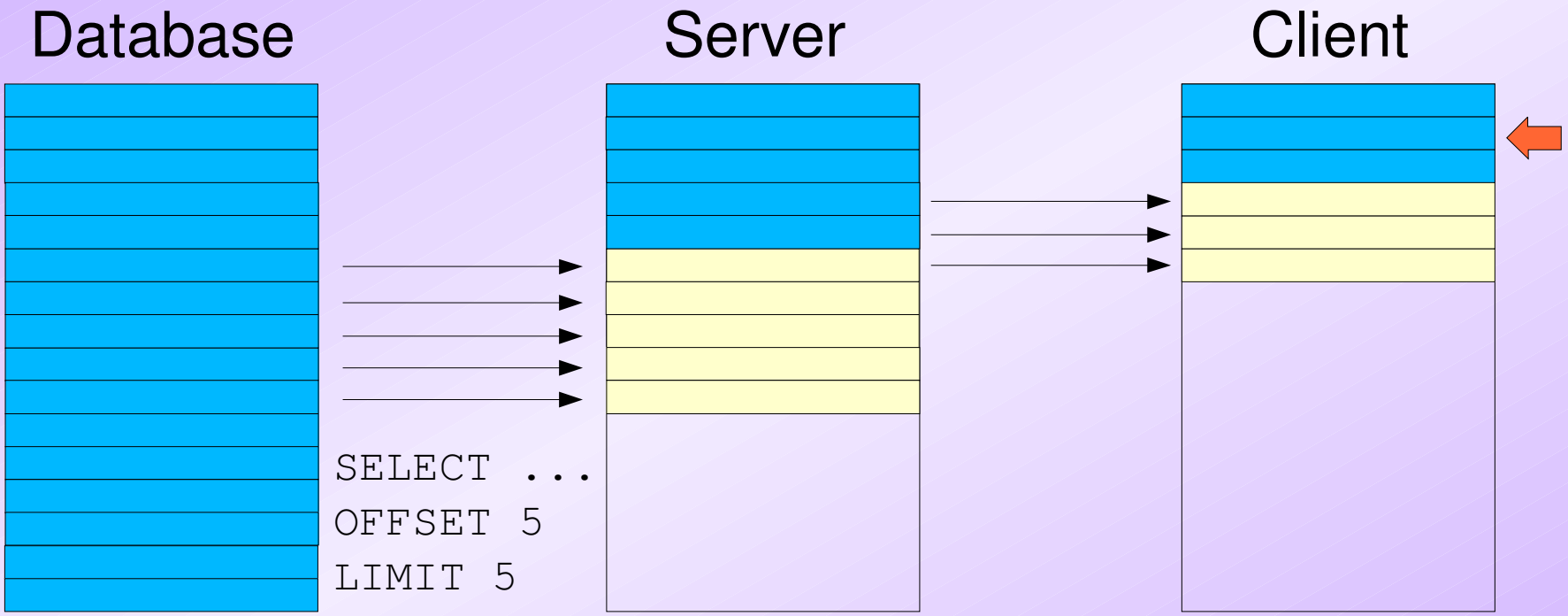
Results



Results



Results



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