Hybrid Shipping Architectures: A Survey

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Outline

- Partitioning query processing
- Partitioning client code
- Optimization of query plans
- Mobile code approaches
- Conclusions and future work

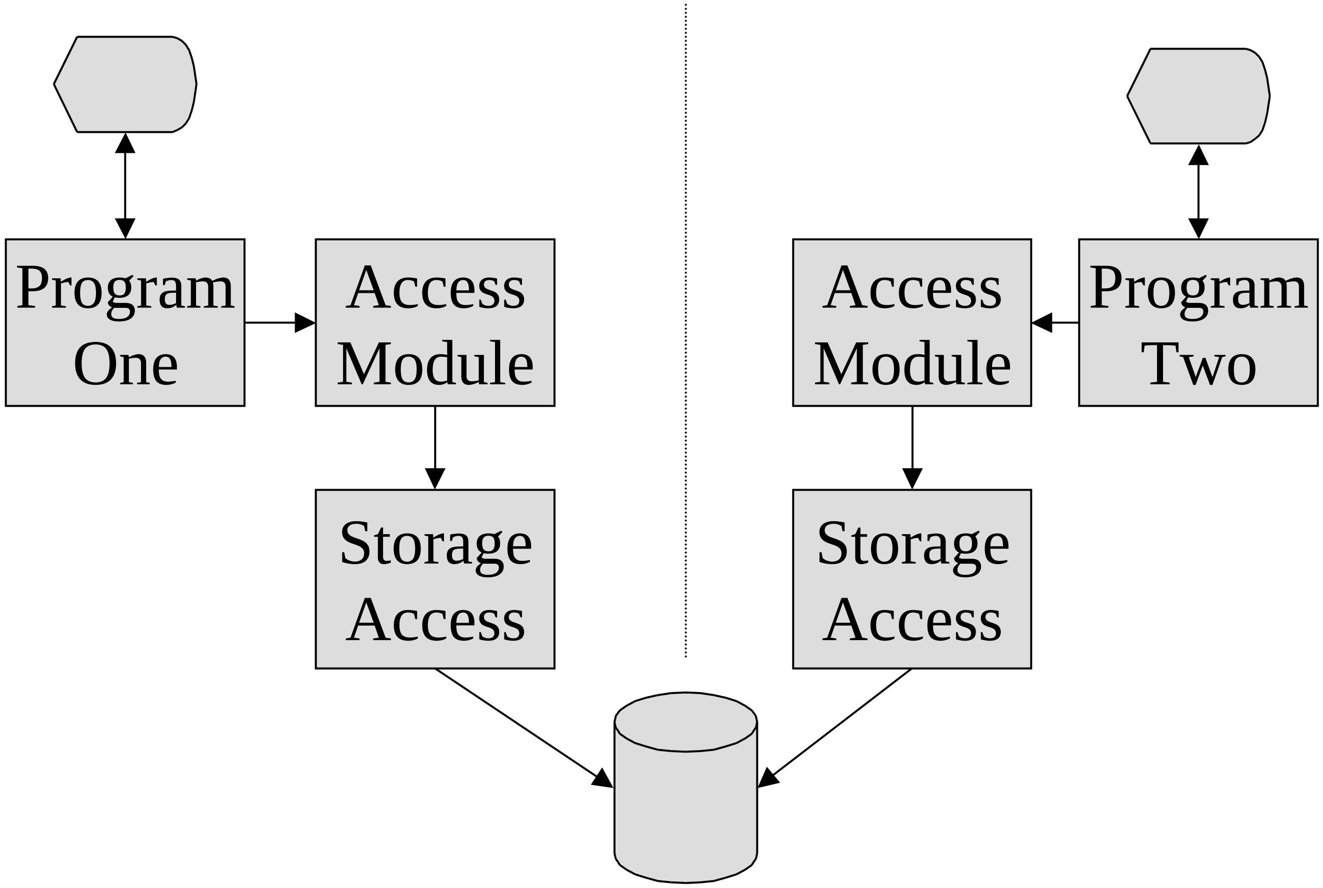
Introduction

- RDBMSs partition applications into a relational portion and procedural portion
- Recent advances have shown how to distribute the relational query processing
- It may also make sense to distribute procedural processing of client programs
- This is possible today, but it is very hard!

