CLOUDERA

An introduction to query processing & Apache Calcite

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@Calcite Online Meetup

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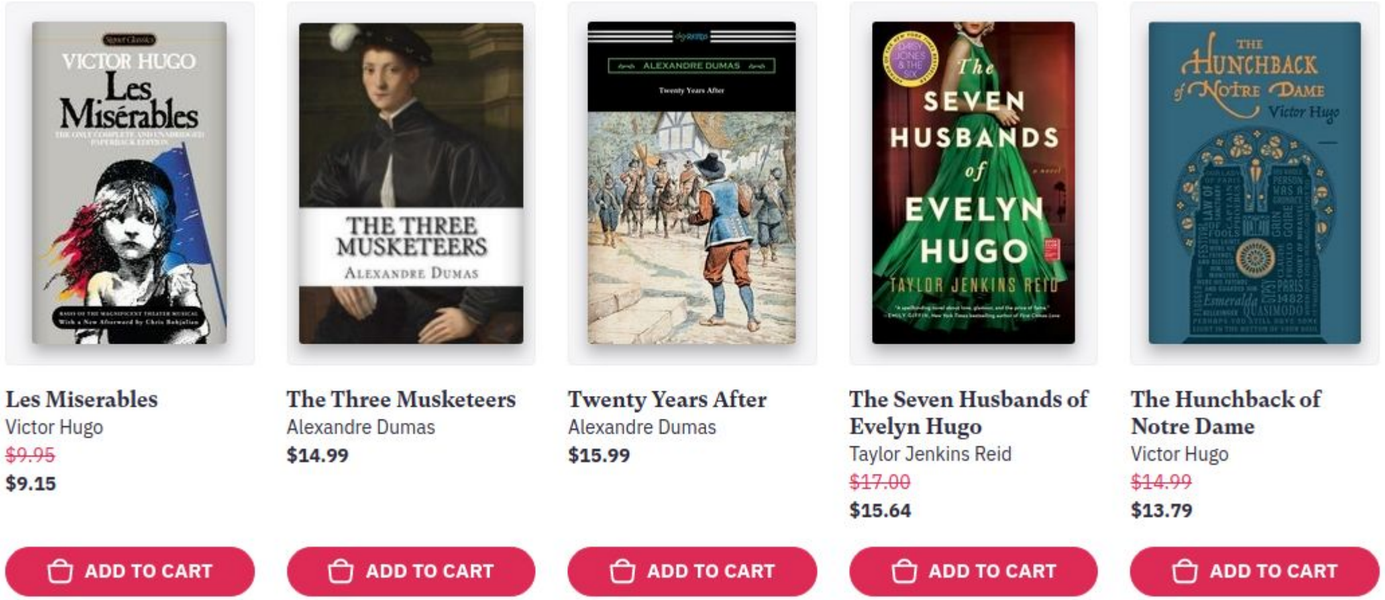
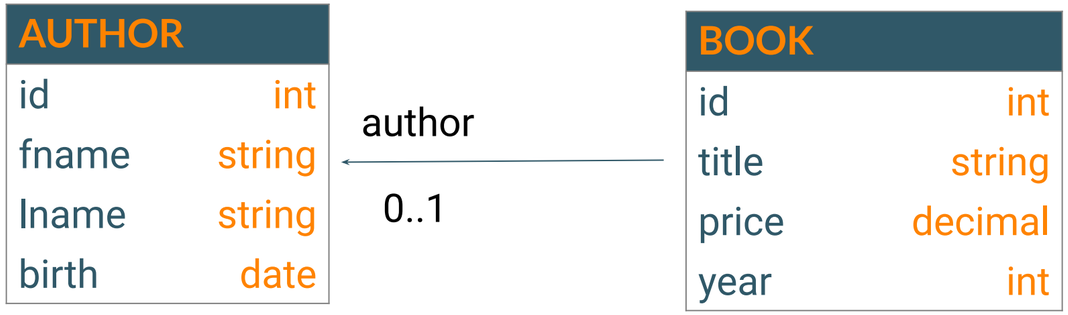
Motivation: Data views



1. Retrieve books and authors
2. Display image, title, price of the book along with firstname & lastname of the author
3. Sort the books based on their id (price or something else)
4. Show results in groups of five

What, where, how data are stored?



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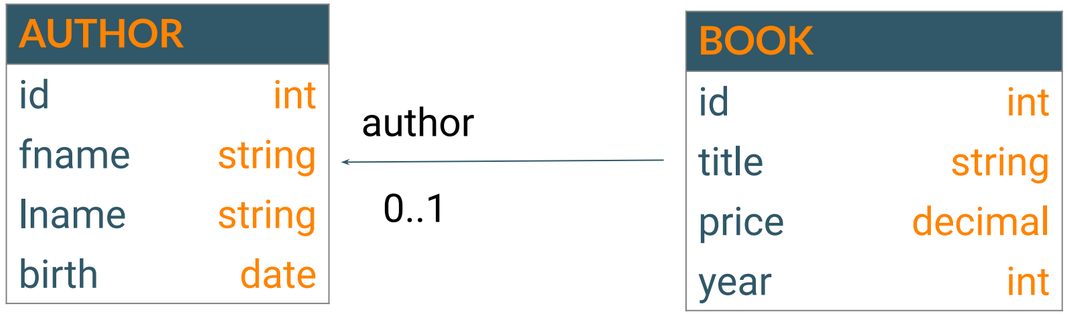
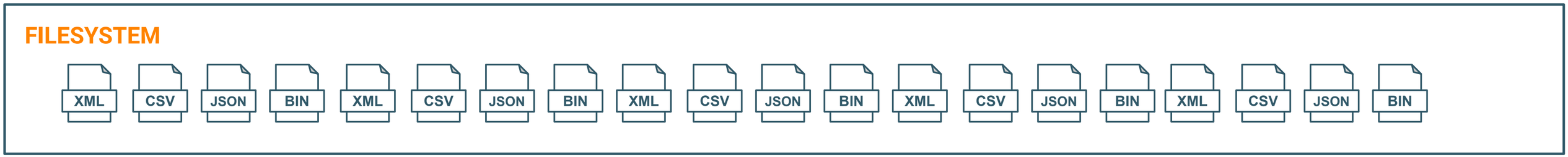




What, where, how data are stored?

AUTHOR	
id	int
fname	string
lname	string
birth	date

author

0..1

BOOK	
id	int
title	string
price	decimal
year	int

APACHE DRILL

APACHE Spark™

ORACLE DATABASE

cassandra

elasticsearch

HIVE

neo4j

hazelcast

Google BigQuery

APACHE HBASE

Lucene

PostgreSQL

redis

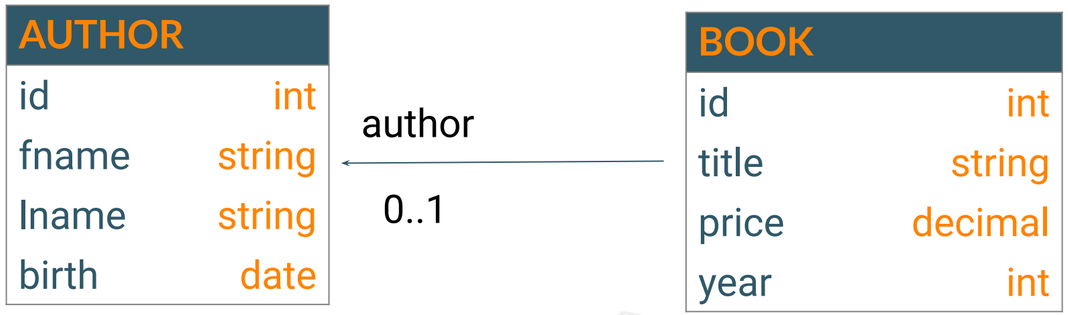
Solr

mongoDB®

FILESYSTEM

XML CSV JSON BIN XML CSV JSON BIN XML CSV JSON BIN XML CSV JSON BIN XML CSV JSON BIN

Many DBMS, different APIs

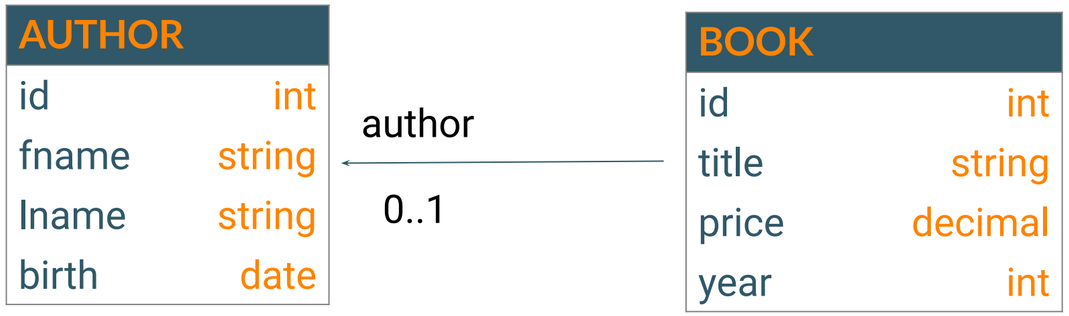


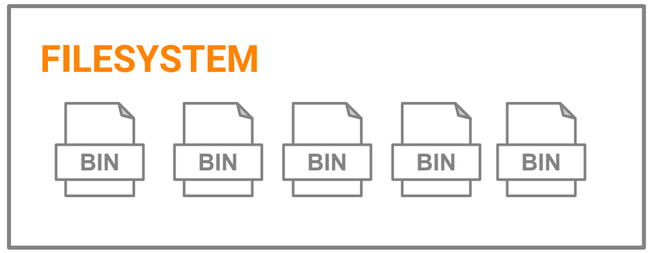
360+ DBMS

FILESYSTEM

XML CSV JSON BIN XML CSV JSON BIN XML CSV JSON BIN XML CSV JSON BIN XML CSV JSON BIN

In-house usecase specific system





- ★ Java based in-memory datastore
- ★ Ultra compact memory/disk format
- ★ High speed serialization/deserialization protocol

