TERADATA M-DBS

SCALABLE MULTIMEDIA DATA WAREHOUSE
FOR 21St CENTURY

Felipe Carino Jr.
NCR Parallel Systems
STANFORD UNIVERSITY (Beat CAL!)

Talk Outline

- Scalable Data Warehouse
  - Teradata Data Warehouse vs Data Mart
  - Growing Pains
  - Parallel Platforms and Teradata RDBMS
  - Information as Strategic Weapon Case Studies
    - Wal*Mart (24 TB) The Big One!
- Multimedia Scalable Data Warehouse
  - (Multimedia) Object/Relational Evolution
  - Medical Knowledge Bank
  - Parallel UDT/UDF Issues

A Data Warehouse Focus: The issues

- The confusion in the industry as to what is “data warehousing”
- The discussion on the differences between what is a database and what is a data warehouse.
- The controvery on what are the critical requirements for a successful data warehouse implementation.

- Information Source & NCR DW GURU:
  - ➤Robert.Armstrong@SanDiegoCA.ncr.com

Sources of the confusion

1. **Thinking that mainframe databases are data warehouses.**
2. **Early data warehouse implementations were just collections of databases.**
   - Result = Limited processing of queries and very long response times.
3. **The misconception that a warehouse is a <u>thing</u> and not a *whole process <u>environment</u>*.**
4. **Vendor claims.**

What is a Database . . What is a Data Warehouse?

1. **Data warehousing is a *<u>process</u>*, not a *product*.**
2. **A data warehouse has no *<u>size</u>* limitations.**
3. **A Departmental Warehouse is a *specific distributed subset* of operational data and processes.**

- Some vendors refer to a departmental warehouse as a "data *<u>mart</u>*."

4. **A Data Mart is a *special purpose subset* of data from the central data store used for special a function or application.**

- Some vendors refer to a data mart as a "departmental warehouse."

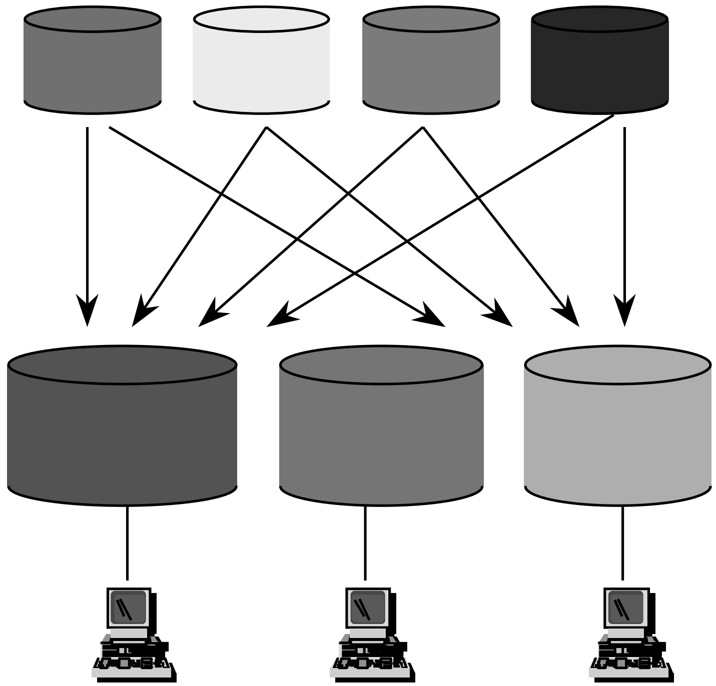
Key Issues: Successful Warehouse Implementation

- **Data Load, Extract, and Maintenance Support.**
- **Reliability, Availability, Serviceablity, Recoverability**
- **Total Cost over five years**
- **Workload complexity**
- **System Management**
- **Database size** (However, do not explore database size until the platform configuration is determined, except to quantify bugetary limitations.)
- **Strategic Importance of Application**
- **Hardware Architecture**
- **Database Engine Portability**
- **Application Transparency**
- **Data Warehouse will GROW !**