Partitioning System Functionality

- Split relational and procedural processing
  - Relational processing can be optimized and executed efficiently
  - Procedural code is flexible and more powerful
  - This gives a clean architecture, with nice separation of concerns
- Relational system provides transparency to client application

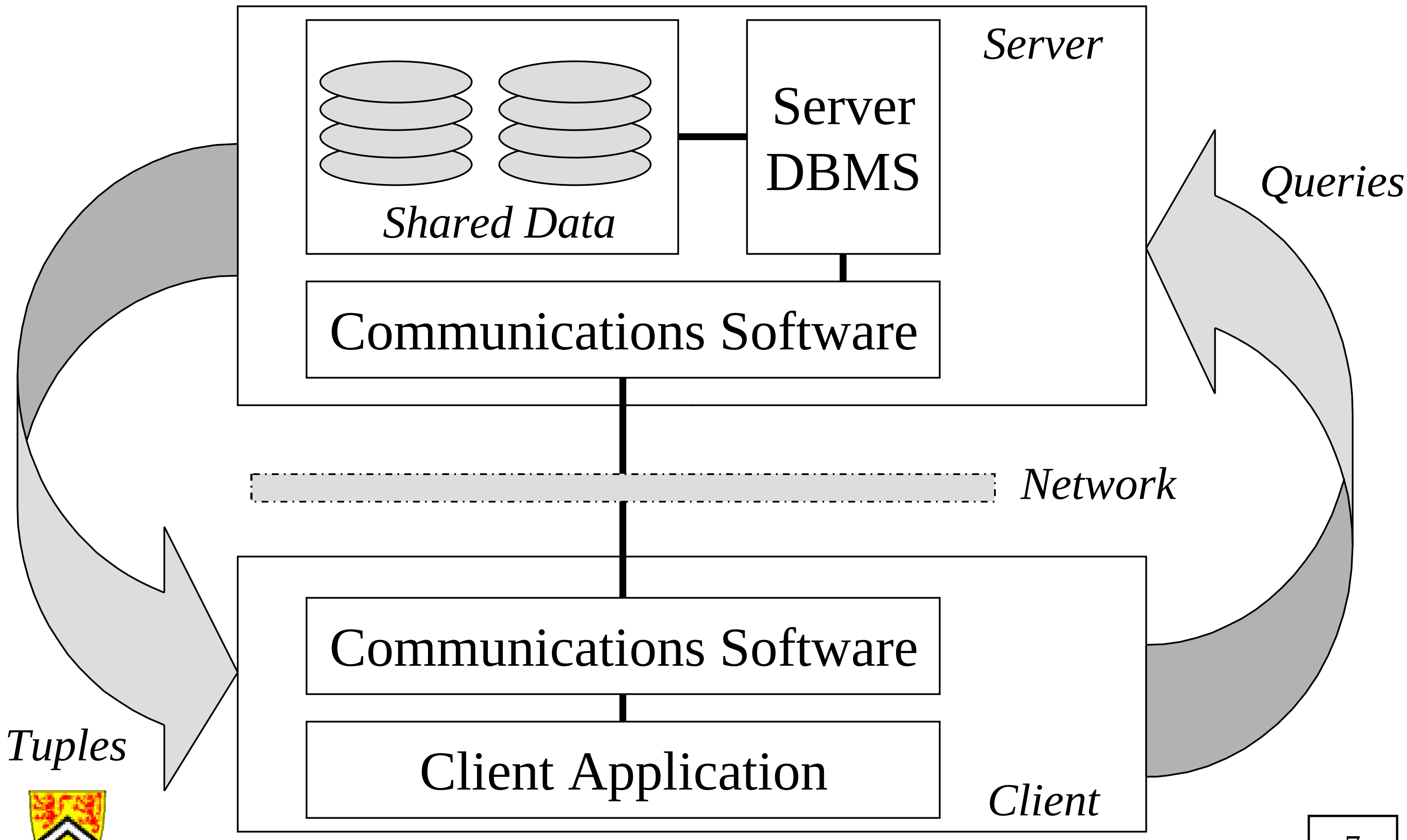
Single Processor System



Using Multiple Computers

- An early idea: Client/Server
  - Data and DBMS on one machine (Server)
  - Client application on another (Client)
- Client sends queries to Server, gets results
- Client resources really only used for client application
- Server is a bottleneck

