Batches
Unified and Efficient Access to RPC, WS, and SQL Services

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Advertisement

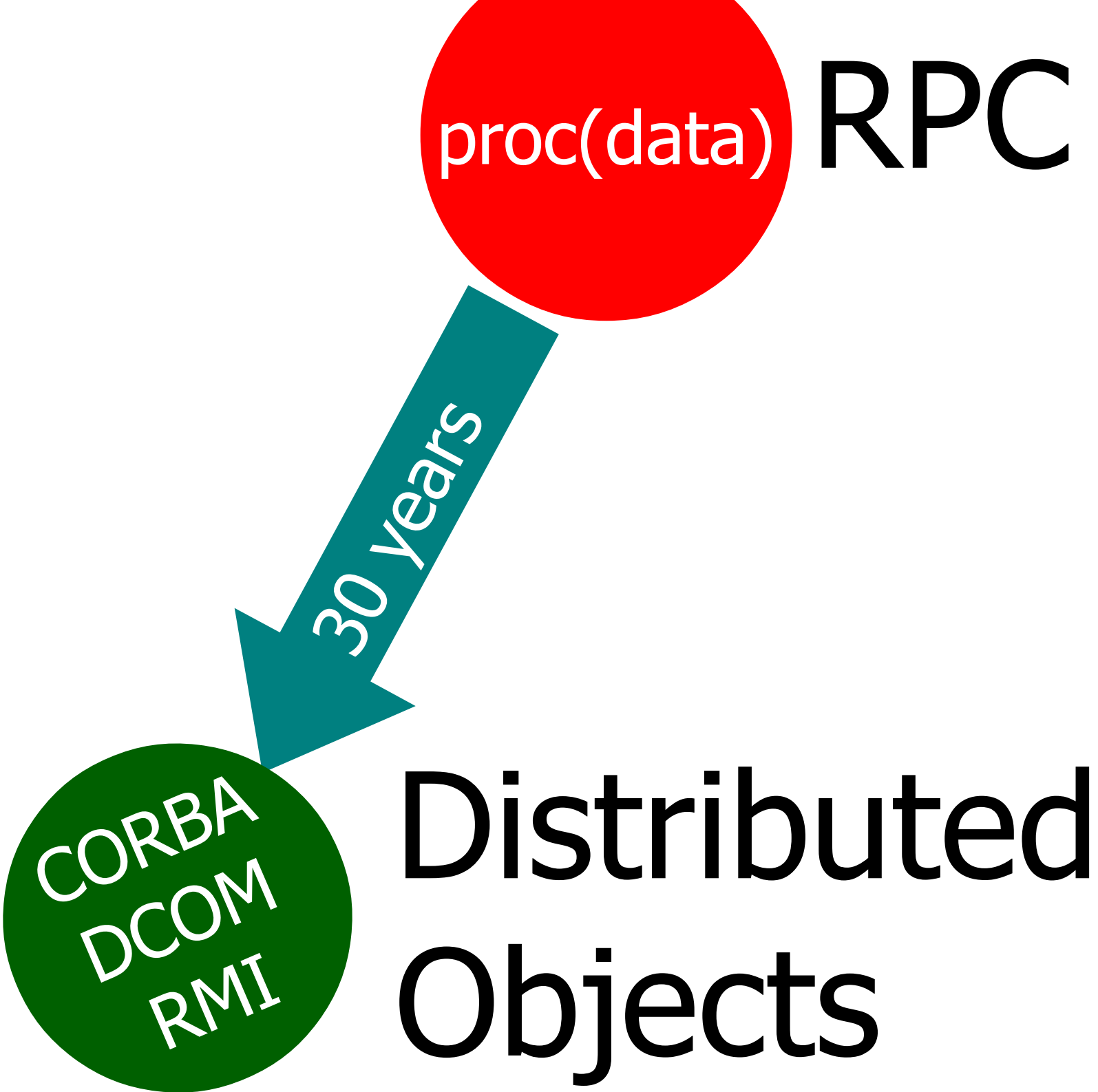
Enso – interpreted integrated DSLs

Hybrid Partial Evaluation

Orc – structured concurrency

Batches – this talk

Three kinds of
"remoteness"