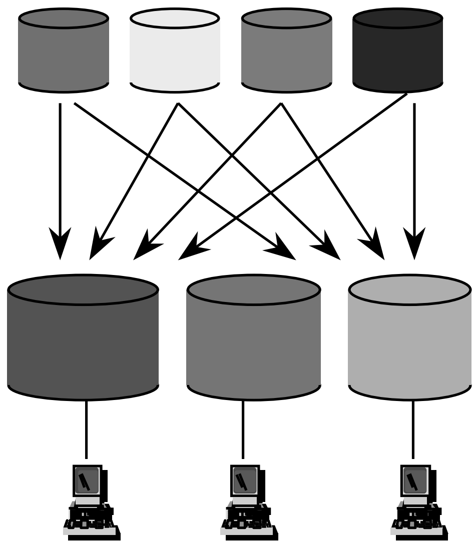
Short Term Gain, Long Term Pain

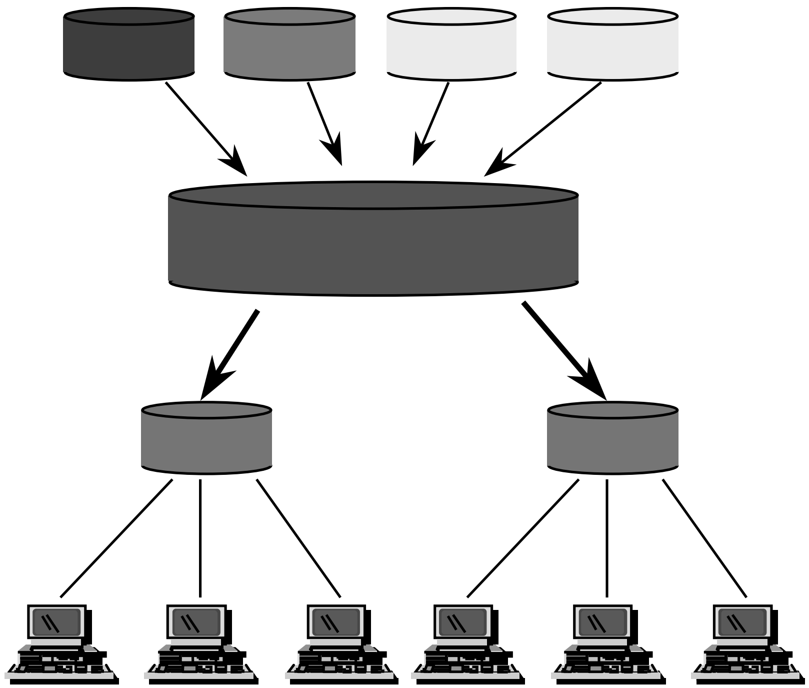
- Definitions
- The Allure of Data Marts
- The Promises and Reality
- Data Marts in Practice
- Why Data Marts Fail
- Laying a Winning Foundation

What is Data Mart Centric??



What is Data Mart Centric??





The Allure Of Data Marts

- Quicker to Implement
- Easier to Manage
- Cheaper to Build
- Higher Query Performance

Quicker to Implement

- The Promise
  - “Load and Go”
  - Known Reports
  - Business Unit Focused
- The Reality
  - Removes Cross Functional Capability
  - Provides no new insight
  - Performs little, if any, data transformation
  - Doesn’t enforce business integrity

Easier to Manage

- **The Promise**
  - **Smaller Data Volumes**
  - **Smaller Workloads**
  - **Known environment**
  - **SMP versus MPP Management issues**
- **The Reality**
  - **Actually harder as more data marts are added**
  - **No standards lead to increased confusion**
  - **Data redundancy as marts are added**
  - **Managed on a node by node basis**