Naive implementation

```
List<Tuple> buildMainView(List<Book> books, List<Author> authors, int limit)
```

Naive implementation

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List<Tuple> buildMainView(List<Book> books, List<Author> authors, int limit)
{
   List<Tuple> result = new ArrayList<>();
   for (Book b : books)
   {









   }


}
```

Naive implementation

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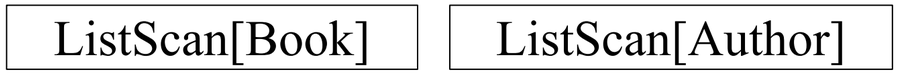
List<Tuple> buildMainView(List<Book> books, List<Author> authors, int limit)
{
   List<Tuple> result = new ArrayList<>();
   for (Book b : books)
   {
      boolean hasAuthor = false;
      for (Author a : authors)



   }


}
```



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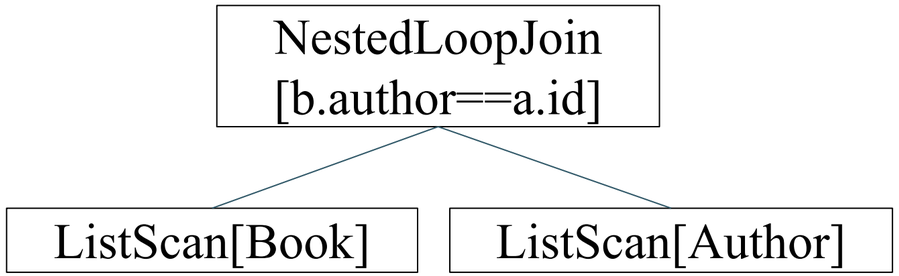
      boolean hasAuthor = false;
      for (Author a : authors)
         if (b.author == a.id)
            hasAuthor = result.add(Tuple.of(b, a));
      if (!hasAuthor)
         result.add(b);
   }


}
```



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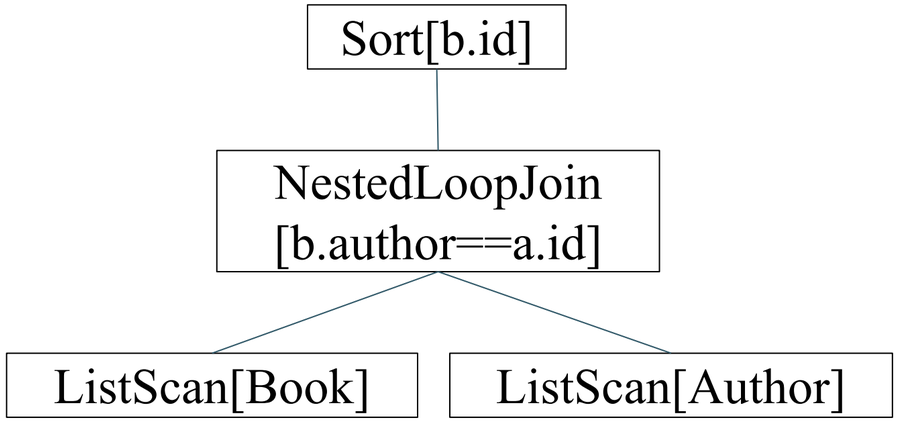
      for (Author a : authors)
         if (b.author == a.id)
            hasAuthor = result.add(Tuple.of(b, a));
      if (!hasAuthor)
         result.add(b);
   }
   Collections.sort(result, Comparator.comparing(t->t.get("b.id", Integer.class)));

}
```



Naive implementation

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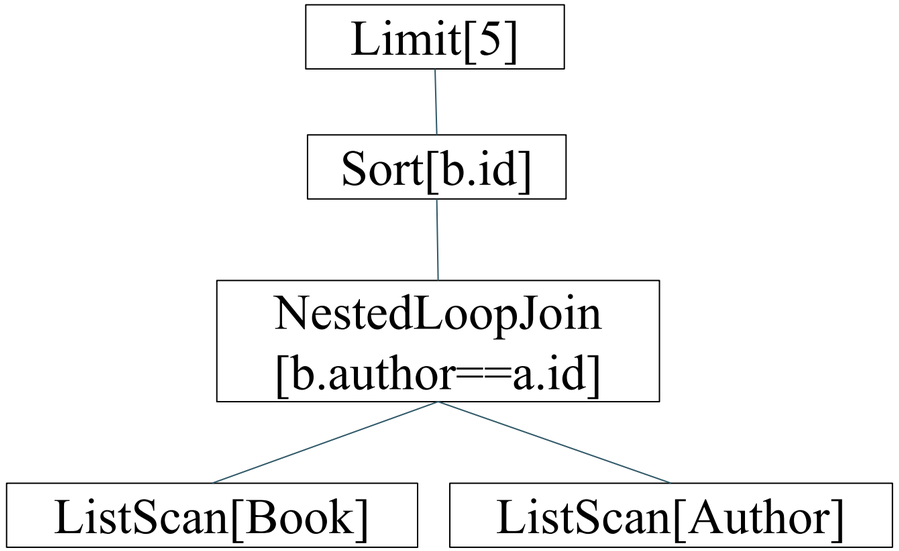
{
   List<Tuple> result = new ArrayList<>();
   for (Book b : books)
   {
      boolean hasAuthor = false;
      for (Author a : authors)
         if (b.author == a.id)
            hasAuthor = result.add(Tuple.of(b, a));
      if (!hasAuthor)
         result.add(b);
   }
   Collections.sort(result, Comparator.comparing(t->t.get("b.id", Integer.class)));
   return result.subList(0, Math.min(limit, result.size()));
}
```



Operations can be re-ordered