proc(data)
RPC
30 years
CORBA
DCOM
RMI
Distributed
Objects

Benefits

- Use existing languages
- Elegant OO model

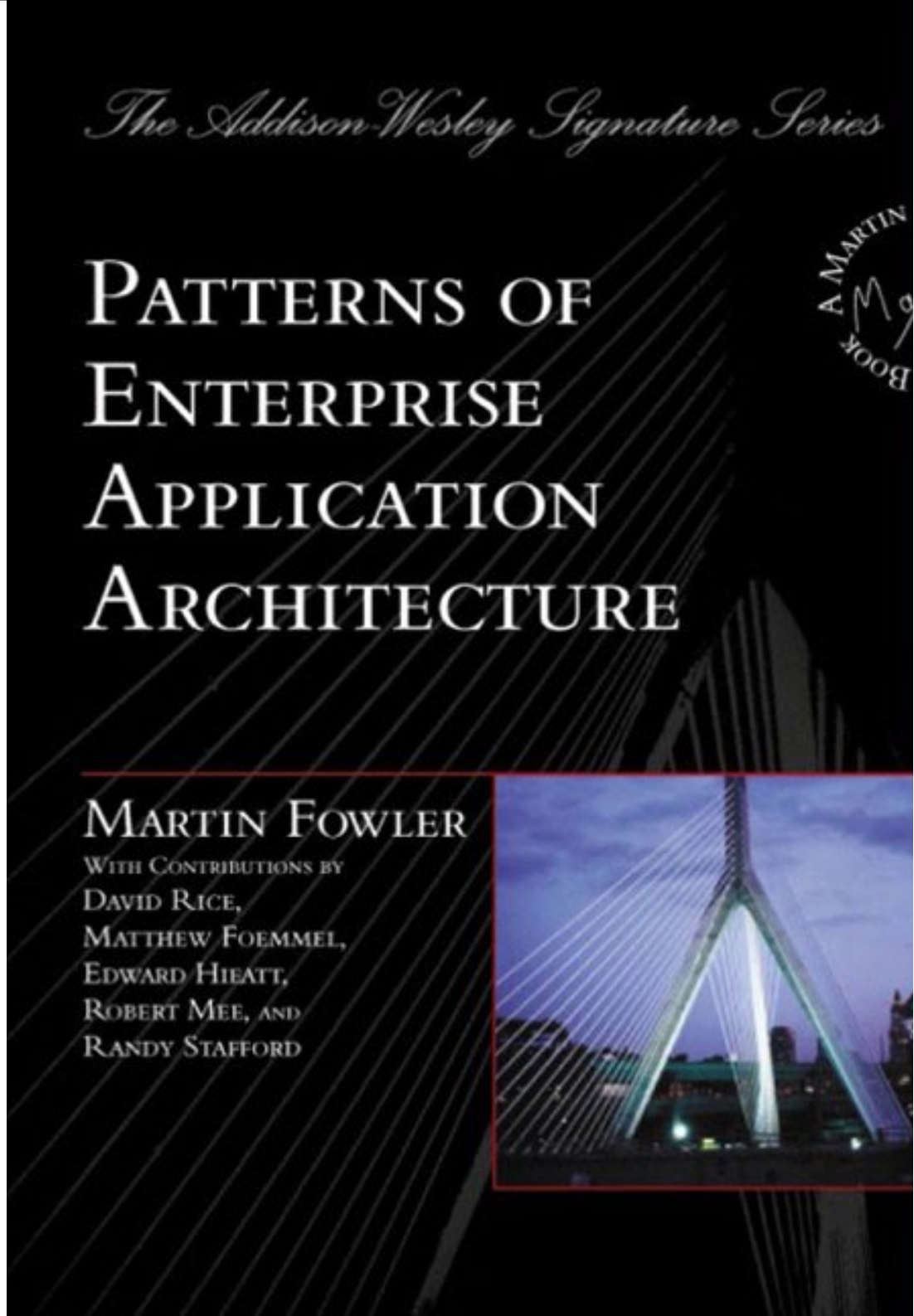
Problems

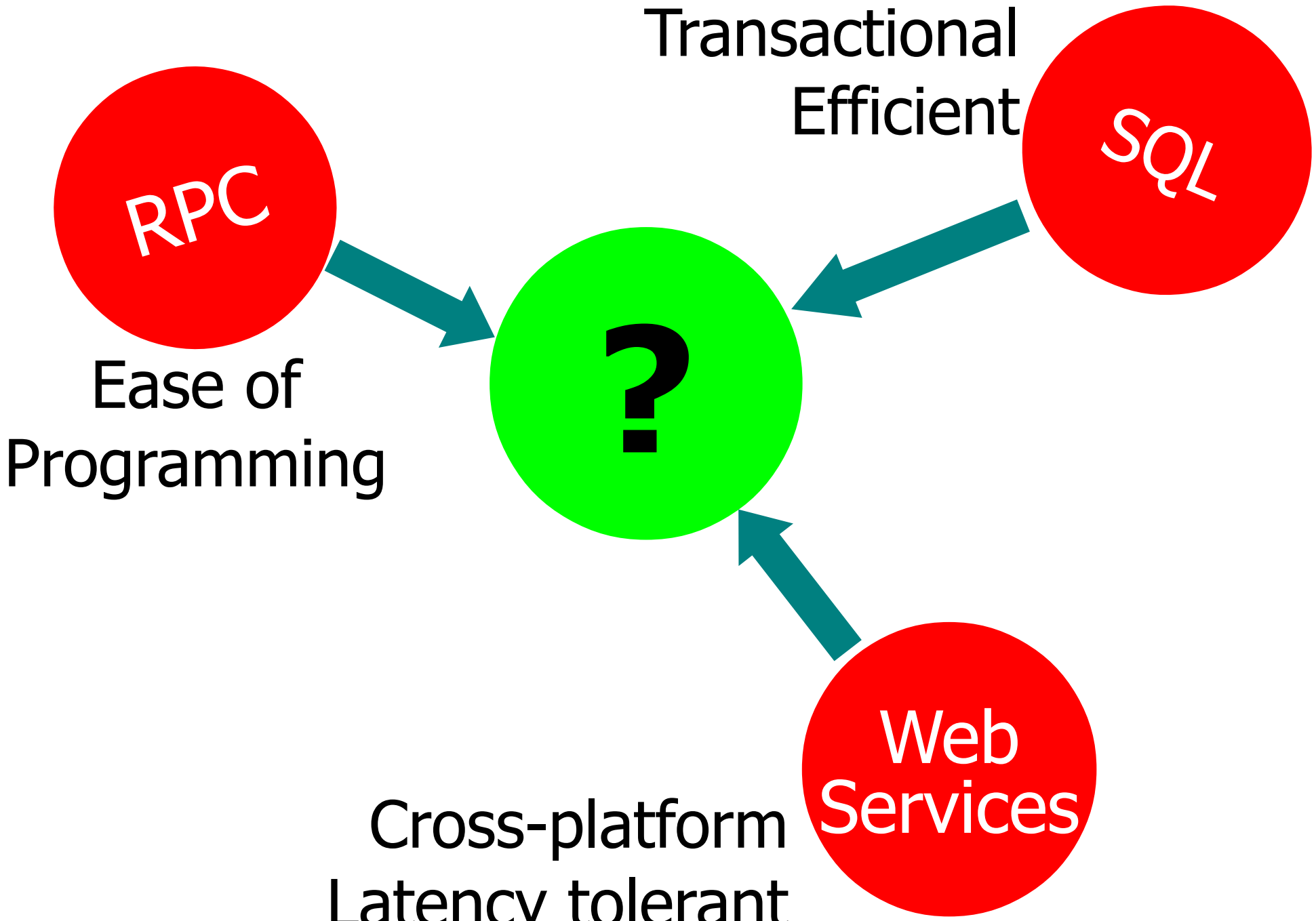
- Latency (many round trips)
- Stateful communication
- Platform-specific

Solutions?

- Remote Façade
- Data Transfer Object

Solutions are as bad as the problem!




Transactional
Efficient
SQL
RPC
?
Ease of
Programming
Web
Services
Cross-platform
Latency tolerant

Impedance Mismatch

"Whatever the database programming model, it must allow complex, data-intensive operations to be picked out of programs for execution by the storage manager..."

David Maier, DBLP 1987

Start Over: Remote Calls

Starting point

```
print( r.getName() );
print( r.getSize() );
```

Notes:
print is local
r is remote

Goals

Fast: one round trip

Stateless communication

do not *require* persistent connection

Platform independent

no serialization of complex user-defined objects

Clean programming model

A Novel Solution: Batches

```
batch ( Item r : service ) {
    print( r.getName() );
    print( r.getSize() );
}
```

Execution model: Batch Command Pattern

1. Client **sends *script*** to the server
   (Creates Remote Façade on the fly)
2. Server **executes** two calls
3. Server **returns results in bulk** (name, size)
   (Creates Data Transfer Objects on the fly)
4. Client **runs the local code** (print statements)

Compiled Client Code (generated)

```
// create remote script
script = <
   out_A( *.getName() )
   out_B( *.getSize() )
>;
// execute on the server
Forest x = service.execute( script );

// Client uses the results
print( x.get("A") );
print( x.getInt("B") );
```

A larger example

```
int limit = ...;
Service<Mailer> serviceConnection =...;
batch ( Mailer mail : serviceConnection ) {
    for ( Message msg : mail.Messages )
        if ( msg.Size > limit ) {
            print( msg.Subject & " Deleted" );
            msg.delete();
        }
        else
            print( msg.Subject & ":" & msg.Date );
 }
```