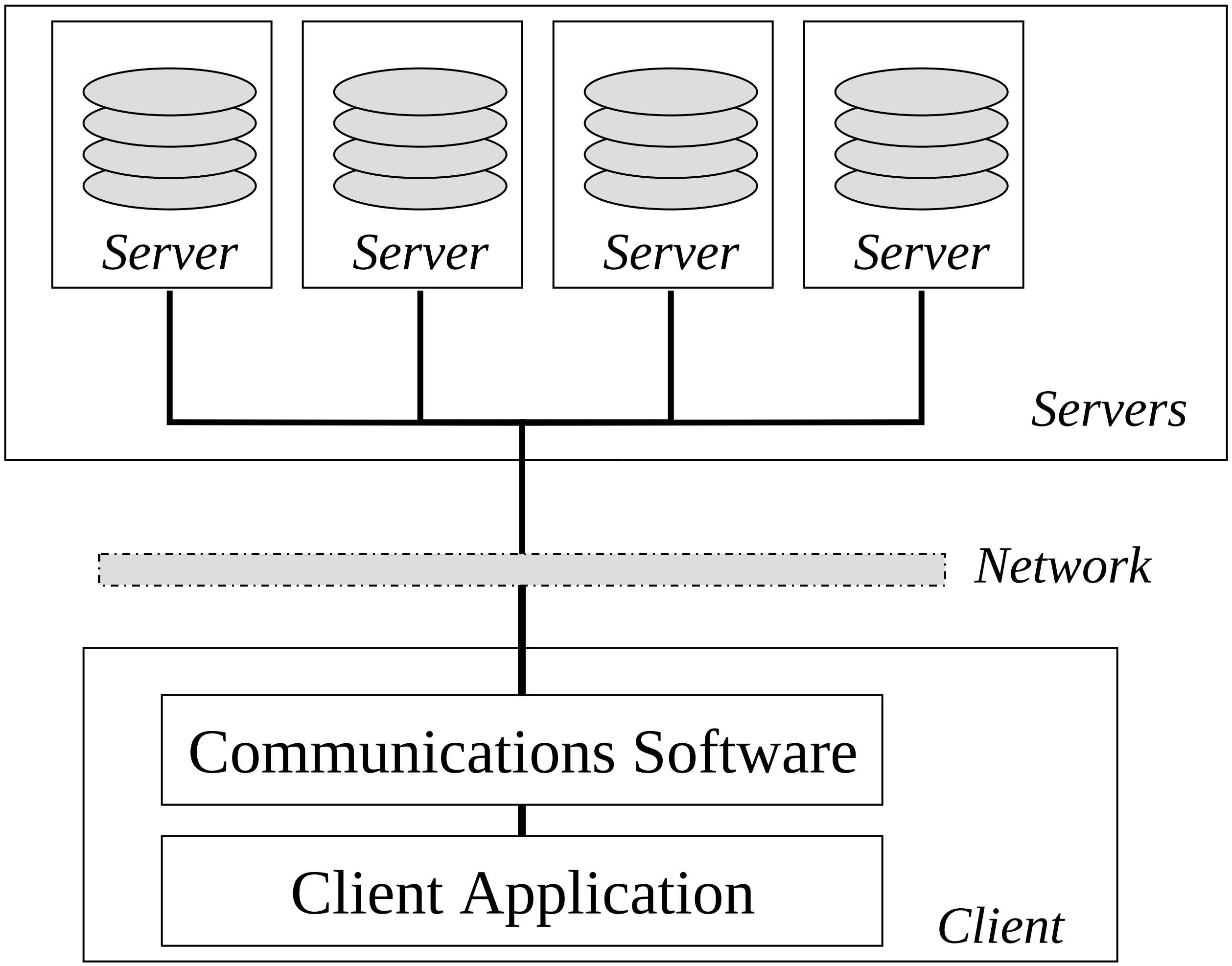
Query Shipping Client Server



Distributed Client Server

- To support more clients, we can:
  - Buy a bigger server
  - Add more servers and partition the data
- Adding more servers is likely cheaper
- Requires data partitioning, distributed query processing, distributed concurrency, …
  - (all of which we've talked about in class)