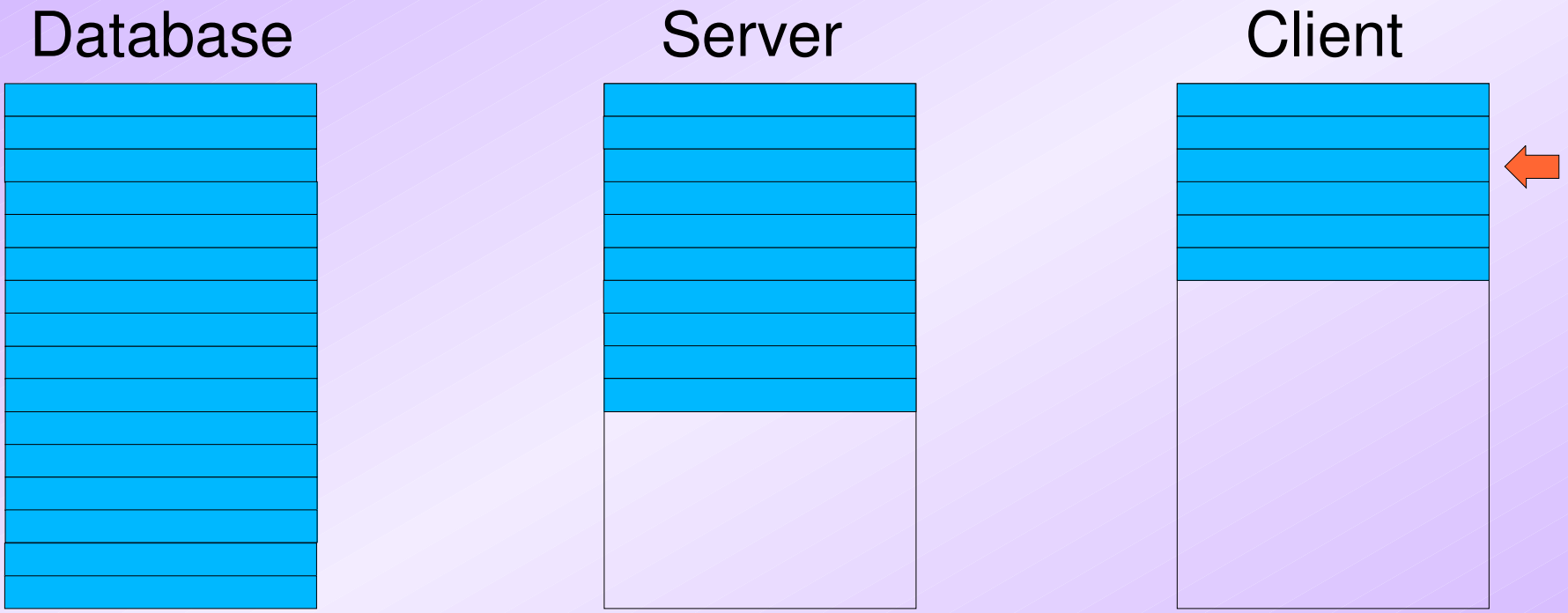
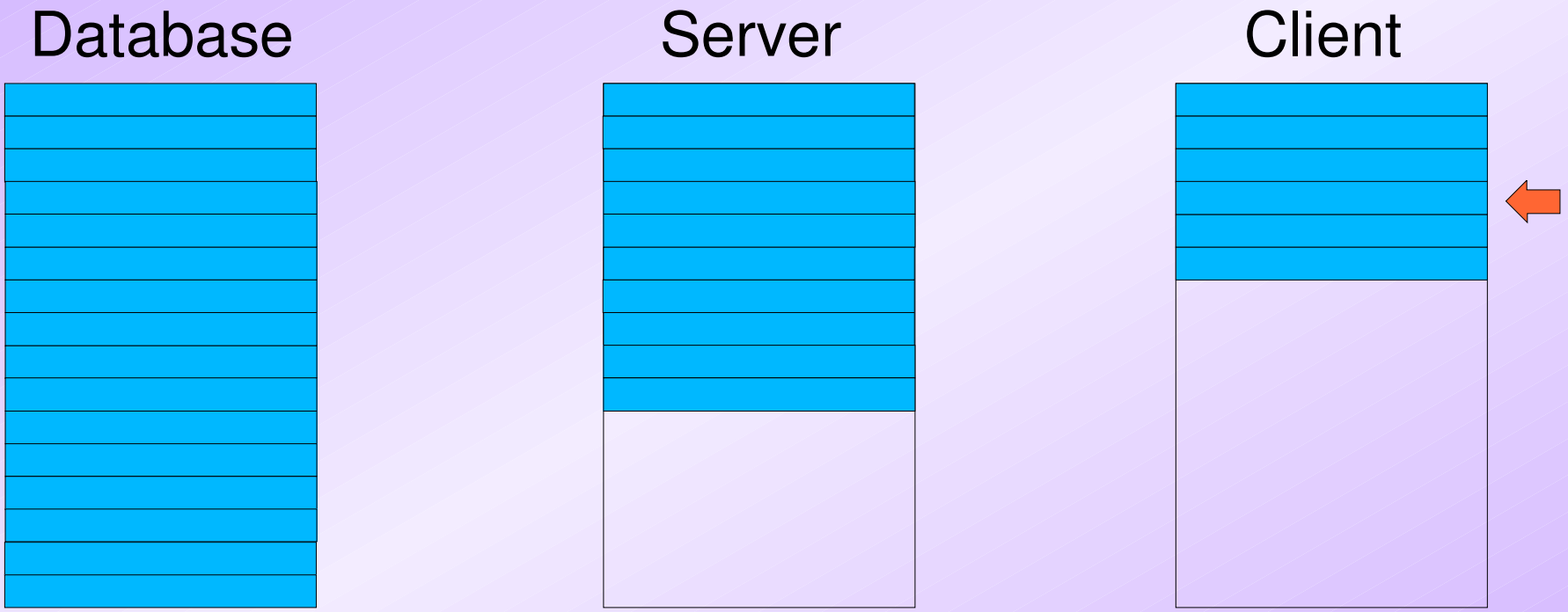
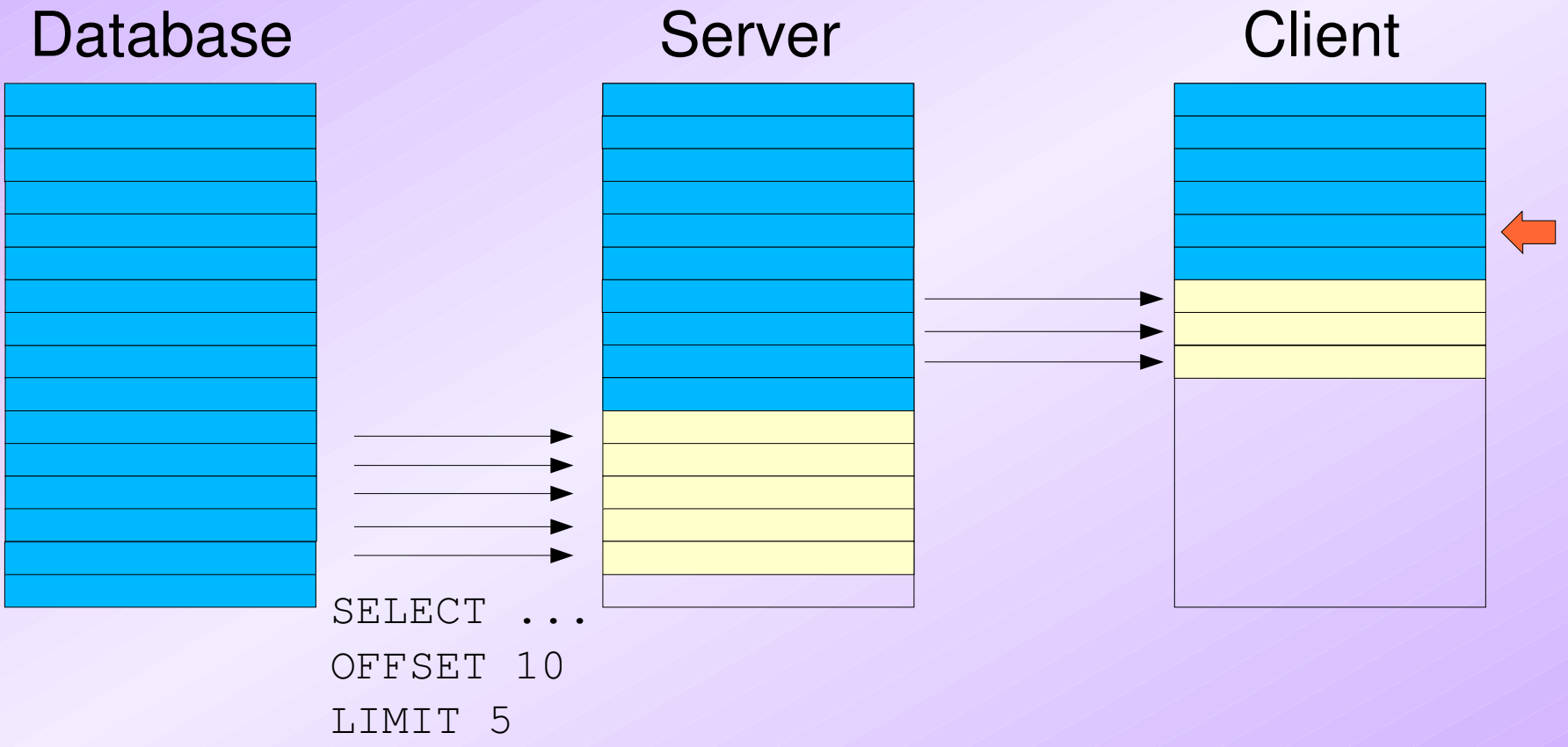