Remote part as Batch Script

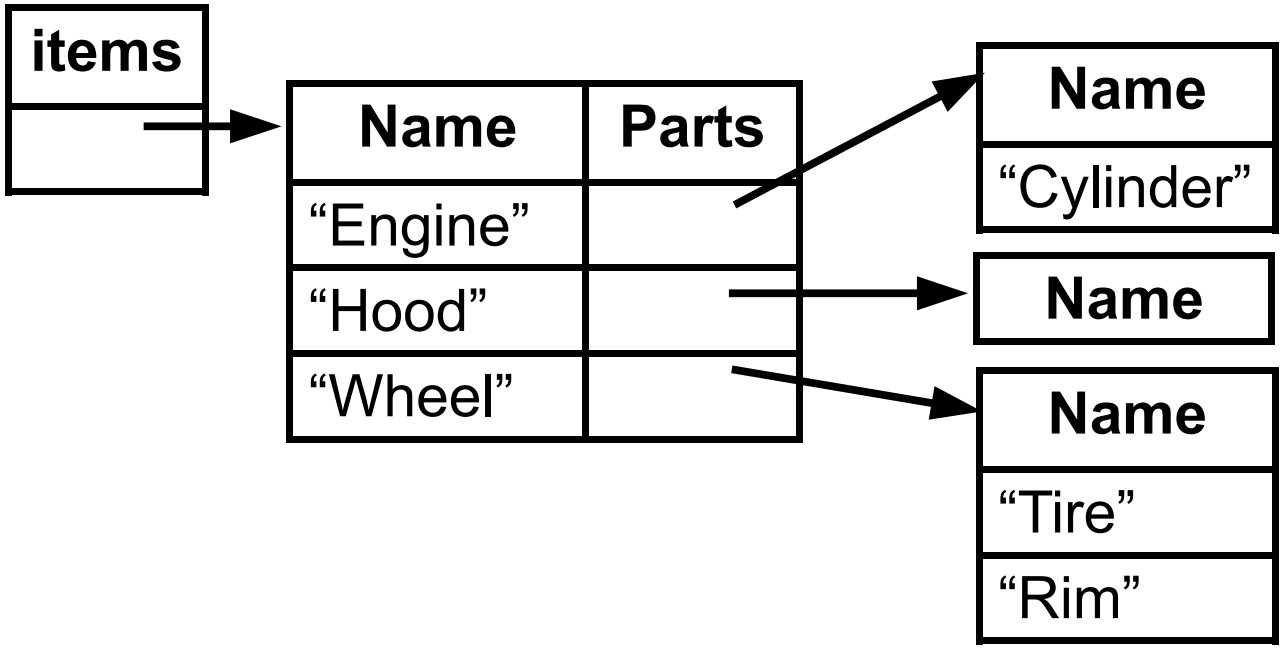
```
script = <
  for ( msg : *.Messages ) {
    out_A( msg.Subject );
    if ( out_B( msg.Size > in_X ) ) {
      msg.delete();
    } else {
      out_C( msg.Date );
    }
  >
```

Compiled code (auto generated)

```
Service<Mailer> serviceConnection =...;
in = new Forest();
in.put("X", limit);
Forest result =
   serviceConnection.execute(script, in);
for ( r : result.getIteration("msg") )
  if ( r.getBoolean("B") )
    print( r.get("A") & " Deleted" );
  else
    print( r.get("A") & ":" & r.get("C") );
```

Forest Structure == Control flow

```
for (x : r.Items) {
  print( x.Name );
  for (y : x.Parts)
    print( y.Name );
}
```



Batch = One Round Trip

Clean, simple performance model

Some batches would require more round trips

```
batch (..) {
    if (AskUser("Delete " + msg.Subject + "?")
        msg.delete();
}
```

Pattern of execution

OK: Local → Remote → Local

Error: Remote → Local → Remote

Can't just mark everything as a batch!

What about Object Serialization?

Batch only transfers primitive values, not objects

But they work with any object, not just *remotable* ones

Send a local set to the server?

```
Set<String> local = … ;
batch ( mail : server ) {
    service.Set recipients = local; // compiler error
    mail.sendMessage( recipients, subject, body);
}
```

Serialization by Public Interfaces

```
Set<String> local = … ;
batch ( mail : server ) {
    service.Set recipients = mail.makeSet();
    for (String addr : local )
        recipients.add( addr );
    mail.sendMessage( recipients, subject, body);
}
```

Sends list of addresses with the batch

Constructors set on server and populates it

Works between different languages

Serialization can be encapsulated in a procedure

Interprocedural Batches

Reusable serialization function

```
@Batch
service.Set send(Mail server, local.Set<String> local) {
    service.Set remote = server.makeSet();
    for (String addr : local )
        remote.add( addr );
    return remote;
}
```

Main program

```
batch ( mail : server ) {
    remote.Set recipients = send( localNames );
```

Exceptions

Server Exceptions

- Terminate the batch
- Return exception in forest
- Exception is raised in client at same point as on server

Client Exceptions

- Be careful!
- Batch has already been fully processed on server
- Client may terminate without handling all results locally

Transactions and Partial Failure

Batches are not necessarily transactional

- But they do facilitate transactions
- Server can execute transactionally

Batches reduce the chances for partial failure

- Fewer round trips
- Server operations are sent in groups

Order of Execution Preserved

All local and remote code runs in correct order

```
batch ( remote : service ) {
   print( remote.updateA( local.getA() ));  // getA, print
   print( remote.updateB( local.getB() ));  // getB, print
}
```

Partitions to:

```
input.put("X", local.getA() );  // getA
input.put("Y", local.getB() );  // getB
.... execute updates on server
print( result.get("A) );              // print
print( result.get("B") );             // print
```

Compiler Error!