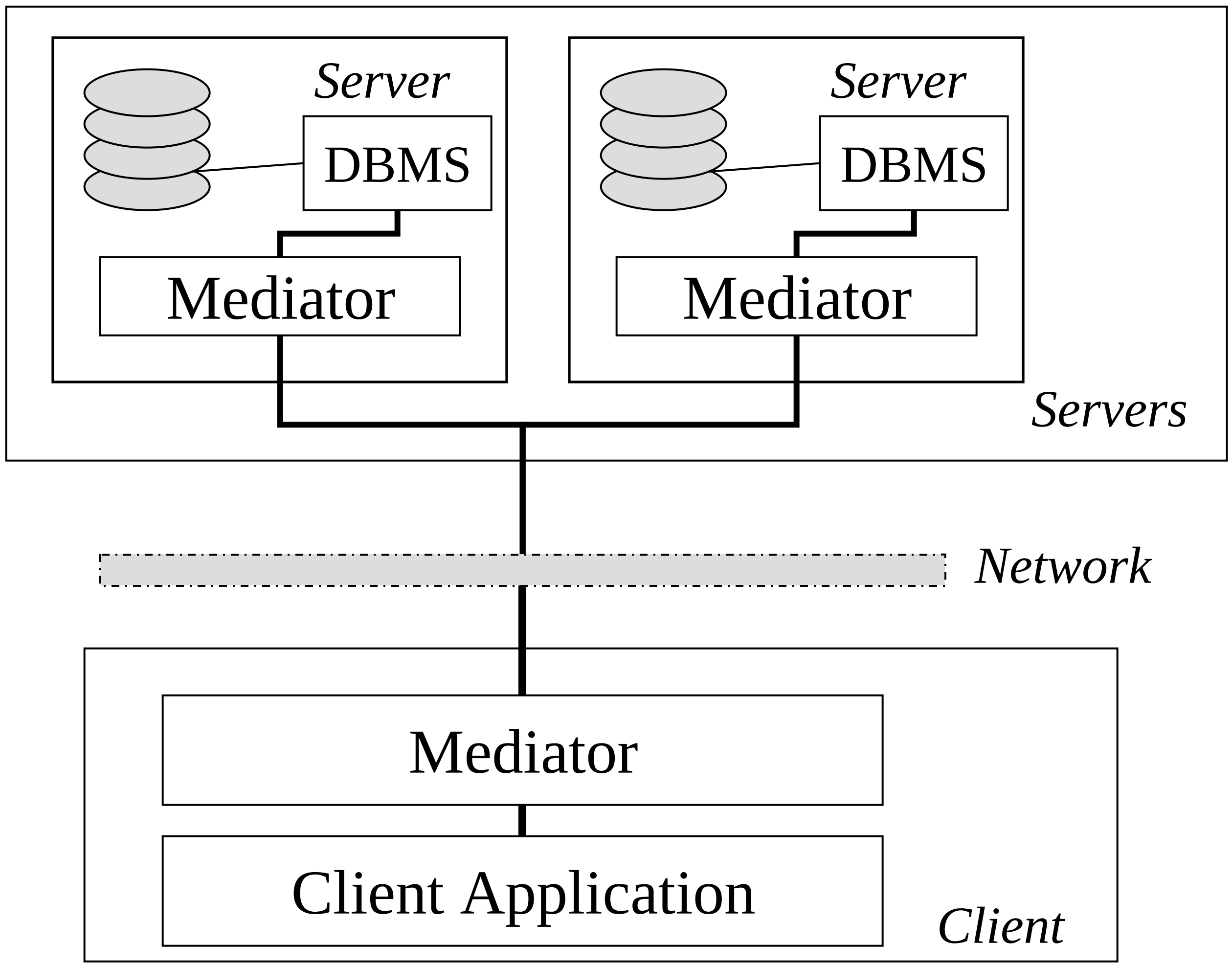
Distributed Client Server



Heterogeneous Processing

- Servers may be heterogeneous
- *Wrappers* can provide a uniform view of servers
- Leads to distributed query processing with some processing on client (at a minimum, what the servers could not handle)