Results

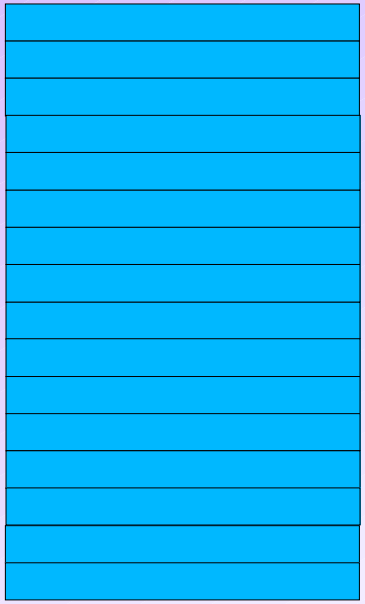


Results

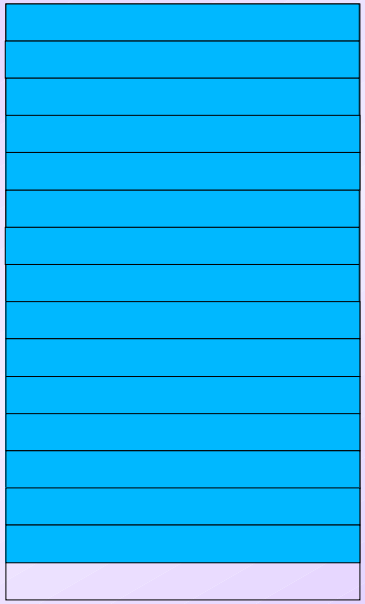


Results

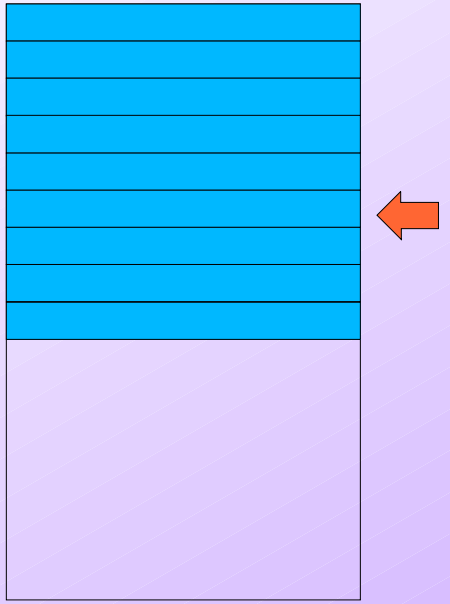
Database



Server

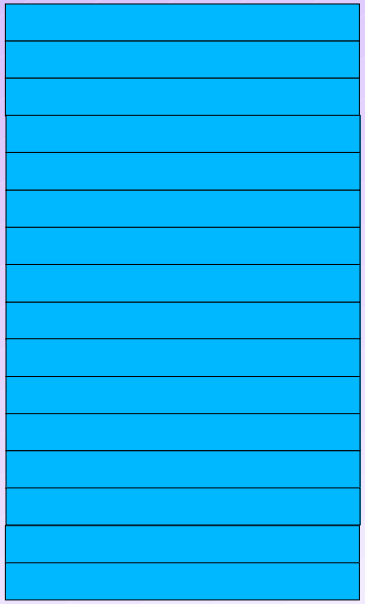


Client