Batch Summary

Client

Batch statement: compiles to Local/Remote/Local

Works in any language (Java, C#, Python, JavaScript)

- Cross-language and cross-platform

Server

Small engine to execute scripts

- Call only public methods/fields (safe as RPC)
- Stateless, no remote pointers (aka proxies)

Communication

Forests (trees) of primitive values (no serialization)

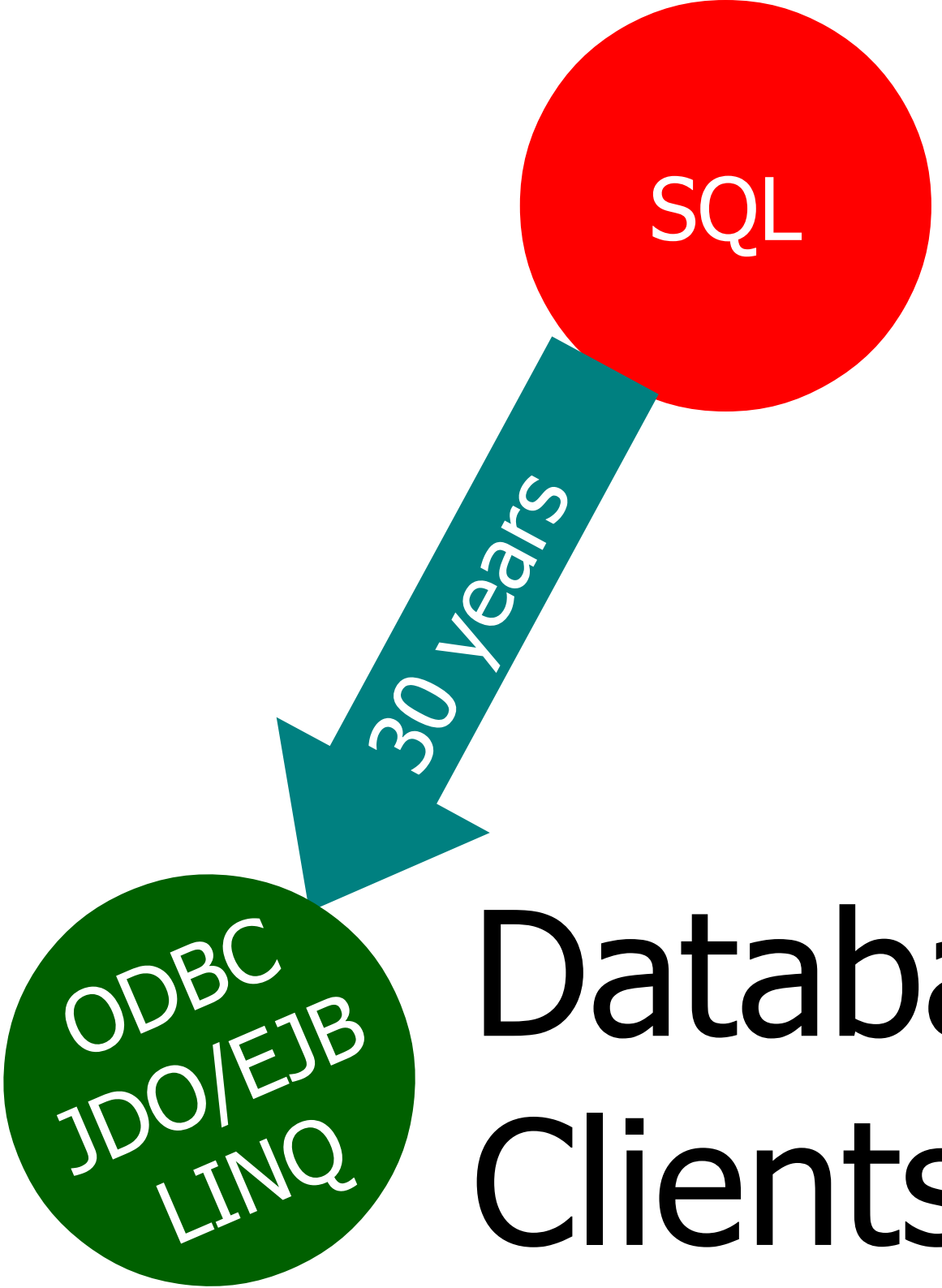
- Efficient and portable

Batch Script Language

e ::= x | c	variables, constants
| **if** e **then** e **else** e	conditionals
| **for** ⊕ x : e **do** e	loops
| **let** x = e **in** e	binding
| x = e | e.x = e	assignment
| e.x	fields
| e.m(e, ..., e)	method call
| e ⊕ … ⊕ e	primitive operators
| $\mathbf{in}_X$ | $\mathbf{out}_X$ e	parameters and results
| **fun**(x) e	functions

⊕ = + – * / % ; < <= == => > & | not

Agree on *script format*, not on *object representation*



Database Clients

Call Level Interface (e.g. JDBC)

```
// create a remote script/query
String q = "select name, size
           from files
           where size > 90";
// execute on server
Statement st = conn.createStatement();
ResultSet rs = st.executeQuery(q);
// use the results
while ( rs.next() ) {
    print( rs.getString("name") );
    print( rs.getInteger("size") );
}
```

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    print( rs.getString("name") );
    print( rs.getInteger("size") );
}
```

In-Memory Objects

```
for ( File f : directory.Files )
    if ( f.Size > 90 ) {
        print( f.Name );
        print( f.Size );
    }
```

Batches ==> SQL

