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The Tao of Teiid

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What is Teiid?

Teiid is an open source solution for scalable information integration through a relational abstraction.

Teiid focuses on:

- Real-time integration performance
- Feature-full integration via SQL/Procedures/XQuery
- Providing JDBC access

Teiid enables:

- Data Services / SOA
- Legacy / JPA integration

Overview

Background

Architecture

Internals

Wrap-up

Q & A

Where did Teiid come from?

Project lineage is from MetaMatrix stating in ~1999.

- Teiid - http://www.jboss.org/teiid
- Teiid Designer - http://www.jboss.org/teiiddesigner
- DNA - http://www.jboss.org/dna/

MetaMatrix was the leader in Enterprise Information Integration (EII) – hence T**eii**d.

Red Hat acquired MetaMatrix in 2007.

Last major MetaMatrix product release, 5.5.3 - 10/2008

Project Status

Open source 2/2009 – heavily refactored from 5.5 line

6.0 Initial release 3/2009

6.1 Teiid / Teiid Designer release 6/2009

6.2 Coming Soon! Embedded/server deployments, Designer-less usage, AdminShell, and much more.

Anticipate a platform release combining Teiid and other JBoss technologies next year.

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Architecture

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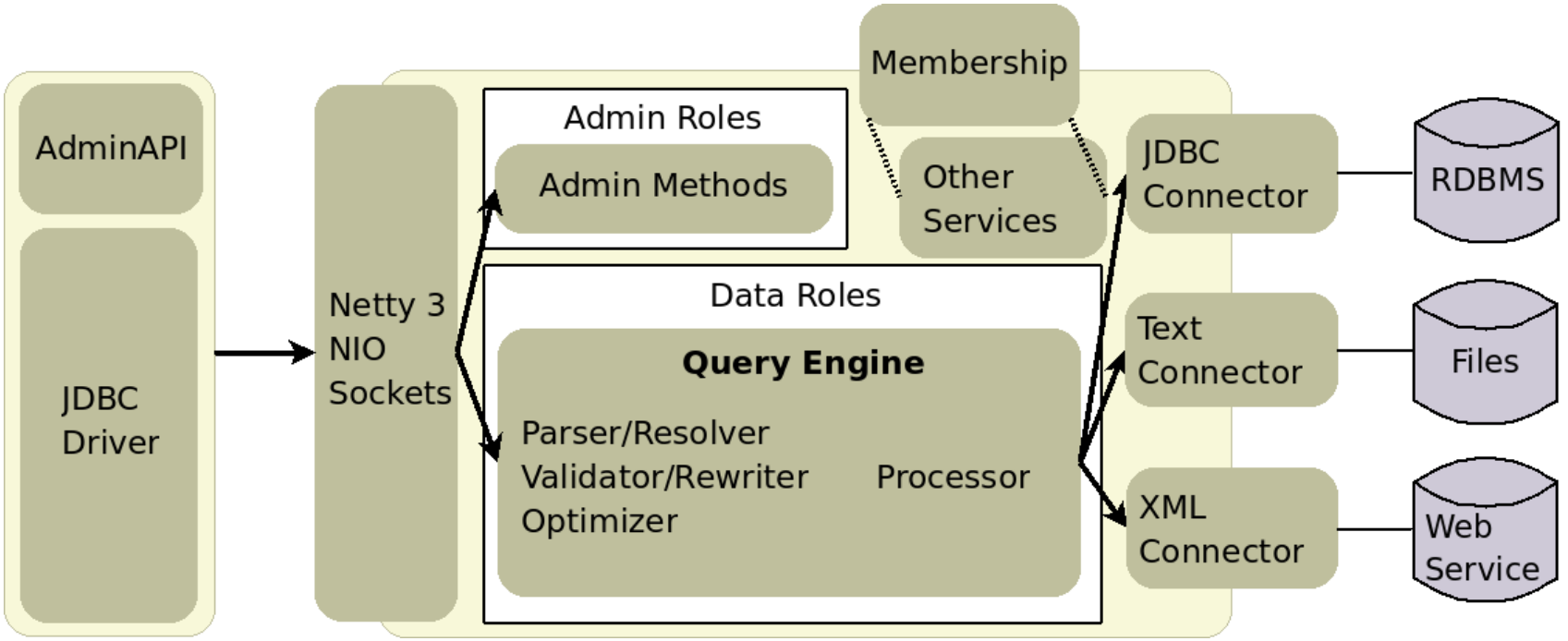
Architecture



SEDA - Connector bindings, socket transport, query engine, admin methods all have queues/thread pools

Each connector binding operates independently

Other services include JBoss Transactions JTA, BufferManager, sessioning, etc.

Connector API

Simplified object form of JDBC with concepts of JCA.

- Pooling, caching, some security handled by the runtime.
- Queries are resolved objects not just a string.

Extended metadata (ConnectorCapabilities) directs the optimizer source query formation.

In addition to out of the box offerings, our JDBC Connector is easily extended.

Can be though of as a JDBC toolkit.