```
List<Tuple> buildMainView(List<Book> books, List<Author> authors, int limit)
{
   List<Tuple> result = new ArrayList<>();
   for (Book b : books)
   {
      boolean hasAuthor = false;
      for (Author a : authors)
         if (b.author == a.id)
            hasAuthor = result.add(Tuple.of(b, a));
      if (!hasAuthor)
         result.add(b);
   }
   Collections.sort(result, Comparator.comparing(t->t.get("b.id", Integer.class)));
   return result.subList(0, Math.min(limit, result.size()));
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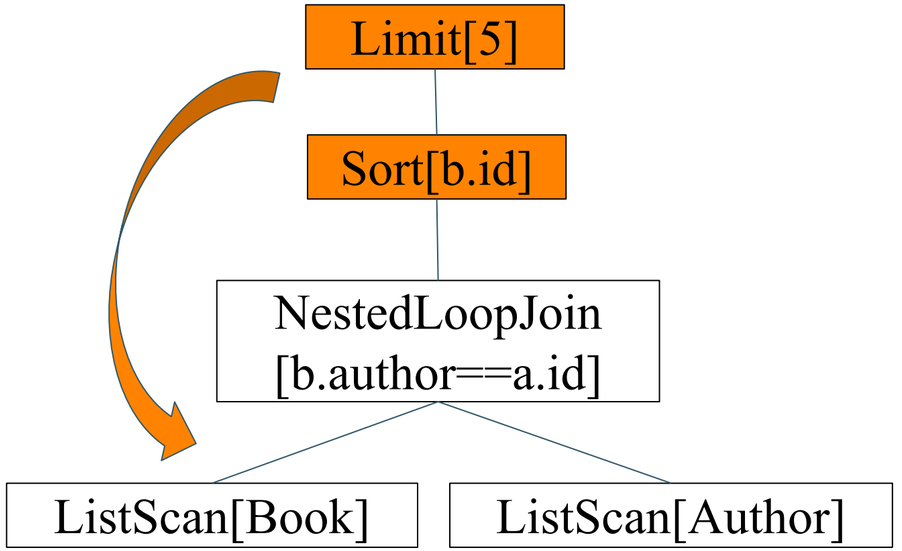
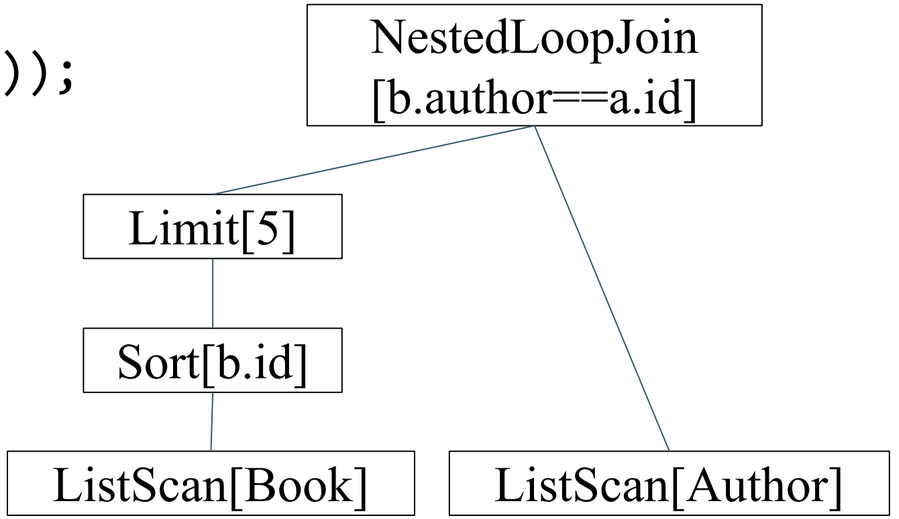
```



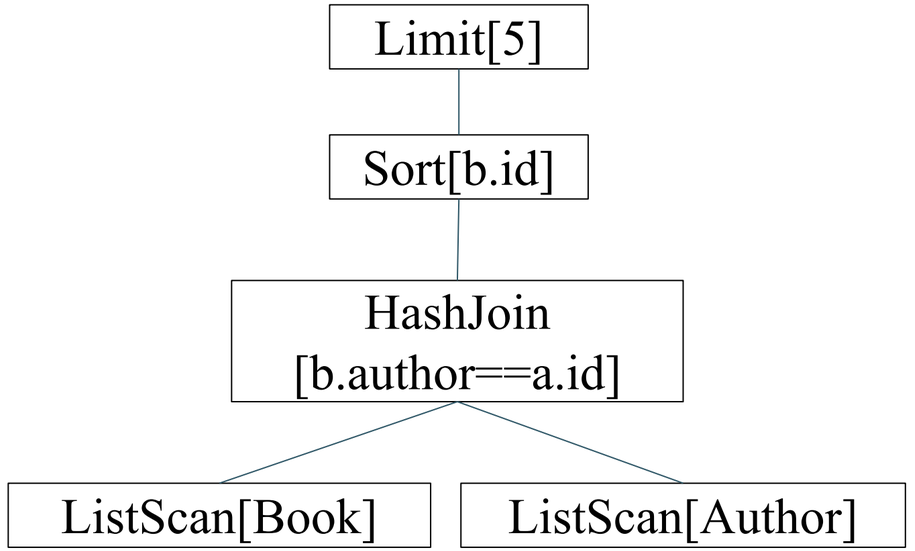
Operations can be re-ordered

```
List<Tuple> buildMainView(List<Book> books, List<Author> authors, int limit)
{
    List<Tuple> result = new ArrayList<>();
   Collections.sort(books, Comparator.comparing(b -> b.id));
   for (Book b : books)
   {
      if (result.size()==limit)
         break;
      boolean hasAuthor = false;
      for (Author a : authors)
         if (b.author == a.id)
            hasAuthor = result.add(Tuple.of(b, a));
      if (!hasAuthor)
         result.add(b);
   }
   return result;
}
```



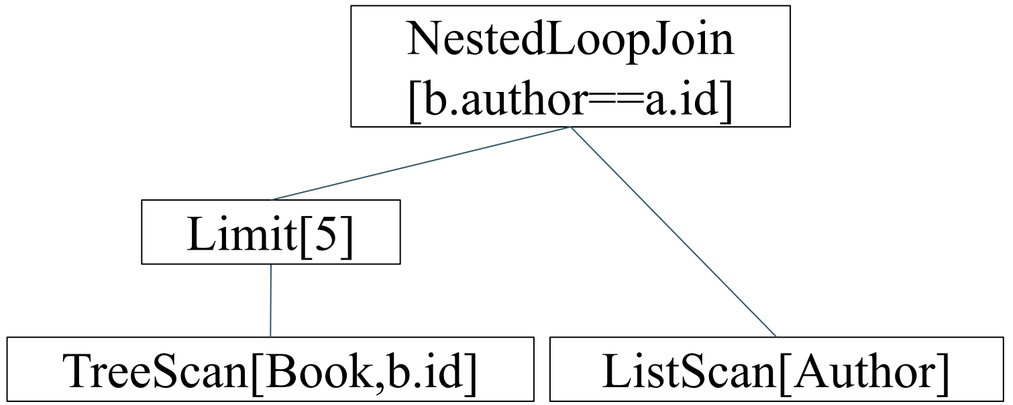
Operations can be implemented differently

```
List<Tuple> buildMainView(List<Book> books, List<Author> authors, int limit)
{
   List<Tuple> result = new ArrayList<>();
    Map<Integer, Author> ixAuthor = new HashMap<>();
   for (Author a : authors)
      ixAuthor.put(a.id, a);
   for (Book b : books)
   {
      Author a = ixAuthor.get(b.author);
      if (a == null)
         result.add(b);
      else
         result.add(Tuple.of(b, a));
   }
   Collections.sort(result, Comparator.comparing(t->t.get("b.id", Integer.class)));
   return result.subList(0, Math.min(limit, result.size()));
}
```



Multiple ways of accessing data

```
List<Tuple> buildMainView(TreeMap<Integer,Book> books, List<Author> authors, int
limit)
{
  List<Tuple> result = new ArrayList<>();
   for (Book b : books.values())
   {
      if (result.size()==limit)
         break;
      boolean hasAuthor = false;
      for (Author a : authors)
         if (b.author == a.id)
            hasAuthor = result.add(Tuple.of(b, a));
      if (!hasAuthor)
         result.add(b);
   }
   return result;
}
```



Observations

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1. Declarative query language

```
SELECT b.id, b.title, b.year, a.fname, a.lname
FROM Book b
LEFT OUTER JOIN Author a ON b.author=a.id
ORDER BY b.id
LIMIT 5
```

Observations

1. Declarative query language
2. Algebraic operators

```
SELECT b.id, b.title, b.year, a.fname, a.lname
FROM Book b
LEFT OUTER JOIN Author a ON b.author=a.id
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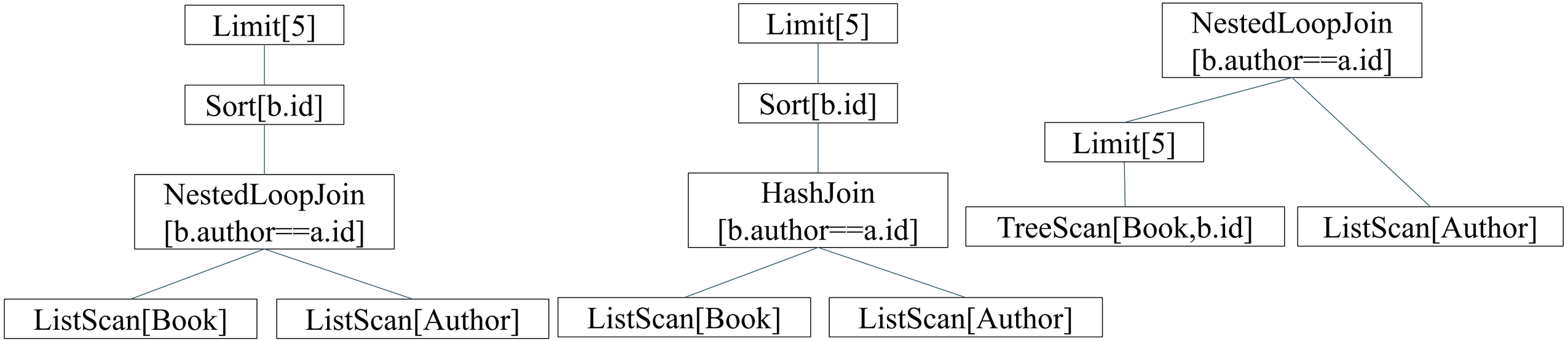
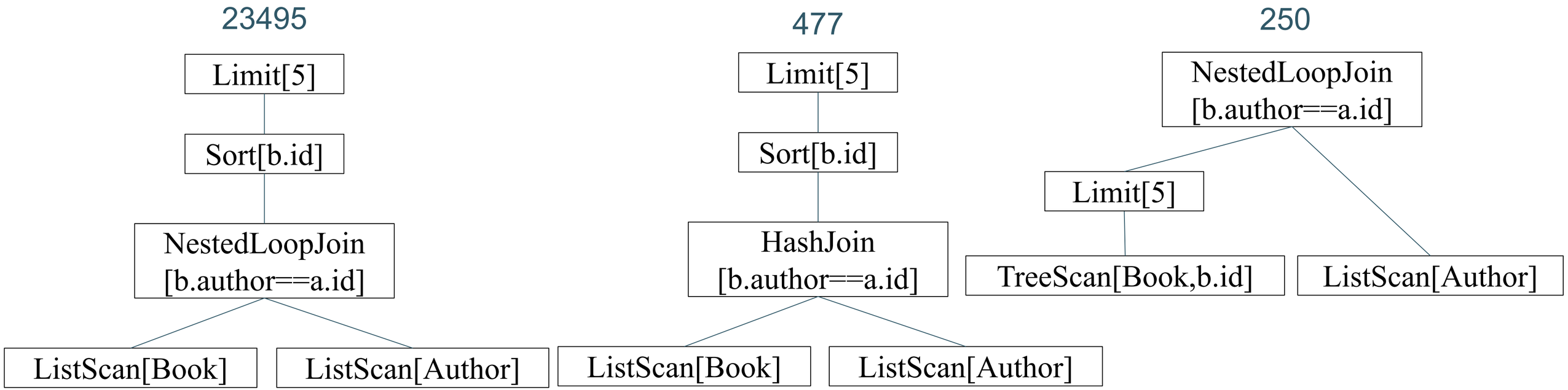