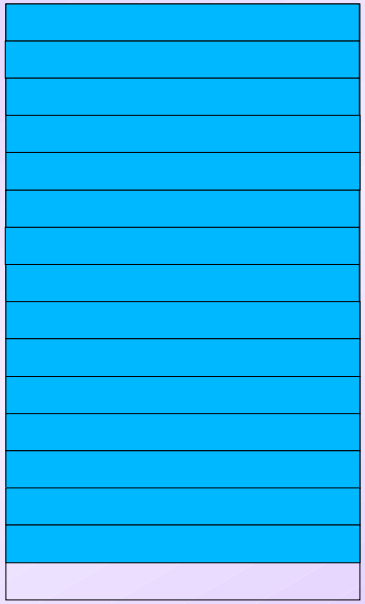


Results

Database



Server



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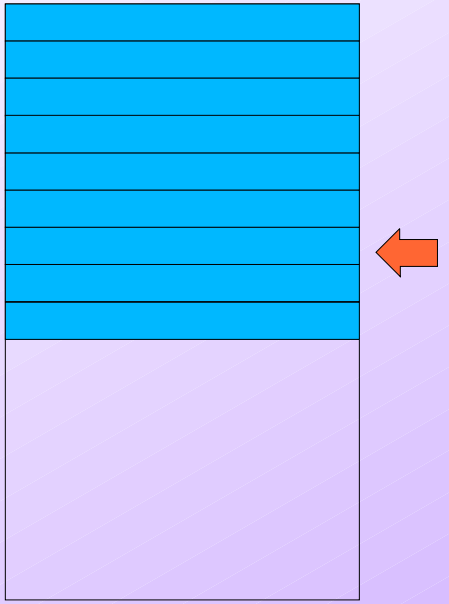
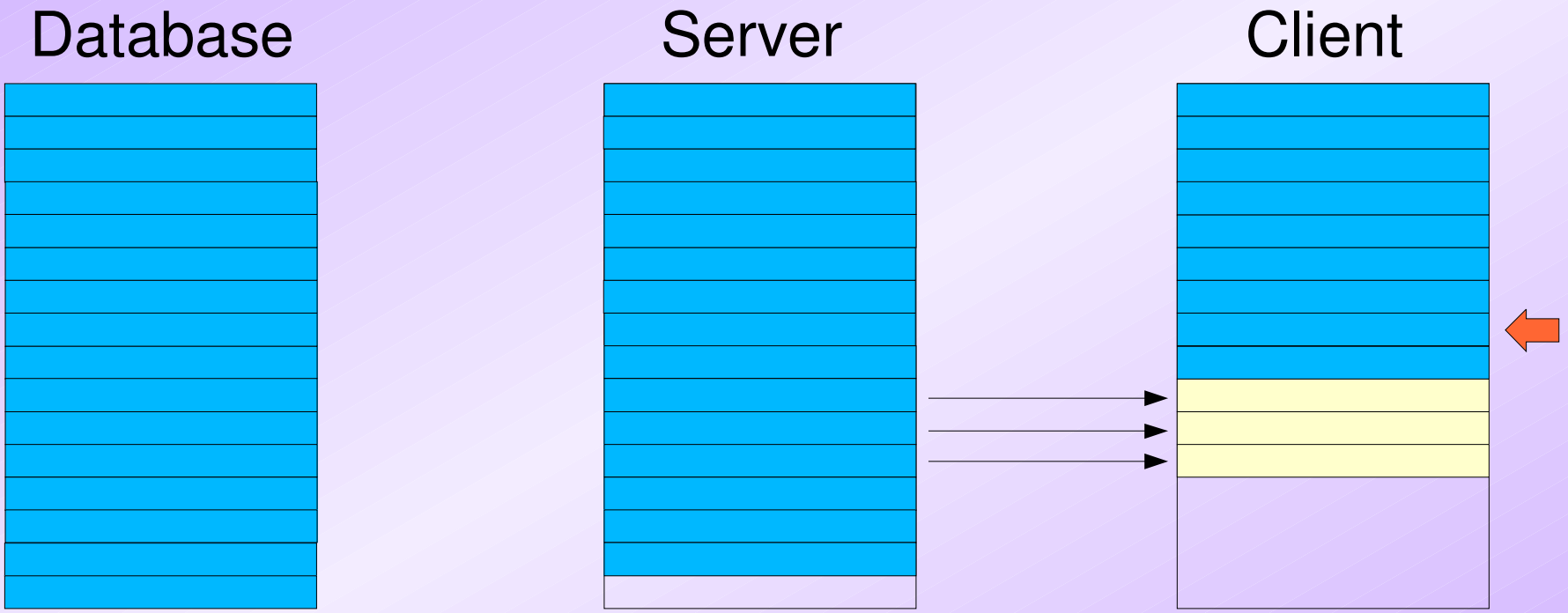
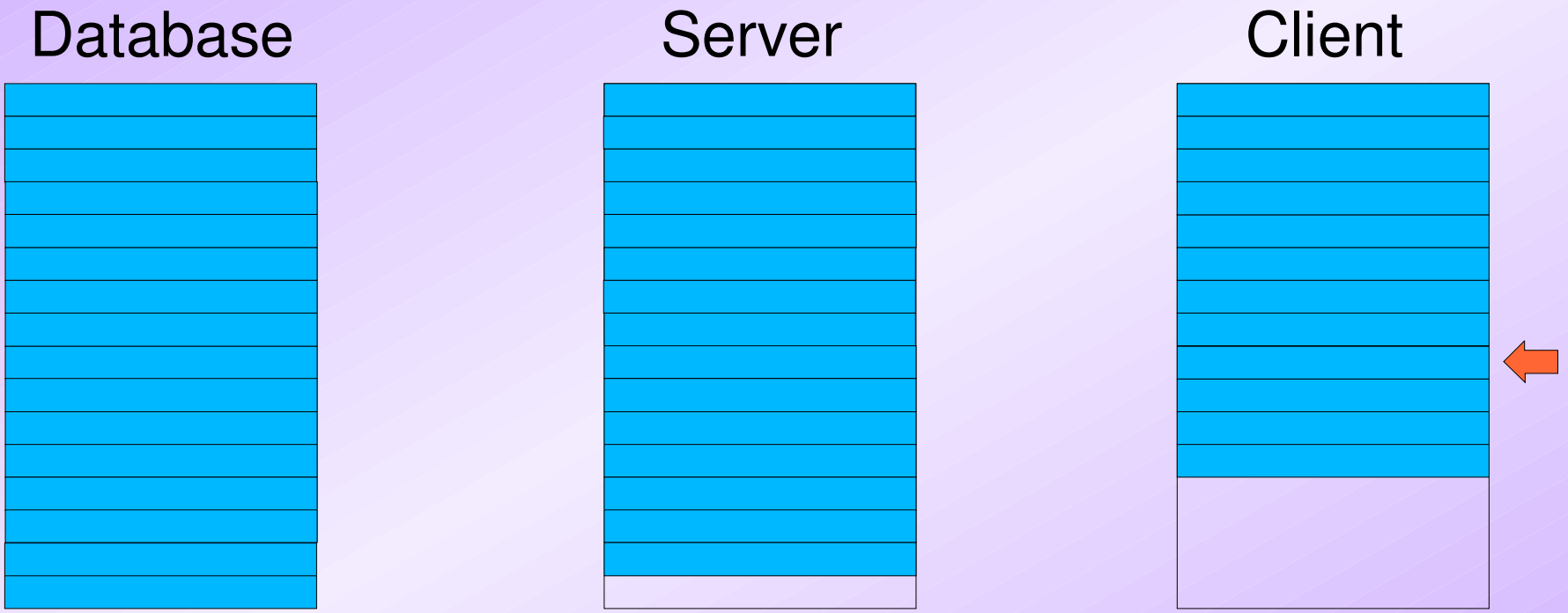