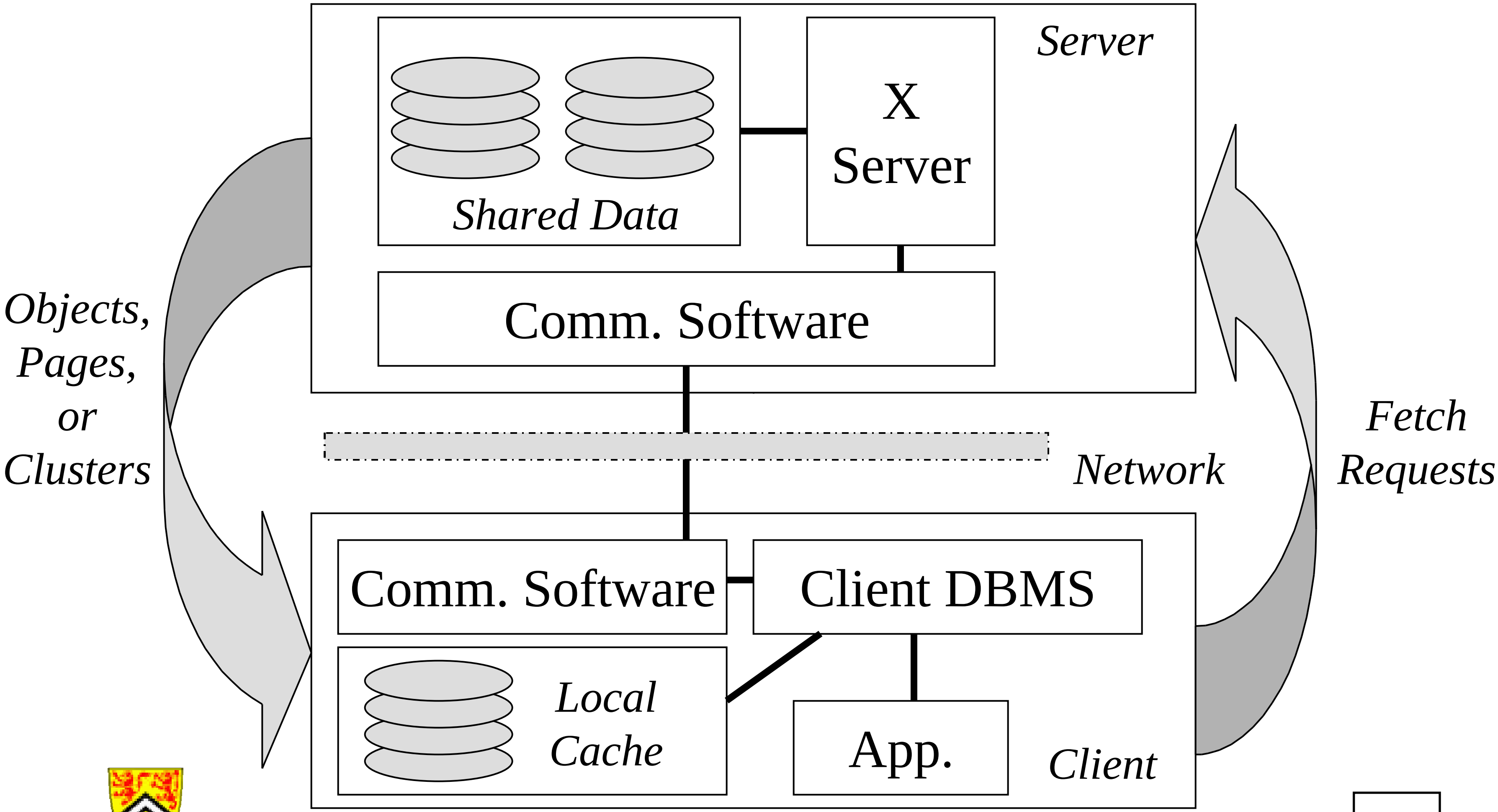
Mediator Architectures



Data Shipping

- Do all query processing at client
- Cache data on clients
- Ship data in from server as needed:
  - Object
  - Disk pages
  - Groups of objects
  - Hybrid of the above
- Typically used by OODBMS

