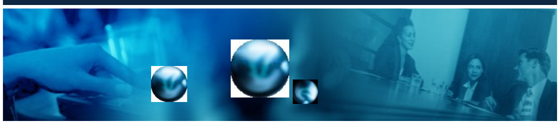
Mariposa:
A wide-area distributed database



Slides originally by Shahed Alam
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Outline

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Motivation

- Build a wide-area Distributed database system
- Single program performing global query optimization using cost-based optimizer will not work well:
  - access constraints
  - charging algorithms
  - site-specific data type extensions
  - scale a large number of possible processing sites
- Traditional distributed DBMS not appropriate in a modern WAN environment
- A new architecture is required

Outline

(wrong) Assumptions in Distributed DBMS

- Static data allocation
  - No handling of changing access patterns
  - Manual transfer of data from site to site
- Single administrator
  - Site selection done by optimizer
  - But what if site belongs to another? Chance of being refused (when site overloaded or indisposed)?
- Uniformity
  - Different hardware, network connections, hard disk space
- Assumptions hold for LAN but not multi-admin WAN

Assumptions for WAN based DDBMS

- Scalability
  - No limit of its ability to scale more sites
- Data mobility
  - Change “home” of object. Available during movement
- No global synchronization
  - Schema changes should not cause sync
- Total local autonomy
  - Sites control own local resources. What objects to store, what queries to run
- Easily configurable policies
  - Easily change individual rules of sites by local administrators

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Discussion Questions

- -- Suppose you need a huge database for an application. What conditions make you to setup a distributed database? What conditions make you to setup a non-distributed database? Can you think of some applications for the two approaches?
- -- What applications can you imagine using Mariposa for? What about systems using the previous assumptions for distributed system?

Outline

1. Motivation
2. Assumptions for DDBMS
3. Economics in Mariposa

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Application of economics to Mariposa

- All Mariposa Clients and servers have accounts with a network bank
- User allocates budget to each query
  - Goal: try to process the query within the budget B(t) by subcontracting to various sites
- Query administered by broker which obtains bids
- Fragments (objects) are the units of storage that are bought and sold (may be split or coalesced)
- Servers buy objects, advertise its services, bids on queries, leaves by selling objects
  - Goal: optimize revenue

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… more economics

- Objects have “current owner” which changes as they are moved
- Object replication based on payment for frequency of updates among copy holders
  - Name servers use the same policy for metadata
- Micro-economic paradigm adopted – each site is seeks to maximize their profit per unit operating time
- Each site has a bidder and storage manager
  - Which objects to buy/sell, which queries to execute
- Administrators may alter behaviour by changing rules at their site

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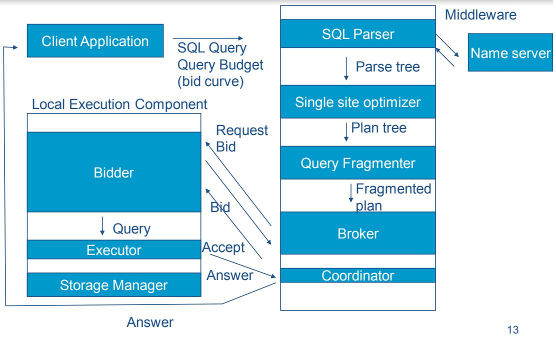
Mariposa architecture



A few more details…

- Rush
  - Low level, very efficient embedded scripting rule language
  - Every Mariposa entity has a rush interpreter
  - Storage manager, bidder, broker coded in rush

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5. Bidding process

Bidding process

- Each query has a budget B(t)
  - B(t) is a non-increasing function of time
- Each query is fragmented into sub-queries
- Strides
  - Multiple fragmented sub-queries that can be executed in parallel
- Broker solves sub-queries using
  - Expensive bid protocol
  - Purchase order protocol

Expensive Bid protocol

- 2 phases
- 1. Request for bids
  - Send portion of query plan being bid
  - Bidder sends back a triple (C,D,E)
    - C= Cost
    - D= Delay (time to process query)
    - E= Expiration date of offer
- 2. notify the winning bidder
- This process used only for complex queries as it is expensive (overhead: too many messages).
- Use Purchase order protocol for simple queries

Purchase order protocol

- Send sub-query to bidder with highest likelihood of winning anyway
  - Keep track of query-history
- Site processes request and sends a “bill”
- Con: Probable budget deficit

Bid Acceptance

- In acceptance only collections of bids for the sub-queries in each stride are considered
- Winning bid must have aggregate cost C and delay D, C = B(D)
- To compare collections of bids we have difference = B(D)-C
- Greedy heuristic algorithm for determining the winner of bids. Starts with the collection of smallest delay

Finding bidders

- Finding bidders
  - Servers post “advertisements” with name servers.
  - Name servers store “ad tables”
    - Advertisements in form of “yellow pages”
    - Example: date of advertisement, sale price, coupons
  - Brokers examine ad tables to locate bidders
  - Brokers remember sites that bid successfully

Setting the bid price

- Bidder sends reply in form (Cost, Delay, Expiration) to broker
  - Cost
    - CPU, I/O (naive), Network resource
    - Optimization: Billing rate per fragment, Adjust cost based on current load, bid on hot list items even if server does not have data
  - Delay
    - Time to process under zero load or current load + safety factor
  - Expiration
    - Set arbitrarily
- Improvements:
  - have rate on a per fragment basis
  - bids based on current load average
  - hot lists of fragments wanted by site

Discussion Question

- Does this bidding process seem like a good model to you? Can you think of other applications for which it might be relevant?

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6. Storage and Name resolution

Storage Management

- Manages fragments to maximize profits in local execution component
- Buying and selling fragments
  - Maintains history of each fragments revenue
  - Contact current owner for fragment revenue before buying (remember : maximize profit)
  - Performs bidding process to sell fragments that it does not want by sending revenue history to bidders
- Splitting or coalescing fragments
  - Break fragments that have high revenues, to lower copies (to redirect traffic to oneself)
  - Coalesce copies if it takes more processing than is required

Naming and Name service

- Unlike traditional centralized name servers, Mariposa has a DECENTRALIZED name registration system
- Names are unordered sets of attributes
- Each object has four structures for naming
  - Internal names: location dependant
  - Full names : uniquely identify an object
  - Common names : shortcuts partially specified
  - Name Contexts : set of affiliated names

Name resolution and discovery

- Every client-server has local name cache to resolve object names
- Broker queries name-server if match not found
- There exists multiple name-servers
- Broker choose name-server based on quality-of-service (staleness of metadata) required

Discussion Questions

- How does Mariposa compare to today's P2P's system? How is it the same? How is it different?

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7. Experiment and Conclusion

Experimental Evaluation

- Environment
  - 3 relations in 3 sites, 11MB data
- Test Purchase order Vs Expensive Bid in LAN vs WAN environment
  - Result
  - Broker: 4.52 (s) for PO Vs 14.08 (s) for EB
- Test Expensive Bid to show how data is moved to a closer site for repeated-query
  - Result: all 3 tables move to site that starts the query

Conclusion

- Traditional approaches to distributed database management unsuitable for asynchronous heterogeneous systems with mobile data
- Micro-economic paradigm for handling query and storage optimization
- This model can reduce the scheduling complexity of distributed interactions
- Does not seek to enforce globally optimal solutions
- Bidding process not unduly expensive

Epilogue

- Where is Mariposa now?
  - Mariposa -> Cohera -> PeopleSoft -> Oracle