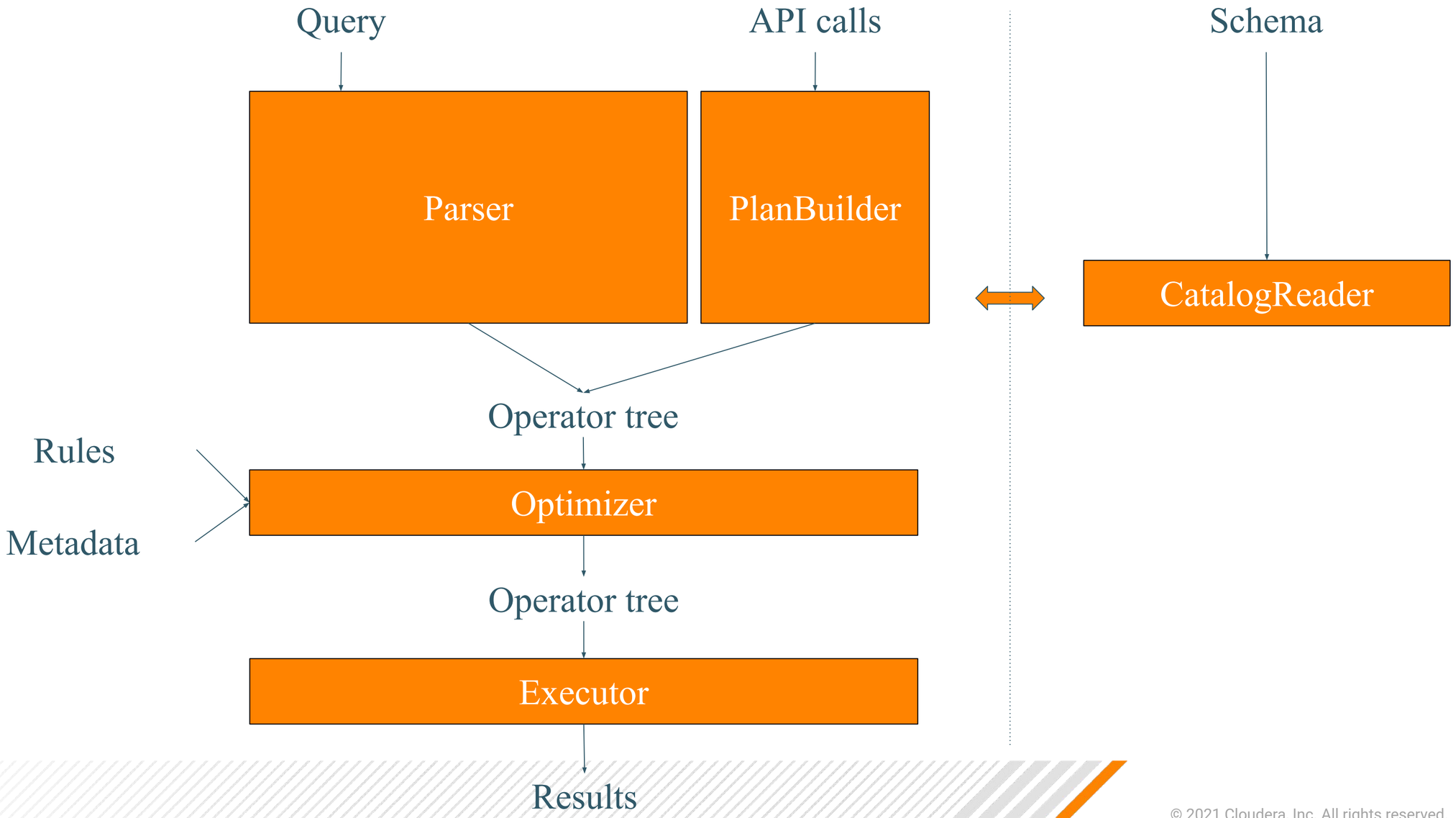
Observations

1. Declarative query language
2. Algebraic operators
3. Query optimizer

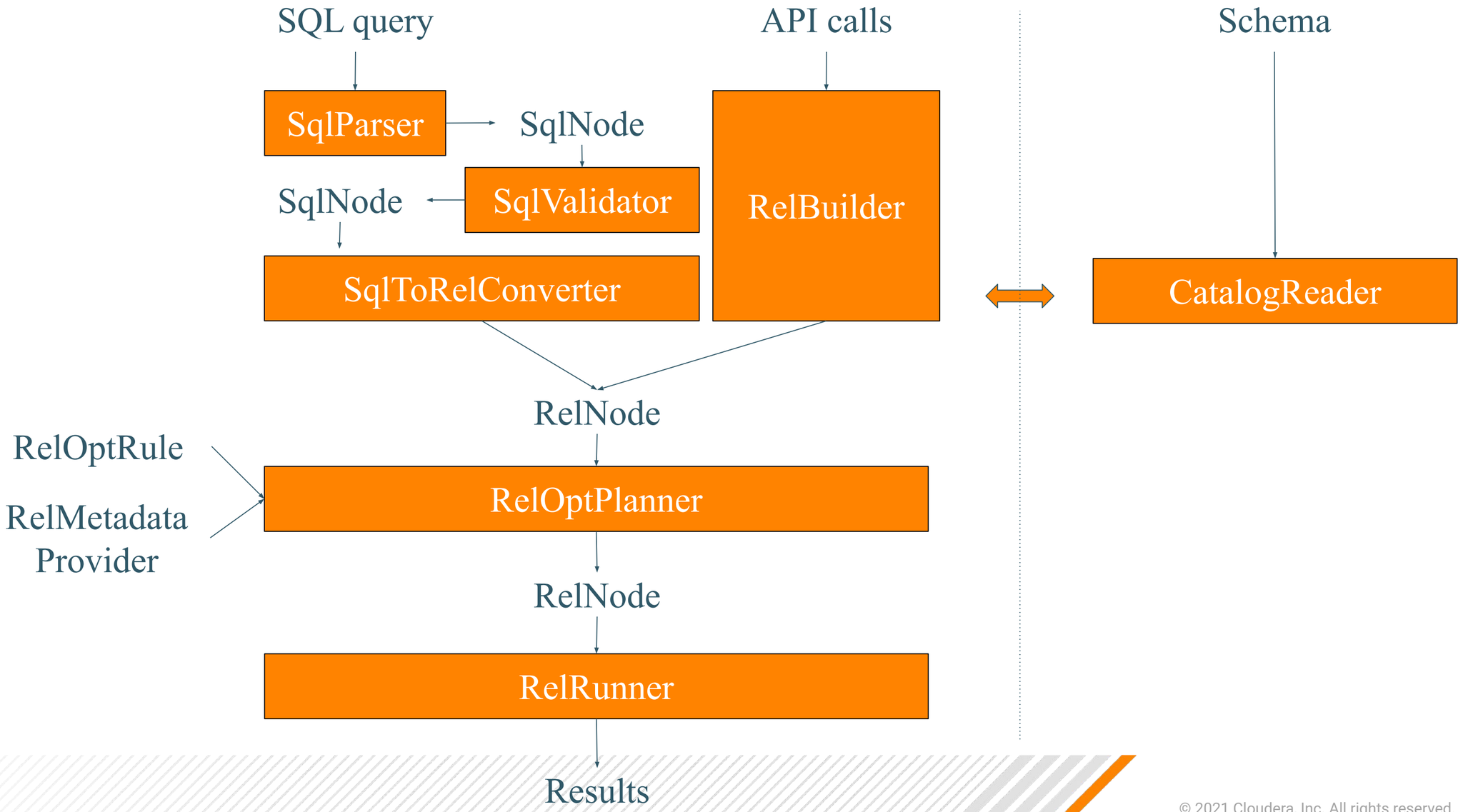
```
SELECT b.id, b.title, b.year, a.fname, a.lname
FROM Book b
LEFT OUTER JOIN Author a ON b.author=a.id
ORDER BY b.id
LIMIT 5
```