Data Shipping Client Server

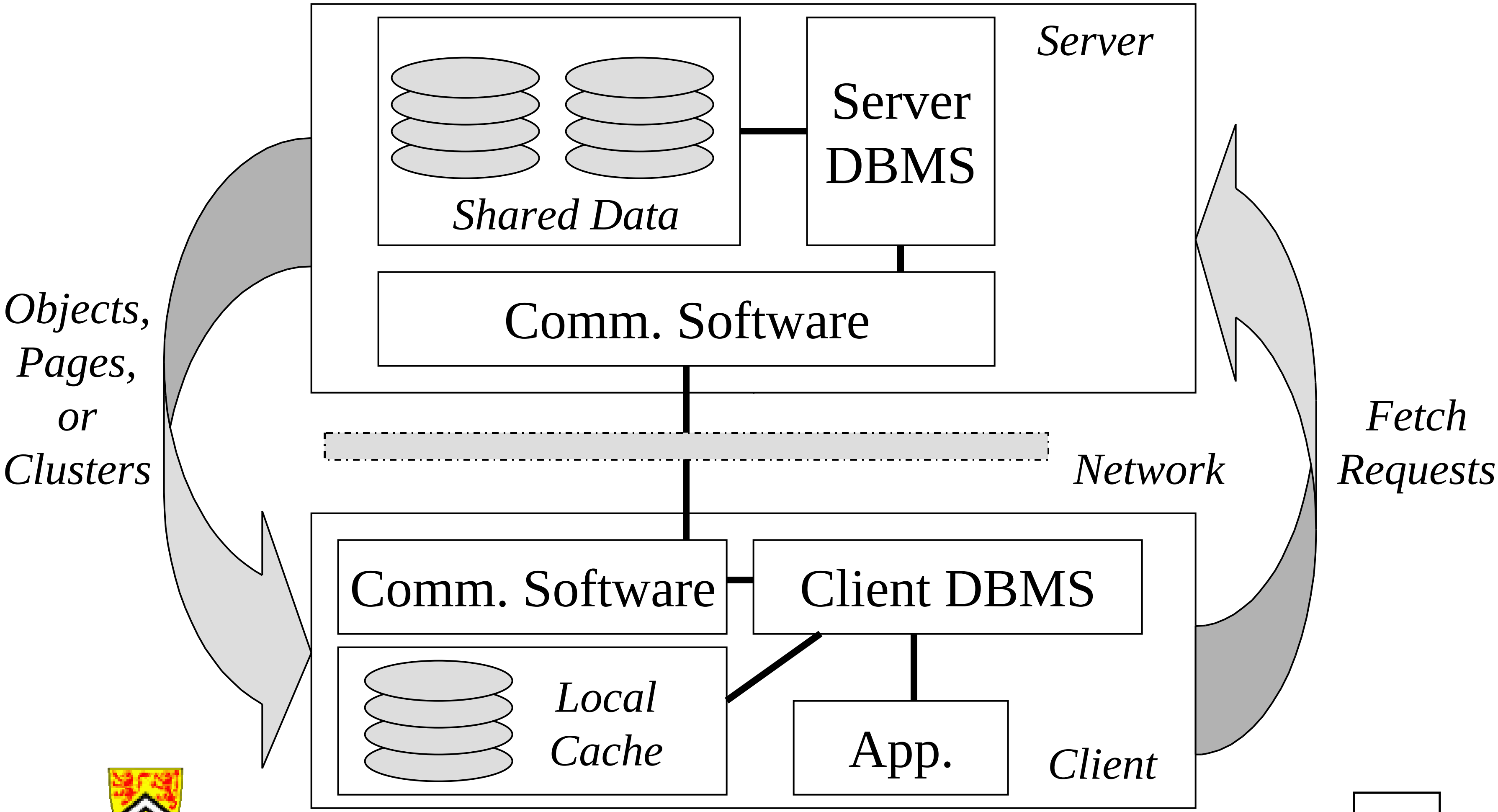


*Delis et al.

Hybrid Shipping

- Query shipping under-uses client resources
- Data shipping under-uses server resources
- Instead, use *Hybrid Shipping*
- Query processing at client *and* at server
  - Gives a form load balancing
  - Can reduce data movement for data inflating or reducing operators
  - Client caching can be used effectively

Data Shipping Client Server



*Delis et al.

Splitting Client Code

- Original systems partitioned apps into relational queries and application code
  - This provides a clean architecture
- Distributed systems originally split execution sites along these dimensions
  - This non-optimal splitting has been addressed for queries
  - The problem remains for application code

Why Move Client Code?

- To take advantage of a powerful server
- To reduce query processing costs (e.g. with selective user functions)
- To minimize network communication costs by executing code closer to the data

A Contrived Example

```
sql = “SELECT emp_id, emp_name ”
      “FROM EMP”;
rs = stmt.executeQuery( sql );
while( rs.next() ) {
  if( isPrime( rs.getInt(1) ) ) {
     System.out.println(rs.getString(2));
  }
}
```

User Defined Functions

```
sql = “SELECT emp_id, emp_name ”
      “FROM EMP WHERE isPrime(emp_id)”;
rs = stmt.executeQuery( sql );
while( rs.next() ) {
  System.out.println(rs.getString(2));
}
```

Client Code on the Server

- DBMS vendors allow:
  - User-defined functions used in queries
  - Stored procedures allow arbitrarily complex procedural code to be executed at the server
- So, what’s the problem?