Results

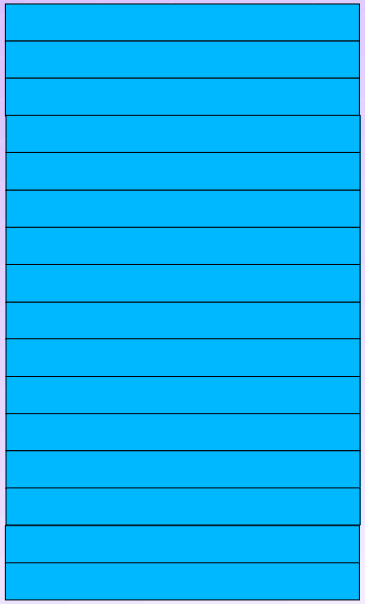


Results

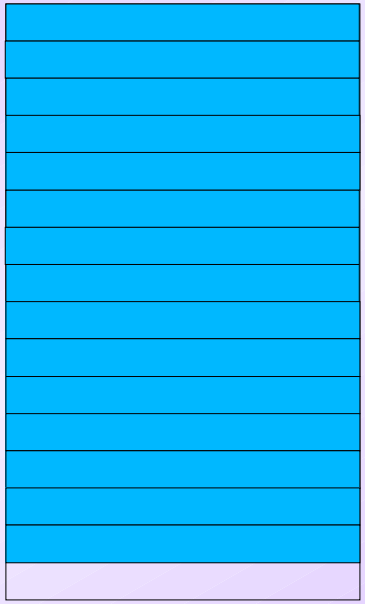


Results

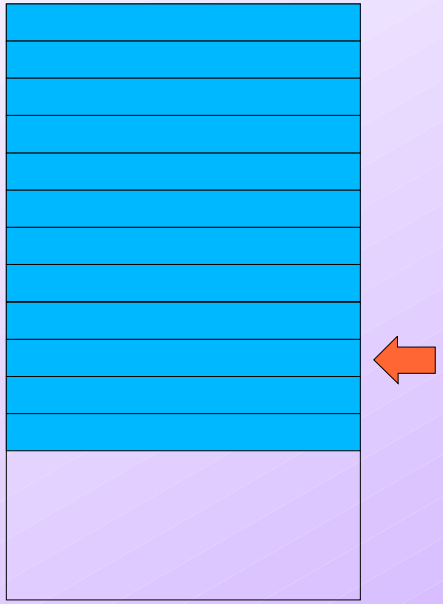
Database



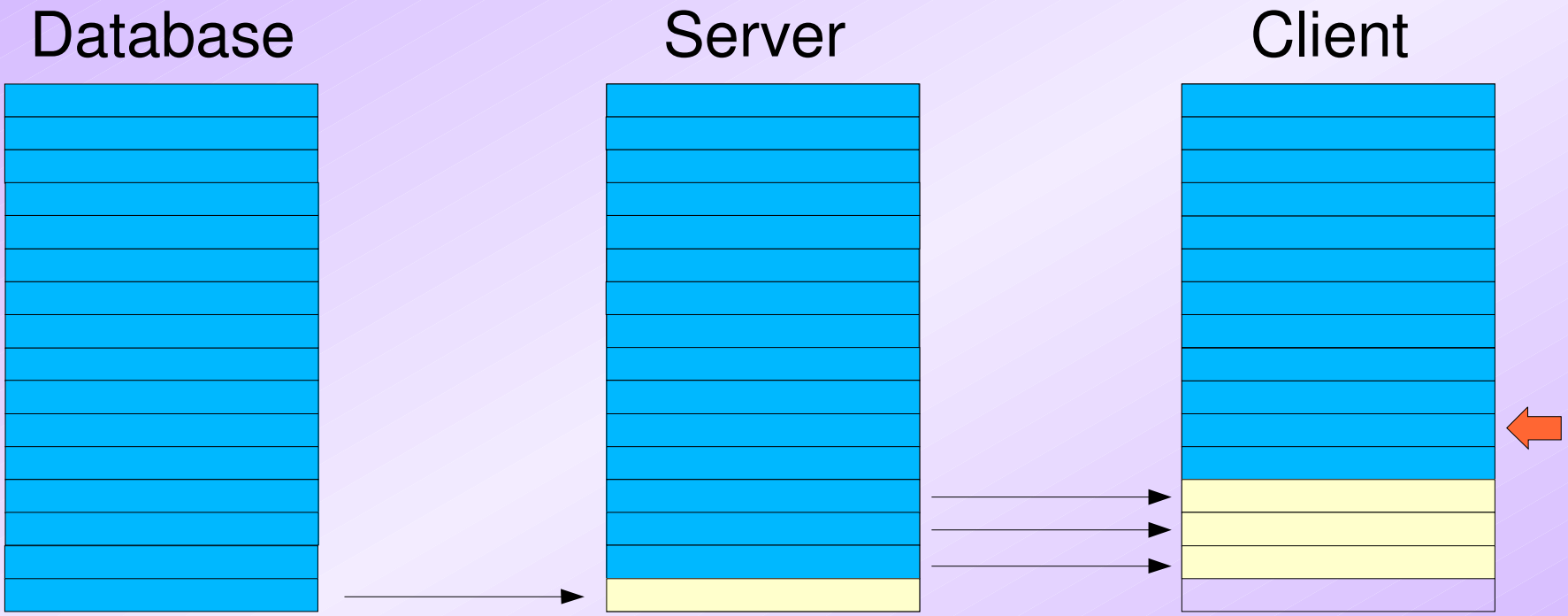
Server



Client



Results




```
SELECT ...
OFFSET 15
LIMIT 5
```

Arbitrary queries – problems

- Badly formed queries may overload database server
- Difficult to optimise database for all queries
  - Which indexes to use?
  - Slow response to complex queries involving multi-table joins