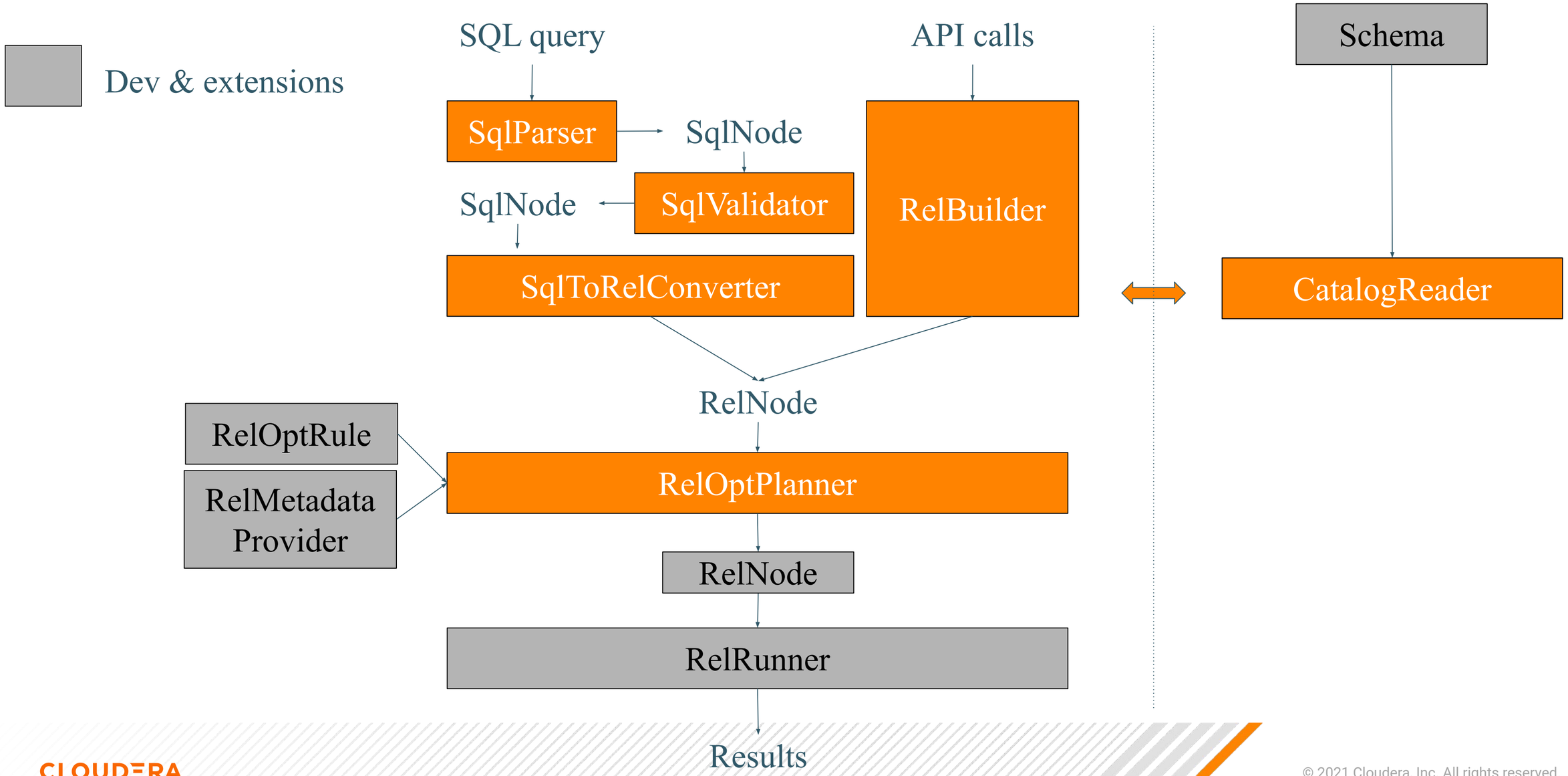
Query processor architecture



Apache Calcite



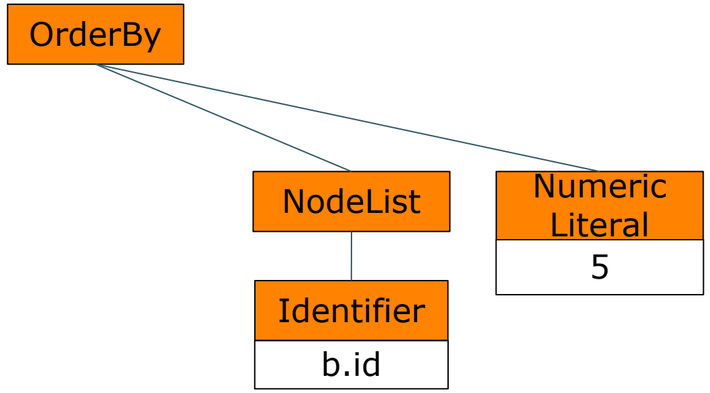
Apache Calcite



Example: Query to AST


```
SELECT b.id, b.title, b.year, a.fname, a.lname
FROM Book b
LEFT OUTER JOIN Author a ON b.author=a.id
WHERE b.year > 1830
ORDER BY b.id
LIMIT 5
```

Example: Query to AST




```
ORDER BY b.id
LIMIT 5
```

Example: Query to AST

SQL query → SqlParser → SqlNode

```
SELECT b.id, b.title, b.year, a.fname, a.lname
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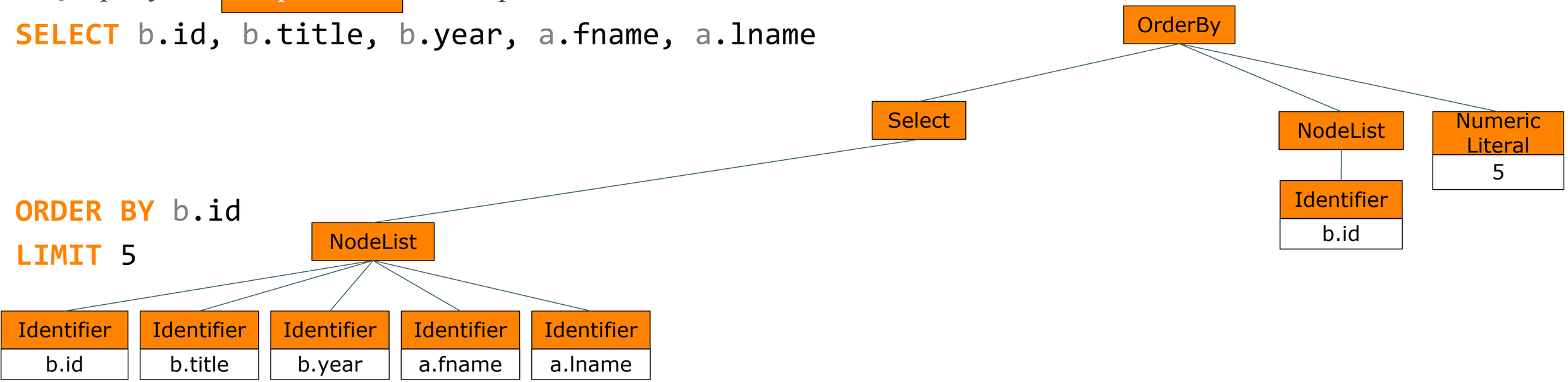
```