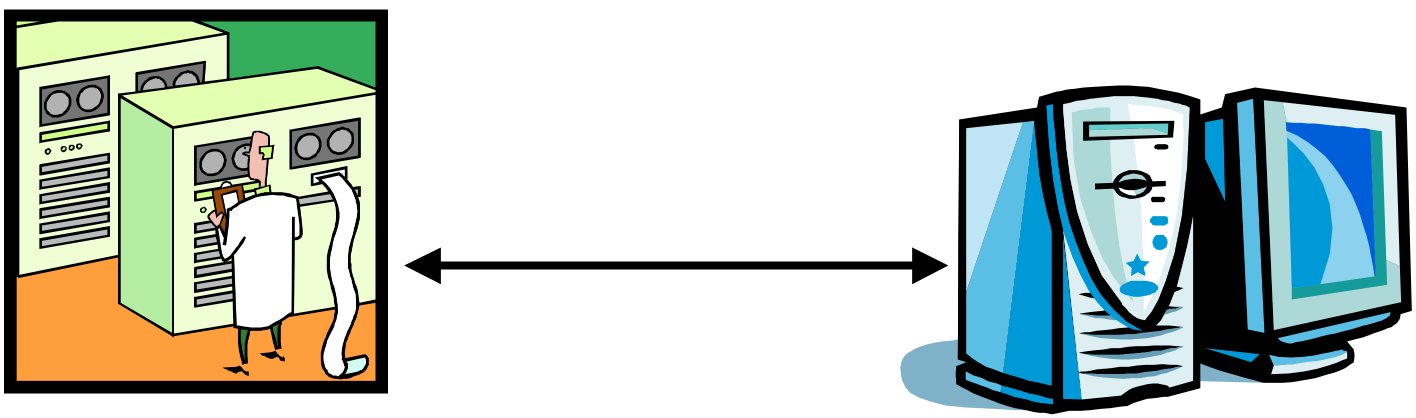
It's TOO HARD!

Getting Code On the Server

- Must be ‘multi-lingual’
  - Server environment doesn’t match client’s (Java in the database simplifies this somewhat)
- Partitioning decision made by the developer
  - Must decide early on (design phase)
  - Programmer intuition is often wrong
  - Cannot easily tune to new systems
  - Cannot adapt to dynamic workload

Partitioning Code: Past Experience

- ICOPS (Brown) and CAGES (North Carolina) automatically partitioned graphics applications between a mainframe host and a ‘satellite’ graphical terminal



CAGES and ICOPS

- Coding for Host/Satellite systems required bilingualism
- Programmers often made incorrect partitioning choices in the design stage
- Design-time partitioning led to vendor lock-in
- Configurable programs addressed these issues
  - Provided a run time that could *monitor* costs
  - Allowed either run-time or compile-time partitioning

Code Shipping: MOCHA

- Allow relational operators and client code to be executed either at client or any server
- Code that is not present is shipped to the appropriate location
- All code that may be shipped implemented as a static function and described in XML
- Optimized only for network costs

Optimizing Distributed Plans

- Optimizer must choose:
  - Access path (e.g. sequential, or an index?)
  - Algorithm for physical operators
  - Join order
  - Expensive predicate placement
  - Intra-query parallelism
  - Execution site for each operator

Optimizing Expensive Predicates

- Rank-order approaches: selectivity and cost
- Some approaches increase join degree
  - Dynamic programming can not handle high join degree (say, higher than 15)
  - Randomized, greedy, or branch-and-bound algorithms may be more effective up to 50-100
- Existing approaches do not support site selection for expensive predicates