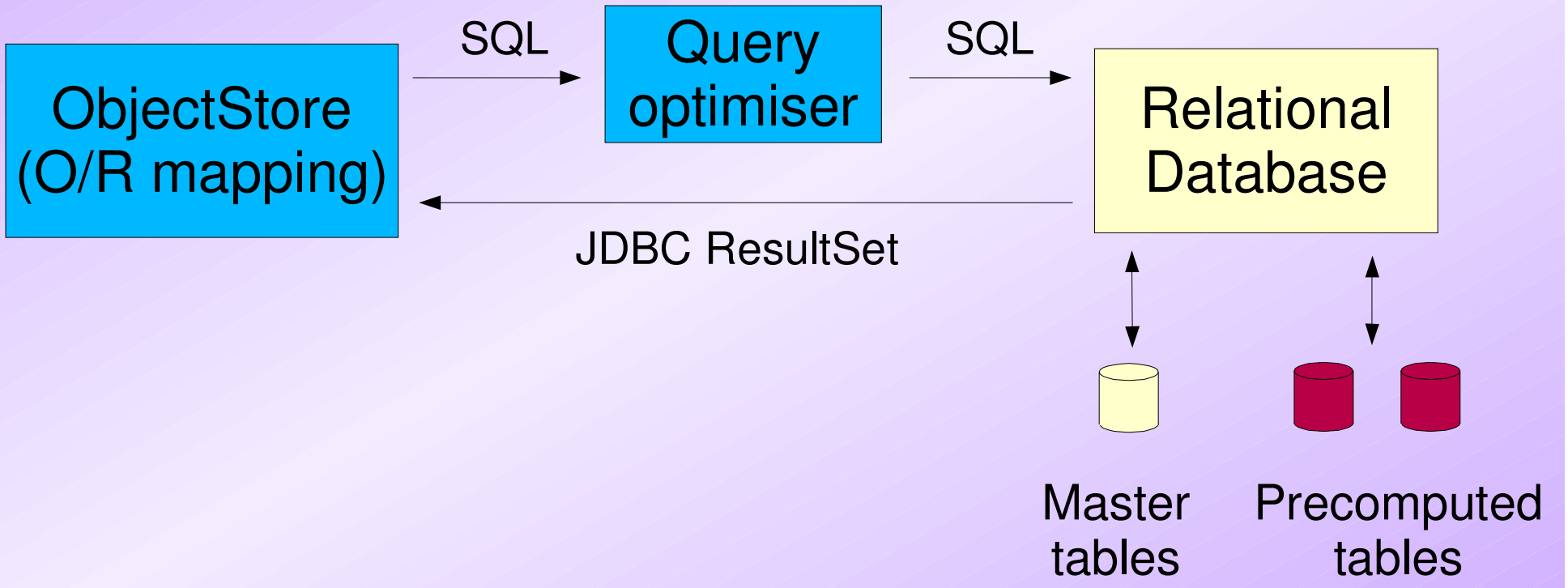
Arbitrary queries – solutions

- Close relationship with database server query planner
  - ask how long a query will take before attempting to run it (~3ms)
  - Disallow queries that will take longer than a certain threshold
- Store data massively redundantly in “precomputed tables” and rewrite incoming queries on-the-fly.