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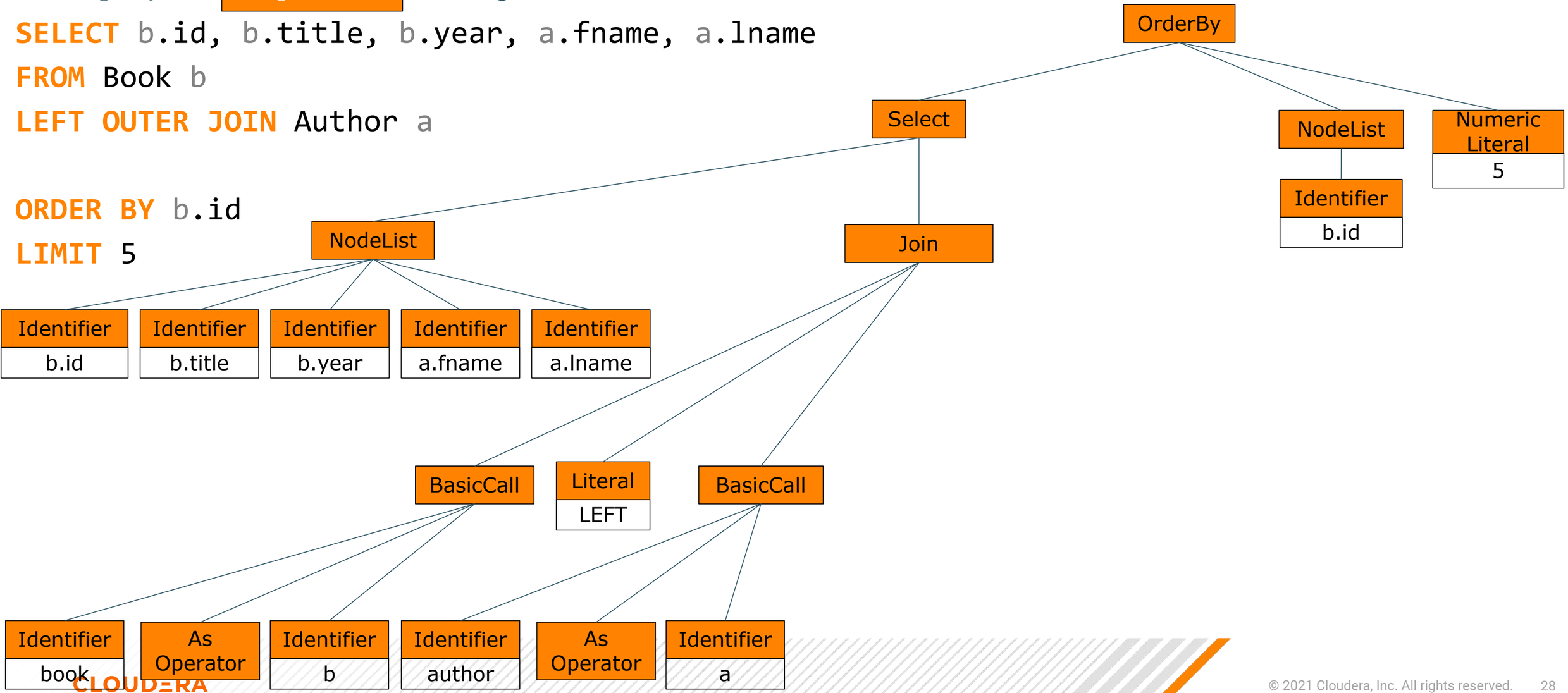