Other Extension Points

Logging (Log4j), specific contexts for audit and commands

MembershipDomains – handle authentication/group assignment. Provide File and LDAP by default.

User defined functions – Implementation method in Java, currently only defined through Designer.

Scripting through AdminShell

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Internals

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Teiid Internals

Integration Features

Planning

Processing

Transactions

Integration Features

Access Patterns – criteria requirements on pushdown queries

Pushdown – decompose user query into source queries

- Remove unused select clause items
- Decompose aggregates over joins/unions

Dependent Joins (can use hints) – feed equi-join values from one side of the join to the other

Optional Join (can use hints) – removes an unused join child

Multi-source connector bindings – allows for multiple homogeneous schemas to be used through the same model.

Copy Criteria – uses criteria transitivity to minimize join tuples.

Planning

Distinct phases: parse, resolve, validation, rewrite, optimization, process plan creation.

Rewrite canonicalizes and simplifies.

The optimization phase follows with rules/hints/costing

- Procedures/XQuery not formally optimized
- Non-federated optimization is similar to mature RDBMS

Optimizer plan structure is a flexible tree - distinct from the command form and processing plans.

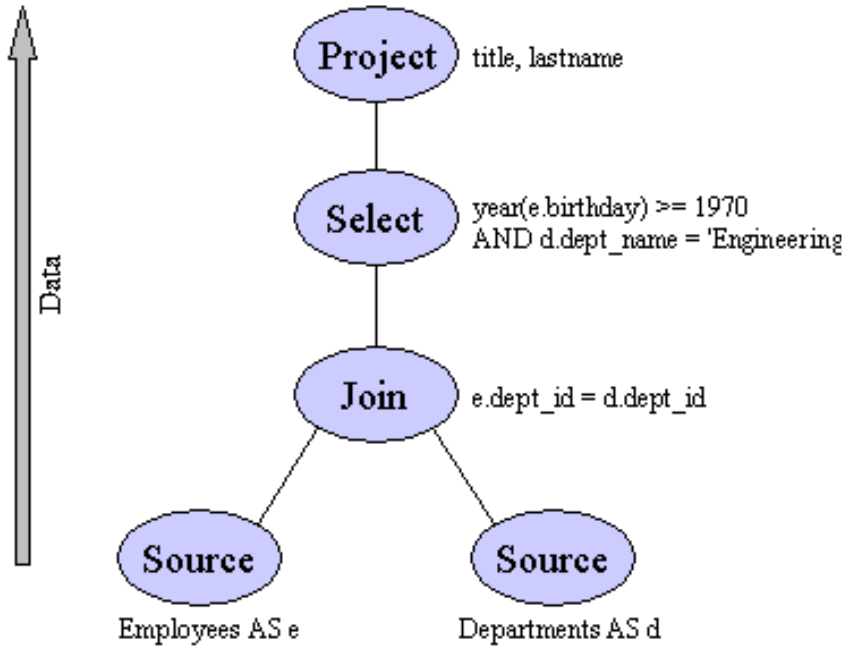
Planning is typically quick and deterministic – prepared plans are recommended

Understanding Planning

- Initial canonical plans follow the logical SQL processing flow:
  - from/where/group by/having/select/order by/limit/into
- Each node corresponds to a logical SQL operation
- Canonical relational plans not performant for federated queries – optimization is necessary
- Processing plans and intermediate plans can be shown in the log/obtained by the client.
  - `select * from …` **`option debug`** - with DETAIL logging

Visualizing a Plan

```
select e.title, e.lastname from Employees as e JOIN
  Departments as d ON e.dept_id = d.dept_id where
  year(e.birthday) >= 1970 and d.dept_name = 'Engineering'
```



=

```
Project(groups=[e] ...)
    Select(groups=[e, d] ...)
        Join(groups=[e, d] ...)
            Source(groups=[e] ...)
            Source(groups=[d] ...)
```

Plan Rules

Initial sequence driven by query form - some rules trigger others

Move/create/delete/modify nodes toward more optimal form

- RemoveVirtual – Removes inline views or nested transformations
- RaiseAccess – Ensures access nodes are raised meaning more will be executed by the connector
- PushSelectCriteria – Moves criteria toward tuple origin
- CollapseSource – Takes plan nodes below an Access node and creates a query (not the final query sent to the source, which will get translated by the connector)
- RulePlanSorts – Combines sort processing operations
- ... many others ...

Many rules correspond directly to federated optimizations – CopyCriteria, AggregatePushdown, RemoveOptionalJoins, etc.