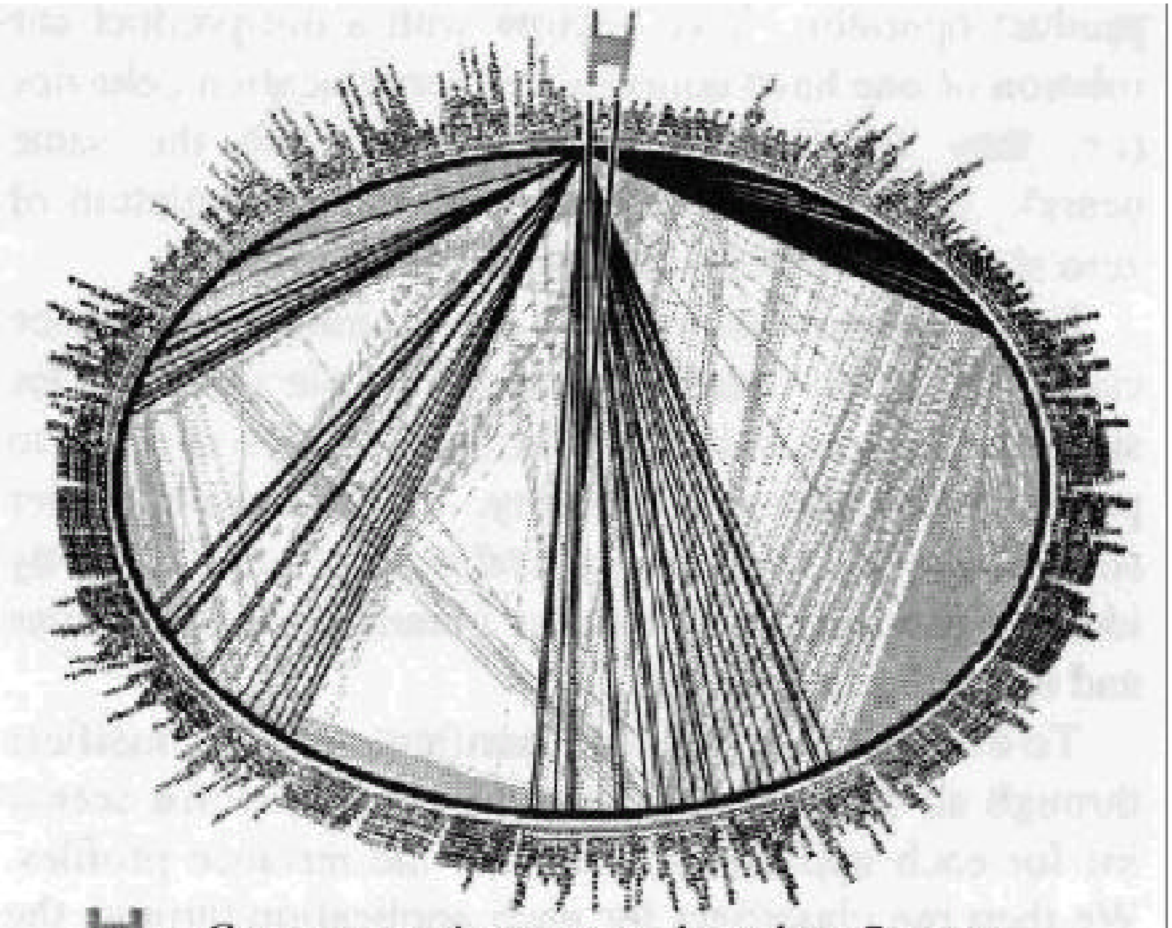
Mobile Code

- User defined functions and stored procedures are not *mobile*
- We would like an approach that can place code dynamically based on system statistics
- Load and run, or on-the fly mobility

Coign

- Coign distributes binary applications written using COM
- Classifies components using training runs
  - Components with similar access paths will be placed near each other
- A commodity flow network is used
  - Max-flow, min-cut graph cutting optimization

Component Communication*



= *Component instances placed on Server.*

Coign’s Experience

- It’s possible to optimize distribution of existing systems
- Non-distributable components constrain the optimization
- Applications designed for distribution were optimized better

Abacus

- Abacus project at CMU also used ADP
  - Provides primitives for data-intensive, distributable components in C++
  - Partitioned during execution based on statistics
  - Moved components using checkpoint/restore
- Partitioning is resistant to bad access plans, since it dynamically adapts to system load

Languages

- We want:
  - Mobility
  - Safety
  - Security
  - Portability
  - Efficiency
- Java is promising; but, is it fast enough?
- Software fault isolation may be faster
- Many other languages are available

Conclusions

- Recent advances have shown good ways to partition the cost of relational processing
- Similar work can be done for user code
  - Automatically detect code that can benefit from partitioning
  - Optimize the partitioning of many functions
  - Execute user code on server efficiently, safely, securely, and transparently

Questions?