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FROM Book b
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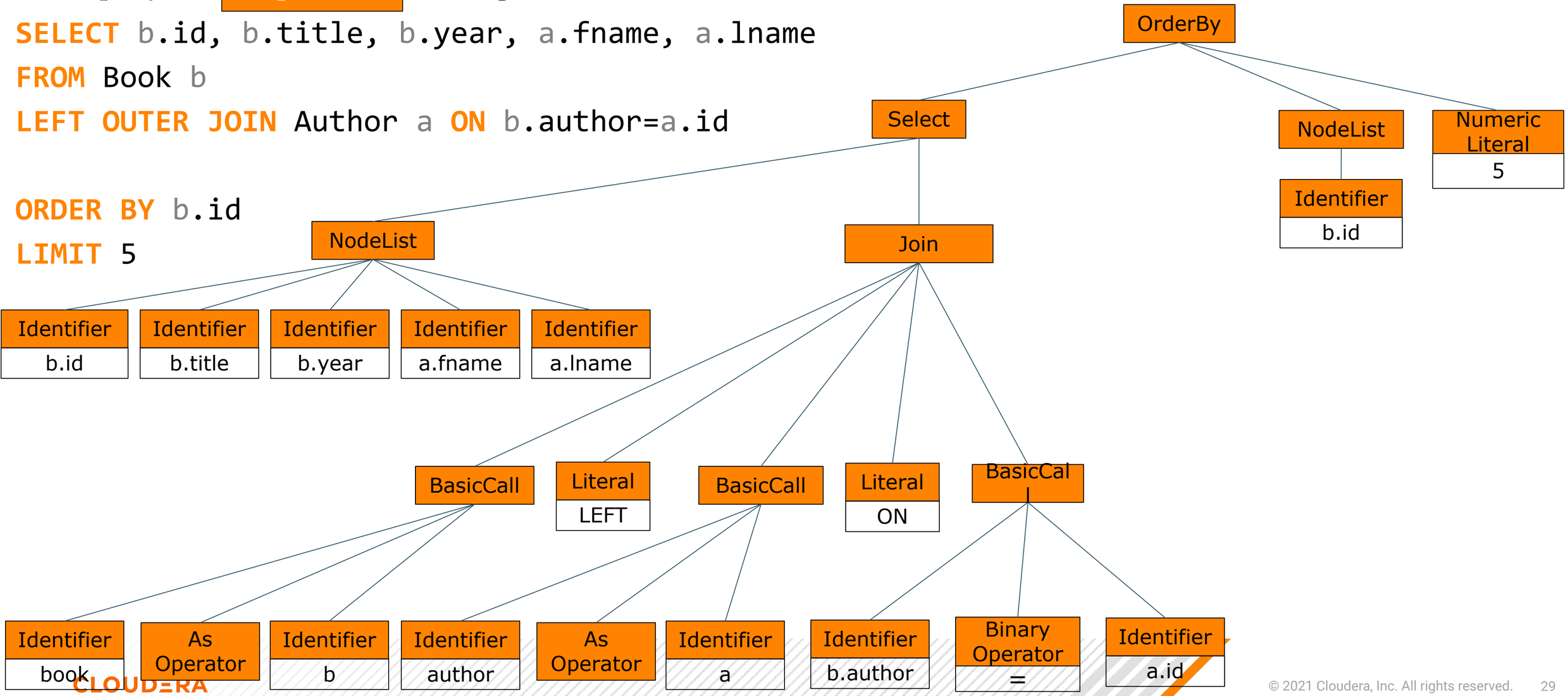
ORDER BY b.id
LIMIT 5
```



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SQL query → SqlParser → SqlNode

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ORDER BY b.id
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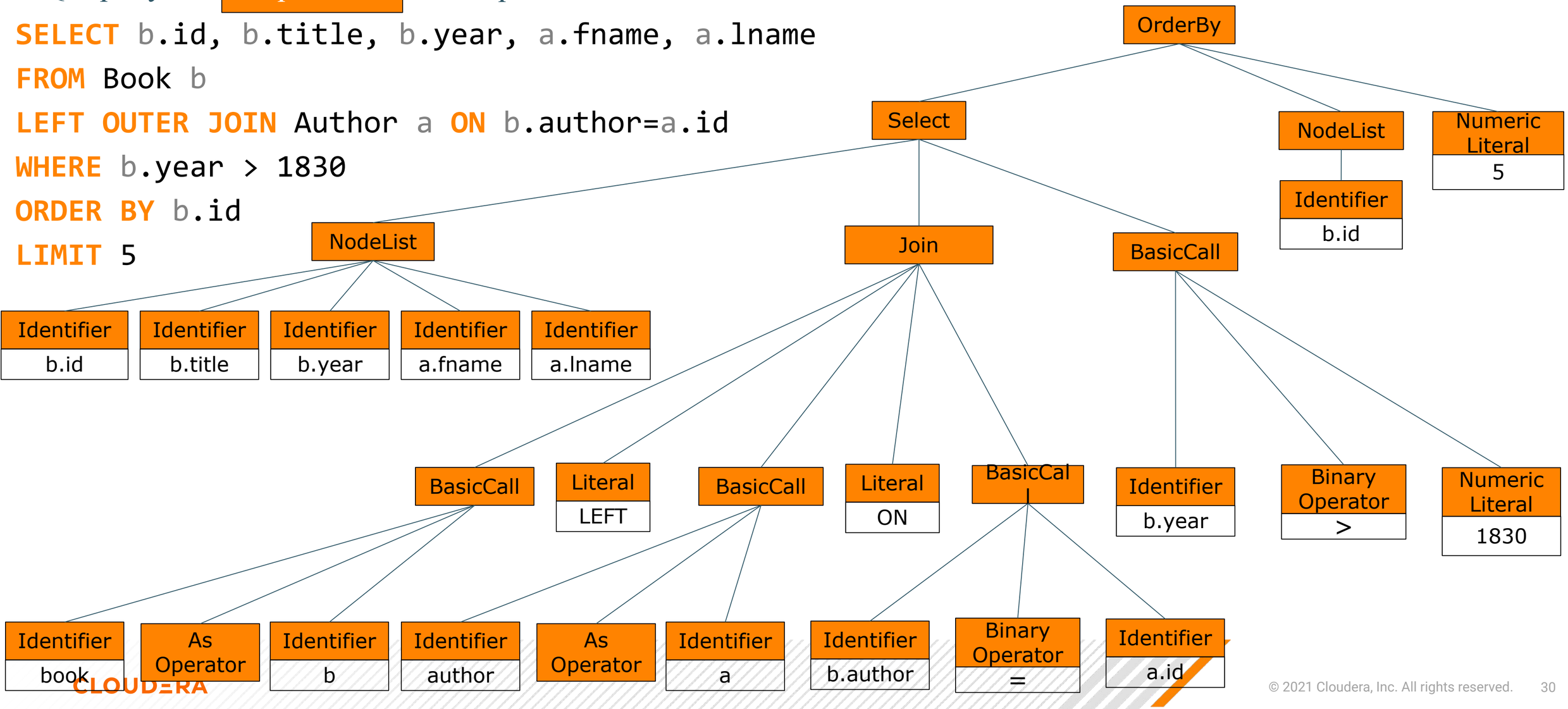
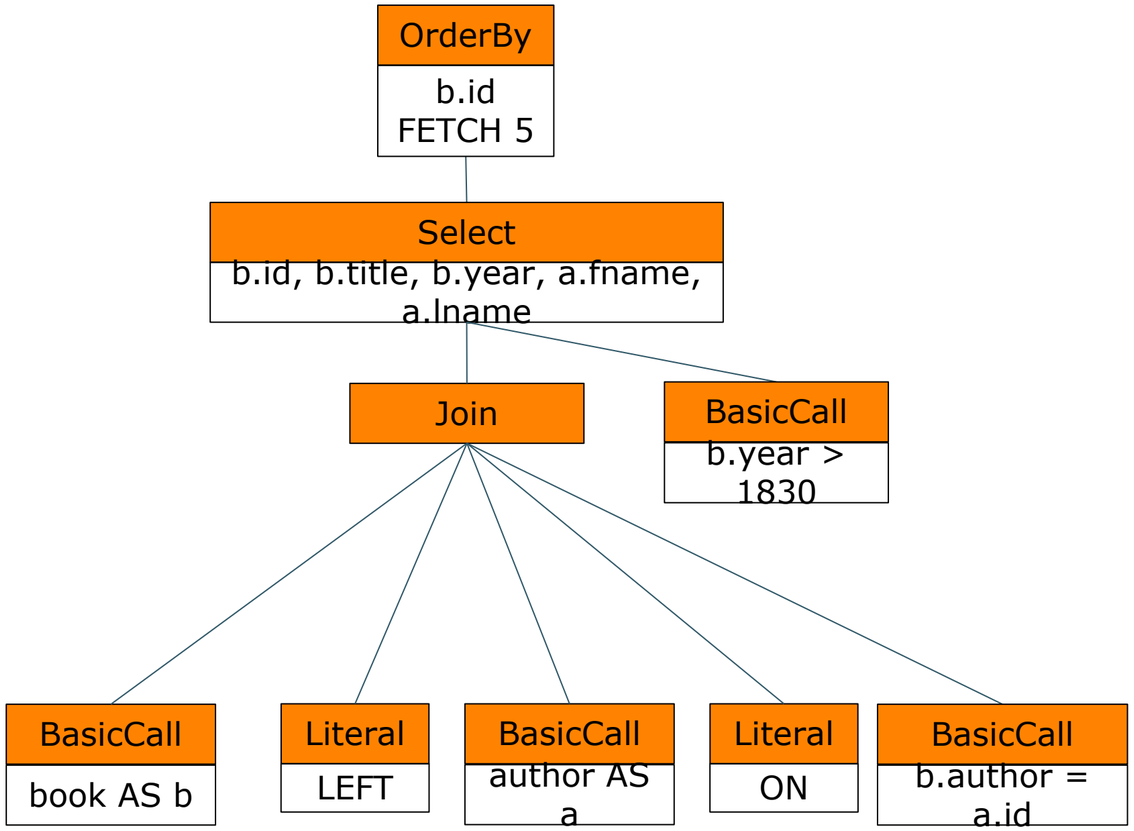
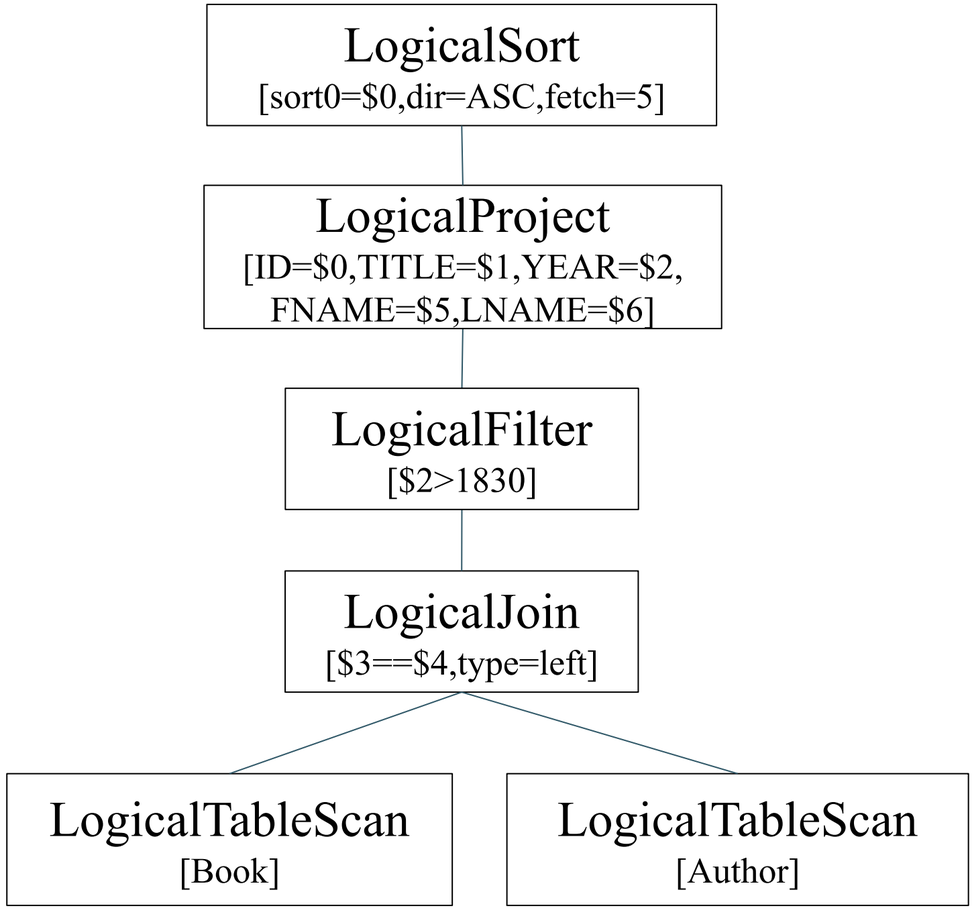


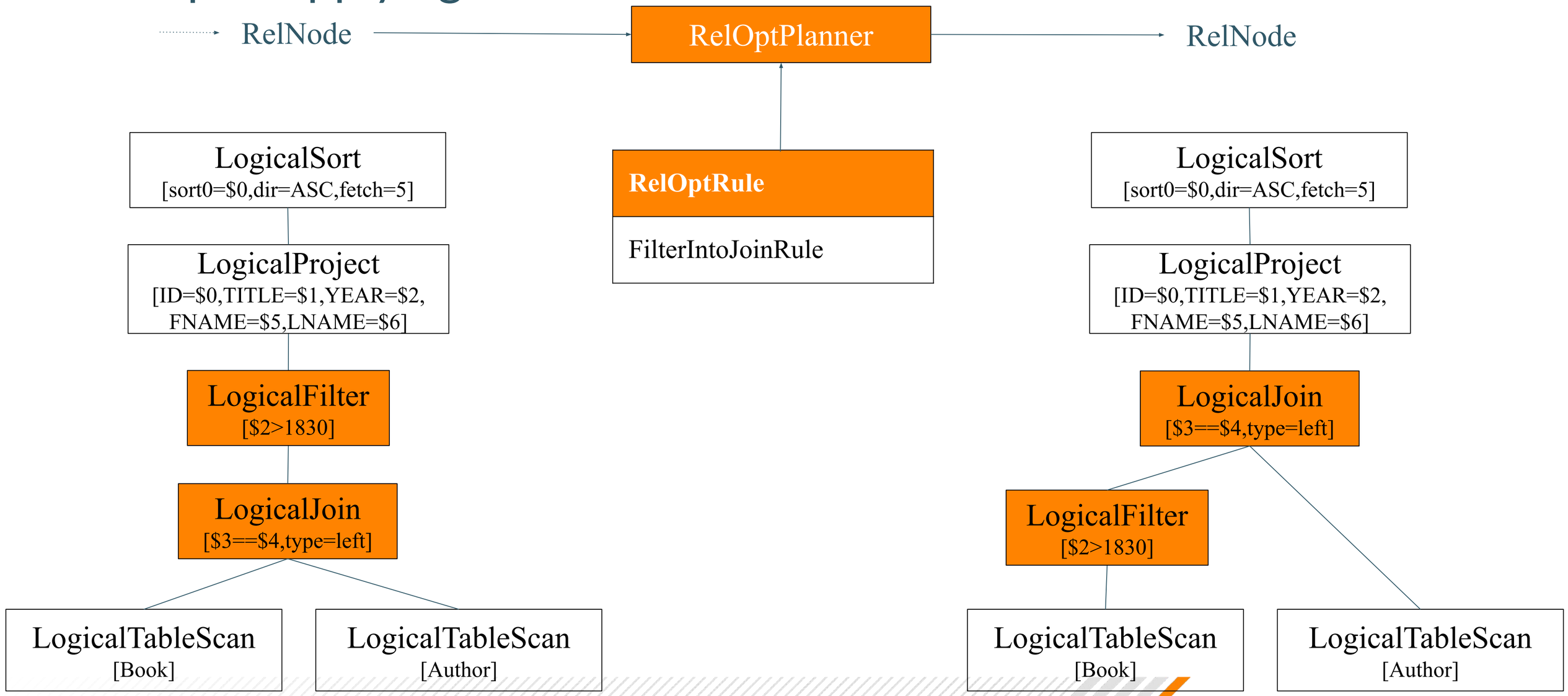
Example: AST to logical plan