```
batch ( Service<FileSystem> directory : service ) {
    for ( File f : directory.Files )
        if ( f.Size > 90 ) {
            print( f.Name );
            print( f.Size );
        }}
```

Batch Script:

< for (f : *.Files)
    if (f.Size > 90) { out_A(f.Name); out_B(f.Size) } >

SQL:

```
SELECT f.Name, f.Size
FROM Files
WHERE f.Size > 90
```

Data Schema = Server Interface

```
public class Northwind {
  Set<Customer> Customers;
  Set<Order> Orders;
  void insertCustomer(Customer c);
  void insertOrder(Order o);
}
```

```
@Table(name="Orders")
public abstract class Order {
  @Id public int OrderID;
  public Date OrderDate;
  public Date RequiredDate;
  public Date ShippedDate;

  @Column(name="CustomerID")
  public Customer Customer;

  delete();
}
```

```
@Table(name="Customers")
public class Customer {
  @Id String CustomerID;
  String CompanyName;
  String ContactName;
  String Country;

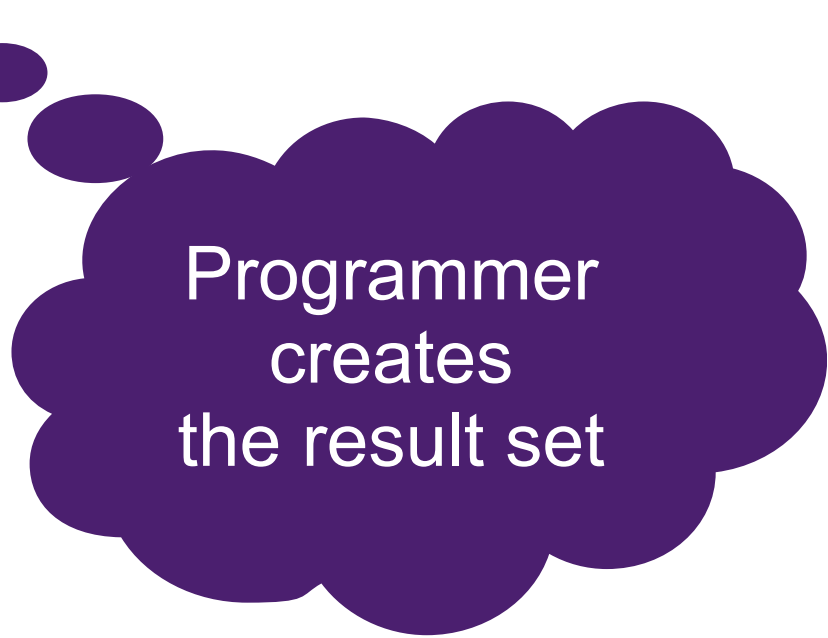
  @Inverse("Customer")
  Set<Order> Orders;

  delete();
}
```

LINQ

```
// create the remote script/query
var results = from f in files
              where size > 90
              select { f.name, f.size };

// execute and use the results
for (var rs in results ) {
    print( rs.name );
    print( rs.size );
}
```



Dynamic Queries in LINQ

```
var matches = db.Course;
// add a test if the condition is given
if (Test.Length > 0)
      matches = matches.Where(
         c => c.Title == Test);
// select the desired values
matches = matches.Select(c => c.Title);
// iterate over the result set
for (String title : matches.ToList())
     print(title);
```

Dynamic Queries in Batches