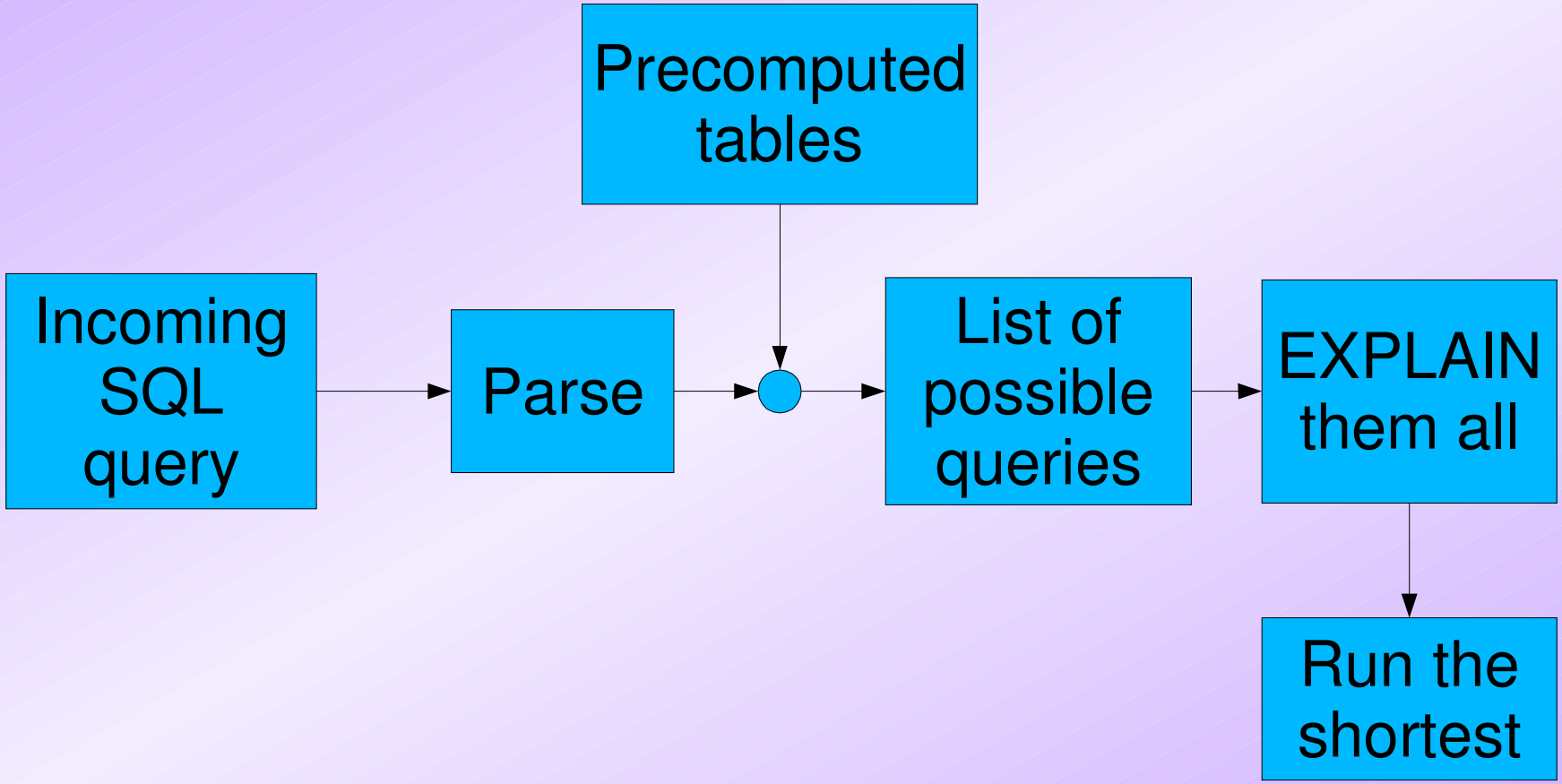
Query optimisation – aims

- Provide a generic way of speeding up complex queries to any read-only SQL database
- Minimal parsing/computational overhead
- Transparent to users/applications
  - no new schema/model to learn
- Make available as standalone module

Query optimisation architecture



Query optimisation



Query optimisation – example

Master tables

Genes

id	name

GOTerms

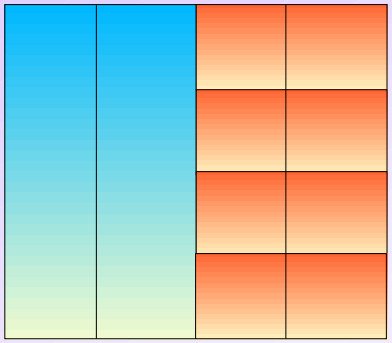
geneid	code

Experiments

geneid	date	type

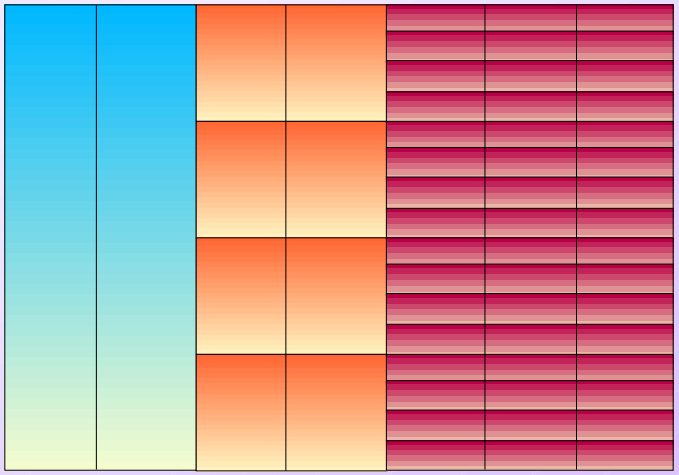
Precomputed tables

GenesGOTerms



```
CREATE TABLE genesgoterms AS
SELECT genes.id AS genes_id,
       genes.name AS genes_name,
       goterms.geneid AS goterms_geneid,
       goterms.code AS goterms_code
FROM genes, goterms
WHERE genes.id = goterms.geneid
```

GenesGOTermsExperiments



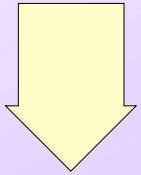
```
CREATE TABLE ....
SELECT ....
FROM genes, goterms, experiments
WHERE genes.id = goterms.geneid
AND genes.id = experiments.geneid
```

FlyMine

Query optimisation – example

"Show dates that gene expression experiments were performed on genes which have GO term GO:0000278 applied"

```
SELECT genes.name, experiments.date
FROM genes, goterms, experiments
WHERE genes.id = goterms.geneid
AND genes.id = experiments.geneid
AND goterms.code = "GO:0000278"
AND experiments.type = "Gene Expression"
```

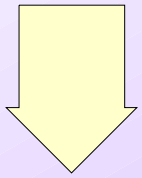


EXPLAIN

5 seconds

Query optimisation – example

```
SELECT genes_name AS name,
       experiments.date
FROM genesgoterms, experiments
WHERE genes_id = experiments.geneid
AND goterms_code = "GO:0000278"
AND experiments.type = "Gene Expression"
```

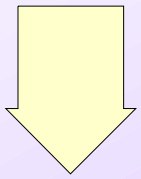


EXPLAIN

1 second

Query optimisation – example

```
SELECT genes_name AS name,
       experiments_date AS date
FROM genesgotermsexperiments
WHERE goterms_code = "GO:0000278"
AND experiments_type = "Gene Expression"
```



EXPLAIN

200ms

Query optimisation – example

- Without optimiser

  Time = 3ms + 5 seconds

  (EXPLAIN) (EXECUTE)

- With optimiser

  Time = 9ms + 100ms + 200ms

  (3 EXPLAINs) (PARSE) (EXECUTE)