SqlNode → **SqlValidator** → SqlNode → **SqlToRelConverter** → RelNode

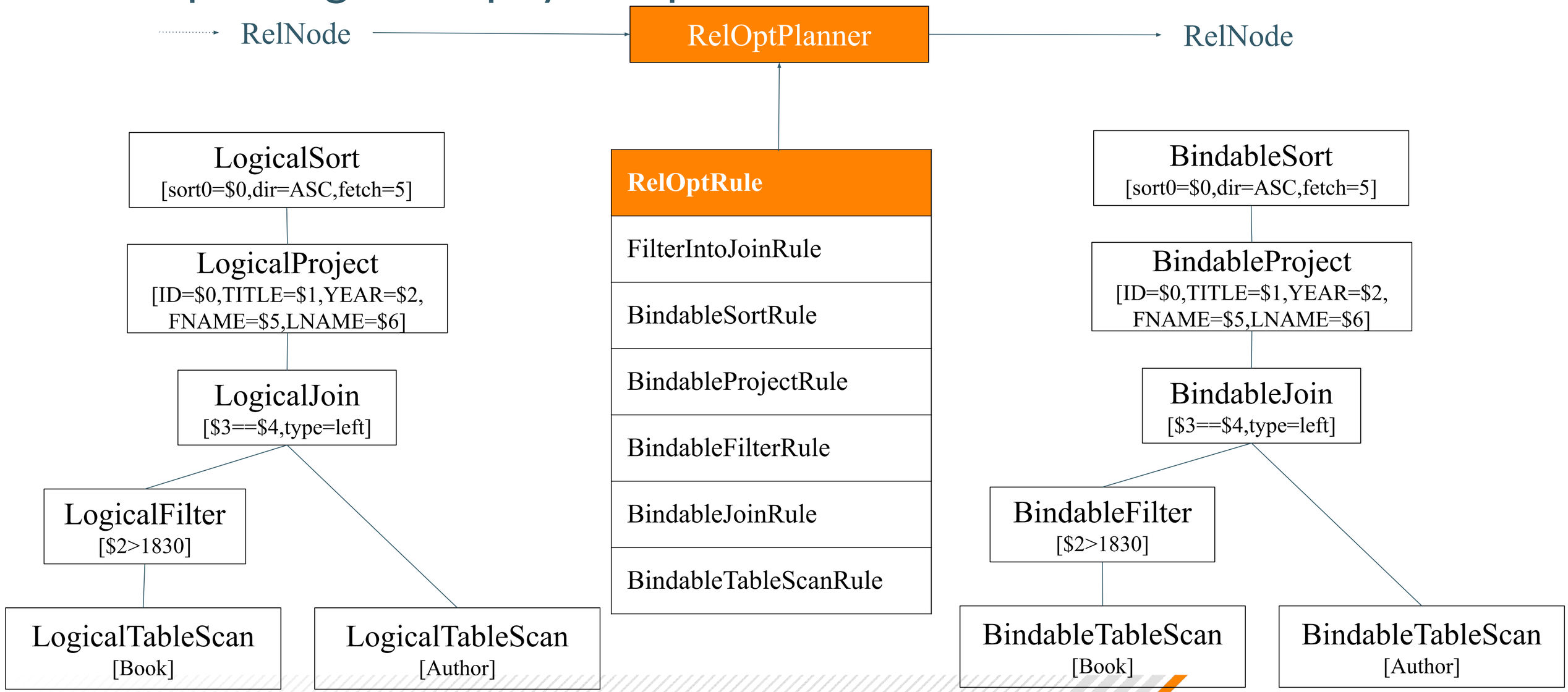




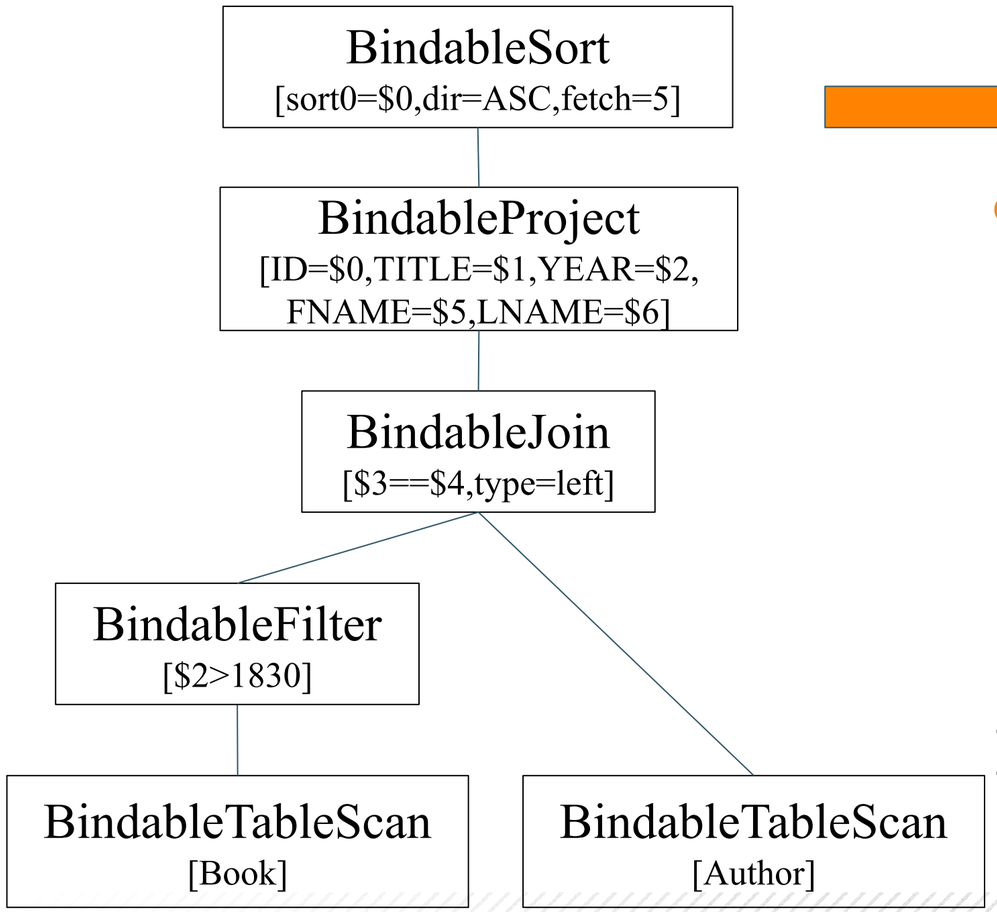
Example: Applying rules



Example: Logical to physical plan



Example: Physical plan execution




```
class BindableExecutor {
     List<Object[]> execute(BindableRel node,
                            DataContext context)
     {
        List<Object[]> result = new ArrayList<>();
       for (Object[] tuple:node.bind(context))
         result.add(tuple);
        return result;
     }
}
```

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