```
batch (db : Database) {
  for (Ticket t : db.Course)
    if (Test.Length == 0 || c.Title == Test)
      print(c.Title);
}
```

Left side of condition is *client-only:* Pre-evaluated

Batches for SQL

Batch compiler creates SQL automatically

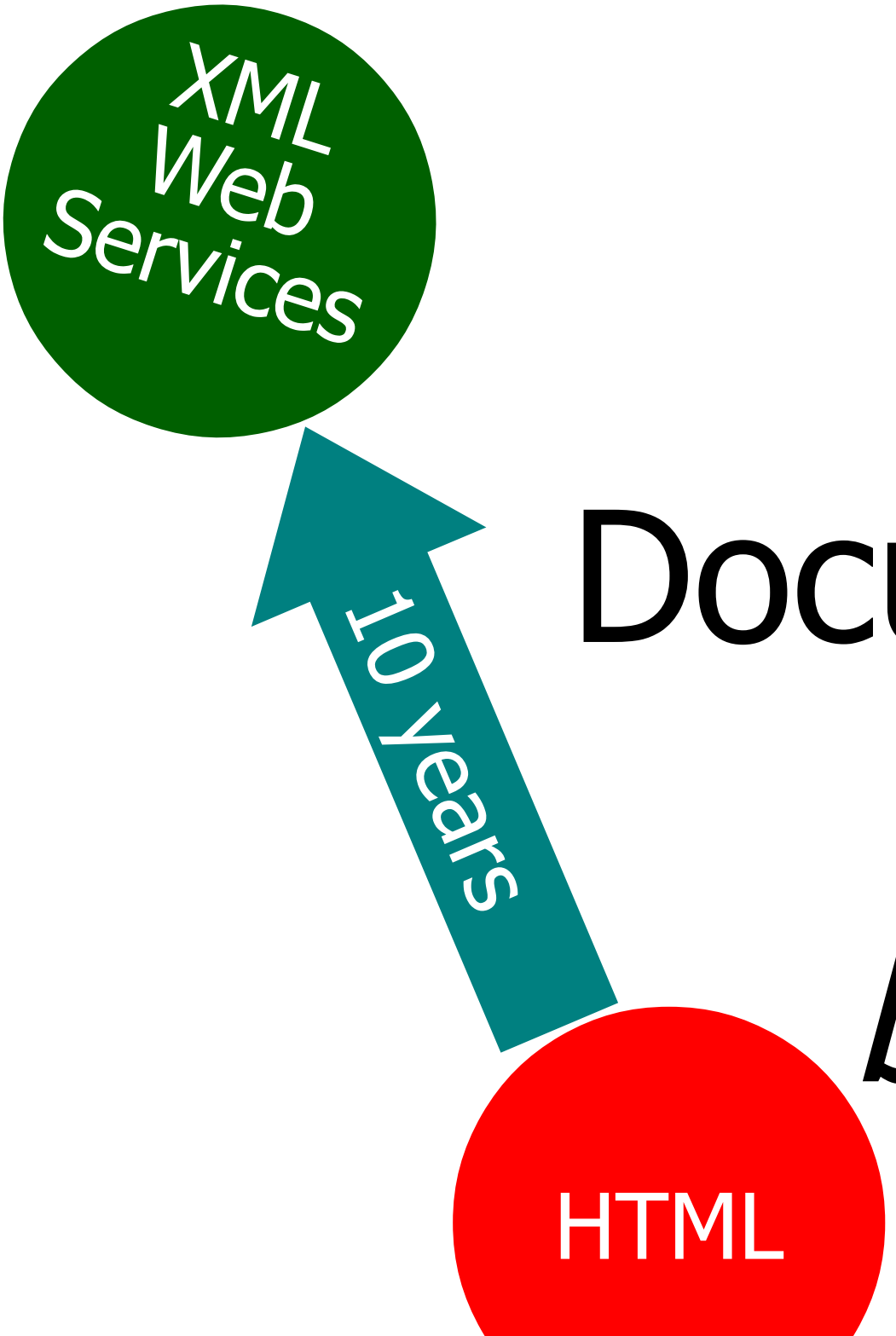
- Efficient handling of nested of loops
- Always a *constant* number of queries for a batch
  - No matter how many (nested) loops are used

Supports all aspects of SQL

- Queries, updates, sorting, grouping, aggregations

Summary

- Clean fine-grained object-oriented programming model
- Efficient SQL batch execution



Web Service Documents *are batches*

Amazon Web Service

```
<ItemLookup>
<AWSAccessKeyId>XYZ</AWSAccessKeyId>
<Request>
  <ItemIds>
    <ItemId>1</ItemId>
    <ItemId>2</ItemId>
  </ItemIds>
  <IdType>ASIN</ItemIdType>
  <ResponseGroup>SalesRank</ResponseGroup>
  <ResponseGroup>Images</ResponseGroup>
</Request>
</ItemLookup>
```

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</Request>
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```

Custom-defined language for each service operation

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<Request>
  <ItemIds>
    <ItemId>1</ItemId>
    <ItemId>2</ItemId>
  </ItemIds>
  <IdType>ASIN</ItemIdType>
  <ResponseGroup>SalesRank</ResponseGroup>
  <ResponseGroup>Images</ResponseGroup>
</Request>
</ItemLookup>
```

for (item : Items) {

out_A(item.SalesRank)

out_B(item.Images)

}

Web Service Client Invocation

```
// create request
ItemLookupRequest request = new ItemLookupRequest() ;
request.setIdType("ASIN");
request.getItemId().add(1);
request.getItemId().add(2);
request.getResponseGroup().add("SalesRank") ;
request.getResponseGroup().add("Images") ;
// execute request
items = amazonService.itemLookup(null, awsAccessKey,
   associateTag, null, null, request, null,
   operationRequest) ;
// use results
for (item : items.values)
  display( item.SalesRank, item.SmallImage );
```

Method names in strings

Batch execution pattern (again!)

Batch Version of Web Service

```
// calls specified in document
batch (Amazon aws : awsConnection) {
  aws.login("XYZ");

  Item a = aws.getItem("1");
  display( a.SalesRank, a.SmallImage );

  Item b = aws.getItem("2");
  display( b.SalesRank, b.SmallImage );
}
```

Fine-grained logical operations

Coarse-grained execution model

Available Now...

Jaba: Batch Java

100% compatible with Java 1.5

Transport: XML, JSON, easy to add more

Batch statement as "for"

for (RootInterface r : serviceConenction) { ... }

Full SQL generation and ORM

Select/Insert/Delete/Update, aggregate, group, sorting

Future work

Security models, JavaScript/Python clients

Edit and debug in Eclipse or other tools

Available now!

Opportunities

Add batch statement to your favorite language

Easy with reusable partitioning library

Scala, C#, Python, JavaScript, COBOL, Ruby, etc...
Monads?