Query optimisation – summary

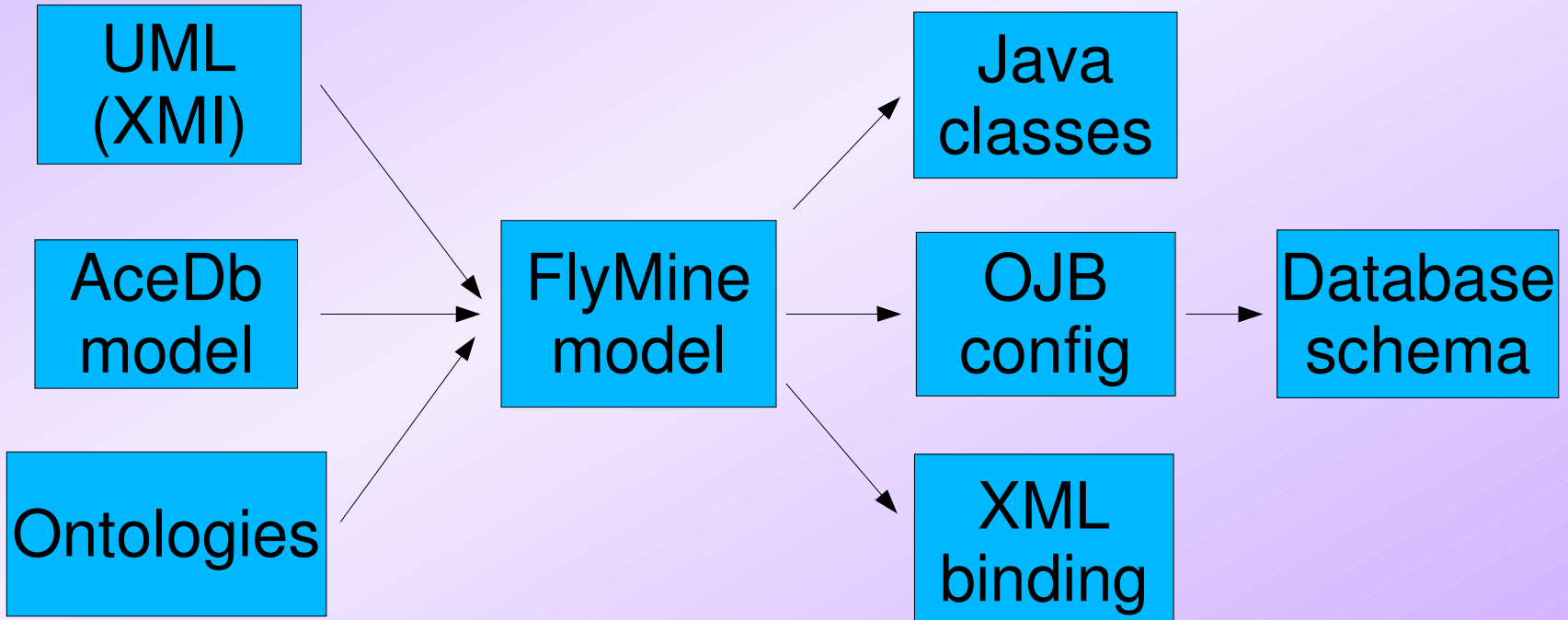
- For complex queries, our SQL optimisation module can produce large speed increases
- Optimisation is transparent to the user or application generating the SQL.
- Choosing which precomputed tables to store is important – may need to analyse incoming queries.

Query optimiser – summary

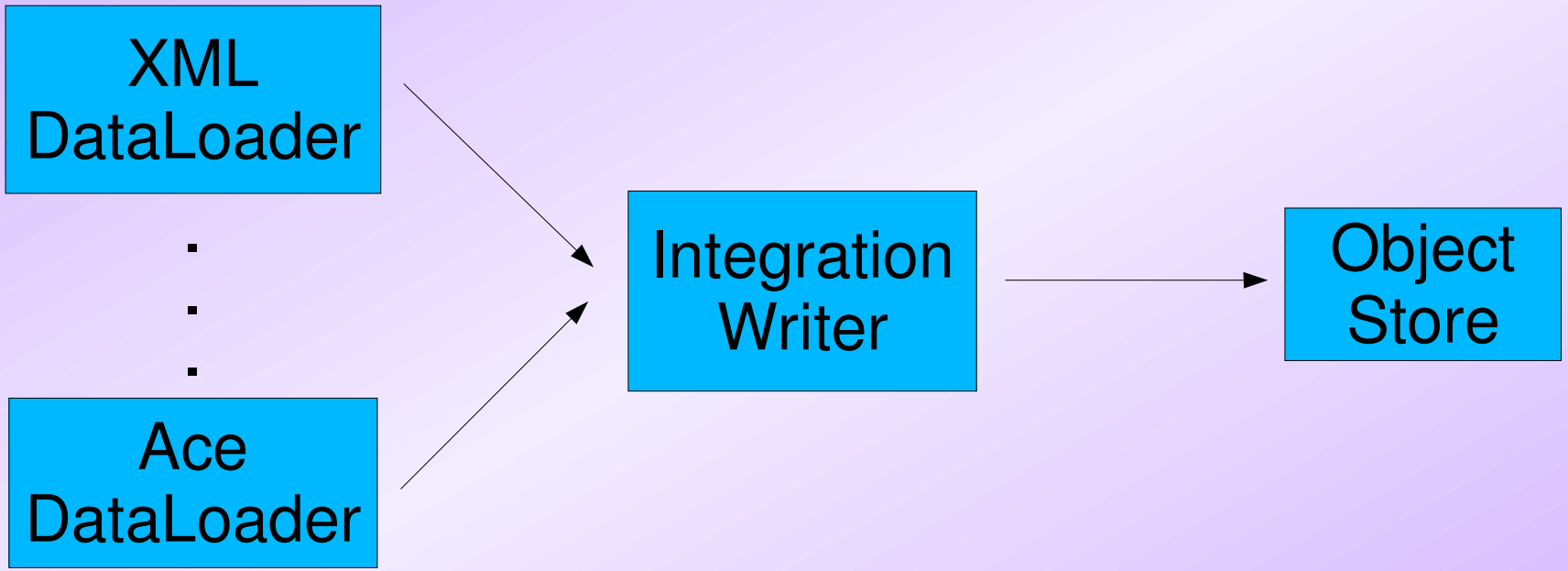
- Optimiser trades off disk space for improved query performance.
- Schema independent.
- Can be used in conjunction with P6Spy to intercept JDBC calls from existing software to a database.
- Available from www.flymine.org !!

Data model

- Data model can be generated from one of a number of sources



Data loading and integration



Summary

- Current status
  - generic SQL query optimiser
  - powerful object database
  - 2 query interfaces (OQL + Java)
  - framework for data loading/integration
  - autogeneration of model-dependent parts from UML or Ace model

Summary

- Coming up
  - graphical query interface
  - web front end
  - web service
  - integrated Drosophila/Anopheles database (genomics, microarray, proteomics, etc)
  - tools for auto-generation of best set of precomputed tables

Acknowledgements

The FlyMine team:

Andrew Varley
Richard Smith
Matthew Wakeling
Mark Woodbridge
François Guillier
Rachel Lyne
Rajasekhar Paidi
Gos Micklem

Download FlyMine from www.flymine.org

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