Example Rule Application

SetOperation(groups=[], props={USE_ALL=true, SET_OPERATION=UNION})
  Project(groups=[BQT1.SmallA], props={PROJECT_COLS=[IntKey]})
    Access(groups=[BQT1.SmallA], props={MODEL_ID=Model(BQT1)})
      Source(groups=[BQT1.SmallA], props={NESTED_COMMAND=null})
  Project(groups=[BQT1.SmallA AS SmallA__1], props={PROJECT_COLS=[SmallA__1.IntNum]})
    Access(groups=[BQT1.SmallA AS SmallA__1], props={MODEL_ID=Model(BQT1)})
      Source(groups=[BQT1.SmallA AS SmallA__1], props={NESTED_COMMAND=null})

==========

EXECUTING **RaiseAccess**

AFTER:
Access(groups=[], props={MODEL_ID=Model(BQT1)})
  SetOperation(groups=[], props={USE_ALL=true, SET_OPERATION=UNION})
    Project(groups=[BQT1.SmallA], props={PROJECT_COLS=[IntKey]})
      Source(groups=[BQT1.SmallA], props={NESTED_COMMAND=null})
    Project(groups=[BQT1.SmallA AS SmallA__1], props={PROJECT_COLS=[SmallA__1.IntNum]})
      Source(groups=[BQT1.SmallA AS SmallA__1], props={NESTED_COMMAND=null})

Join Planning

The most complicated parts of the optimizer

It is not exhaustive, but does consider ordering (left linear), satisfying access patterns, and algorithm ([Partitioned] Merge / Nested Loop)

Ordering/algorithm is only important for federated joins. Once a join is pushed, it's declarative to the source

Merge joins have dependent variants, which can have large impact on performance – especially an unnecessary dependent join (see `makenotdep`)

Use of Costing

- Specified as attributes at the table and column level - will have a runtime interface soon
- Mostly based on cardinality with a simplistic cost model of execution
- Assign costs to different join ordering and implementations to pick the best one
- Using small, or inappropriate values, could lead to unexpected performance
- See plan info “Estimated Node Cardinality”, “Estimated Independent/Dependent ...”, etc. for values used in planning.

Processing

A relational processing plan is composed of discrete operations organized as a tree – very similar to the optimizer form:

AccessNode – Source Query/Procedure
GroupingNode – Grouping operations and aggregate calculation
JoinNode – Joins the left and right tuple sources together
LimitNode – Honors limits and offset
ProjectNode – Converts tuples (select clause)
SelectNode – Applies selection (where clause) criteria
SortNode – Sorts incoming tuples
...

Procedure plans are composed of instructions.

Tuples are processed in batches. The BufferManager is set to a specific memory limit; excess batches are written to disk.

Processing algorithms are sort based, variants chosen during planning and processing.

Example Process Plan

```
select * from System.DataTypeElements
```

ProjectNode(1) [dt.Name AS DataTypeName, c.NAME, ...]
JoinNode(2) [PARTITIONED SORT JOIN (SORT/**SORT_DISTINCT**)] [INNER JOIN]
\ criteria=[c.PARENT_UUID=dt.UID]
AccessNode(3) SELECT c.PARENT_UUID, ... FROM SystemPhysical.COLUMNS AS c
ProjectNode(4) [dt.NAME, dt.IS_BUILTIN AS IsStandard, ...]
JoinNode(5) [MERGE JOIN (SORT/SORT)] [LEFT OUTER JOIN]
\ criteria=[dt.UUID=a.ANNOTATED_UUID]
AccessNode(6) SELECT dt.UUID, dt.NAME, ... FROM SystemPhysical.DATATYPES AS dt
AccessNode(7) SELECT a.ANNOTATED_UUID, ... FROM SystemPhysical.ANNOTATIONS AS a

Shows decomposition into 3 source queries.

Also the optimizer has combined a distinct operation into JoinNode(2) loading of the right child.

Handling Load

Memory Usage – the BufferManager acts as a memory manager for batches (with passivation) to ensure that memory will not be exhausted.

Non-blocking source queries – rather than waiting for source query results processor thread detach from the plan and pick up a plan that has work.

Time slicing – plans produce batches for a time slice before re-queuing and allowing their thread to do other work (preemptive control only between batches)

Caching – ResultSets at the connector and user query level can be reused on a session or vdb basis

Transactions

Three scopes

- Global (through XAResource)
- Local (autocommit = false)
- Command (autocommit = true)

All scopes are handled by JBoss Transactions JTA

Command scope behavior is handled through txnAutoWrap={ON|OFF|OPTIMISTIC|PESSIMISTIC}

Isolation level is set on a per connector basis.

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Wrap Up

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Performance

Raw (cpu-intensive) overhead is typically sub-millisecond per prepared user query.

Integration performance – check the processing plan. We'll usually have the best form.

Consider using UDFs (Java) for reusable subroutines rather than stored procedures.

Client result sets can be scroll insensitive and backed by the BufferManager.

Differences with traditional Java DBs

- Flexible planning architecture
- Geared to high-performance integration processing – task specific queues and thread pools, advanced buffer management, batching, etc.
- Lack of DDL support
- Loose constraint handling
  - pk/fk, unique, and type constraints are in metadata, but are not enforced at runtime.
- Temp tables backed by BufferManager rather than a relational/indexed storage engine.

Future Releases

We'll look even more like a database - direct usage of DDL for metadata.

More features around materialization, data locality, and caching.

Continued integration with other JBoss projects.

More design-time integration with Eclipse DTP
http://www.eclipse.org/datatools/

QUESTIONS?

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