Optimization by partial evaluation

What about multiple servers in batch?

Client → Server*

Client ↔ Server

Client → Server → Server

Generalize "remoteness": MPI, GPU, ...

Concurrency, Asynchrony and Streaming

Related work

Microsoft LINQ

Batches are different and more general than LINQ

Mobile code / Remote evaluation

Does not manage returning values to client

Implicit batching

Performance model is not transparent

Asynchronous remote invocations

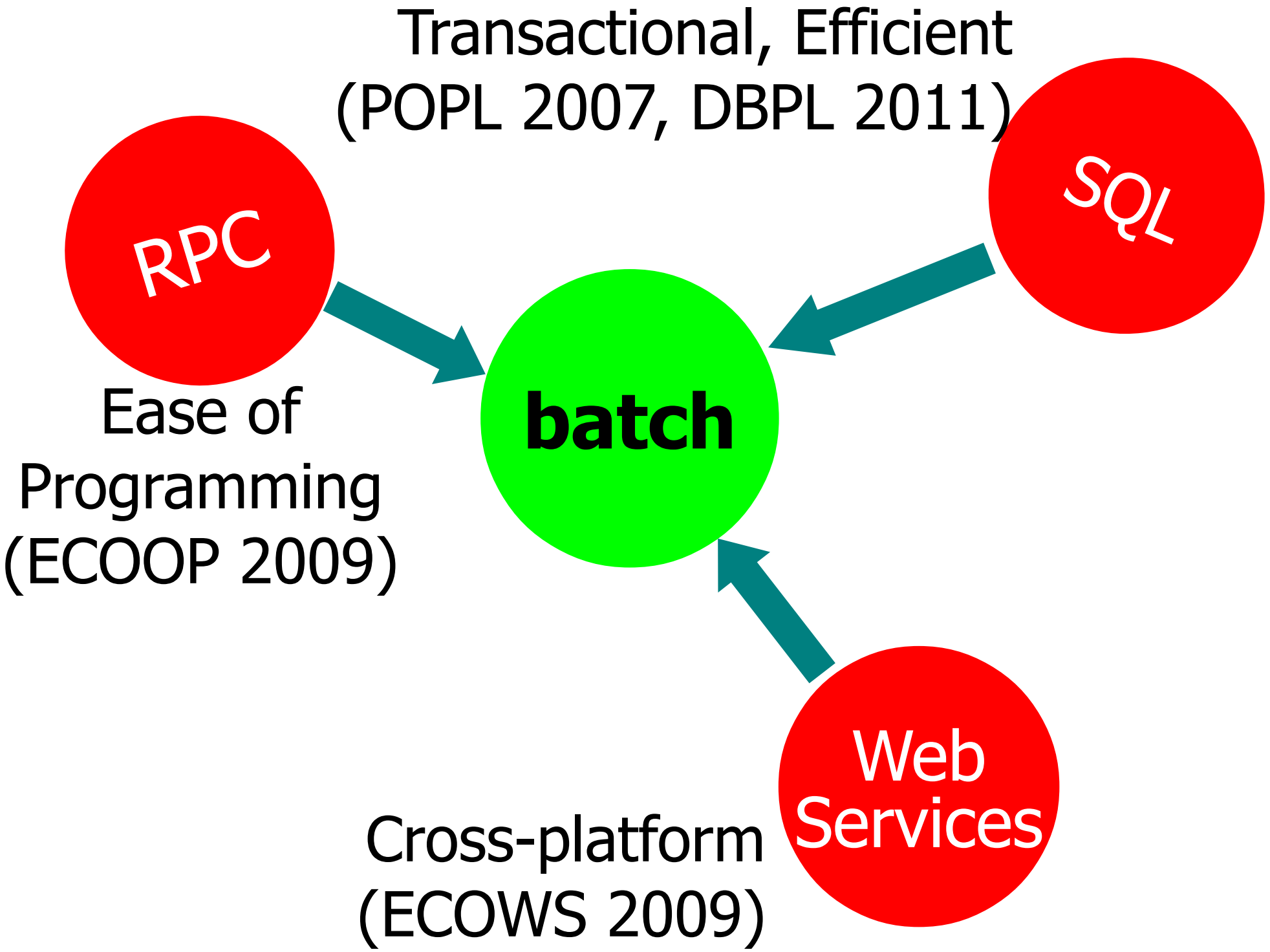
Asynchrony is orthogonal to batching

Automatic program partitioning

binding time analysis, program slicing

Deforestation

Introduce inverse: ***reforestation*** for bulk data transfer


Transactional, Efficient
(POPL 2007, DBPL 2011)
RPC
SQL
batch
Ease of
Programming
(ECOOP 2009)
Web
Services
Cross-platform
(ECOWS 2009)

Conclusion

Batch Statement

General mechanism for partitioned computation

Unifies

Distributed objects (RPC)

Relational (SQL) database access

Service invocation (Web services)

Benefits:

Efficient distributed execution

Clean programming model

No explicit queries, stateless, no proxies

Language/transport neutral

Requires adding batch statement to language!