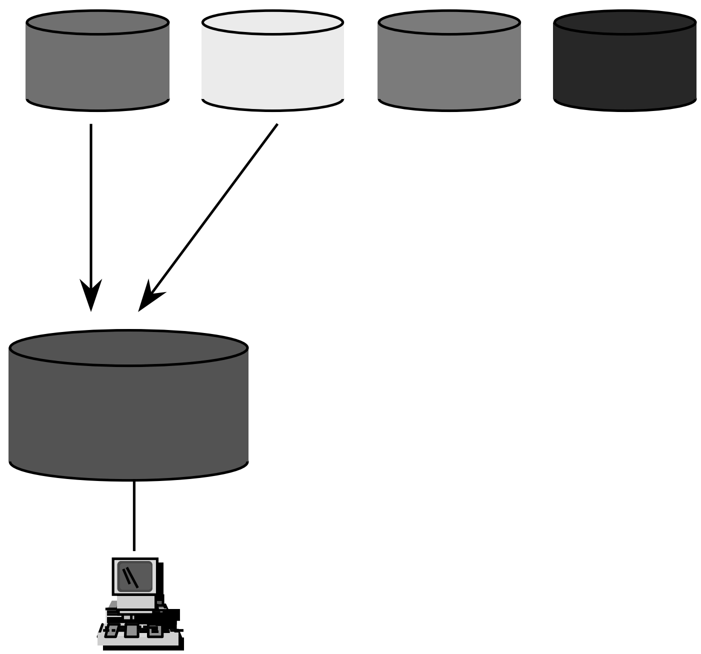
Cheaper to Build

- **The Promise**
  - **Smaller platforms and DASD**
  - **Less DBA resources necessary**
- **The Reality**
  - **HW/SW less than 20% of a solution**
  - **Real cost is adminstration and application**
  - **More DBA's as marts are added**
  - **In order to reduce implementation cost, many critical steps are ignored**

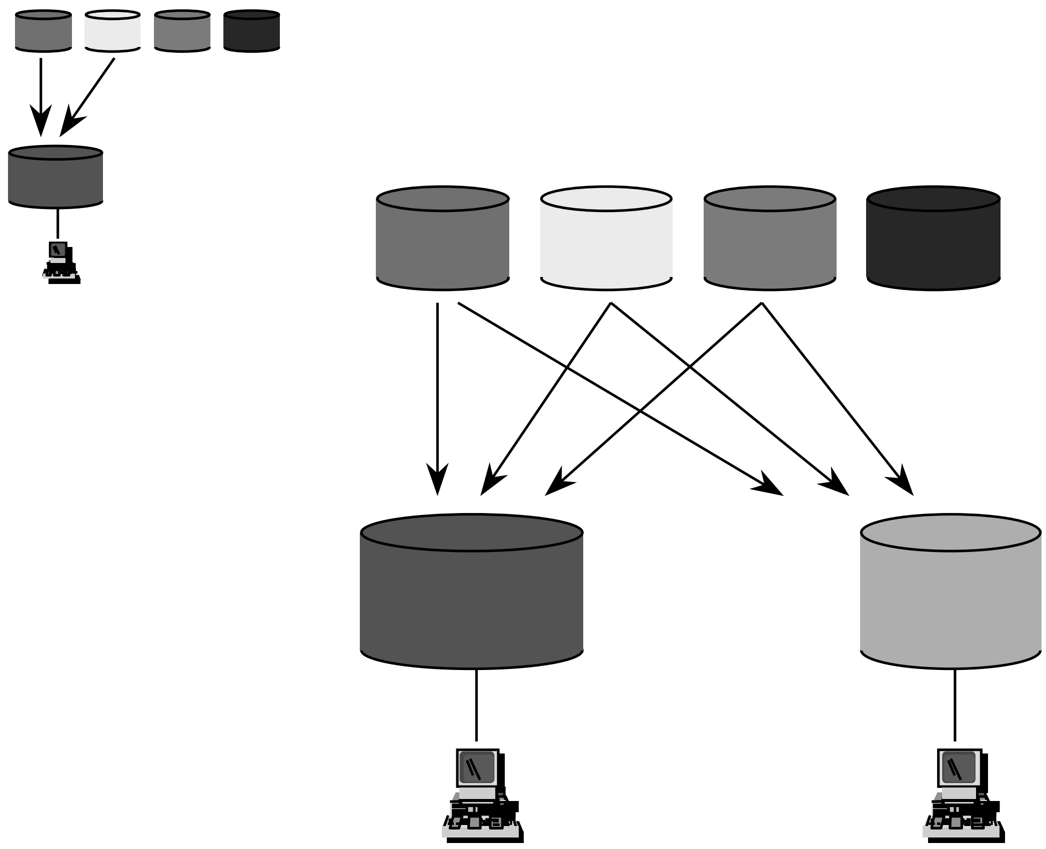
Higher Query Performance

- **The Promise**
  - **“Sub-second” response**
  - **Answering the questions users want to ask**
  - **Drill Down and Drill Across**
- **The Reality**
  - **Usually requires Star Schema, which limits growth**
  - **Only answers “known” questions**
  - **No exploratory capabilitybeyond planned queries**
  - **Fast answers are not necessarily better answers**
  - **Response time is from thought to action**

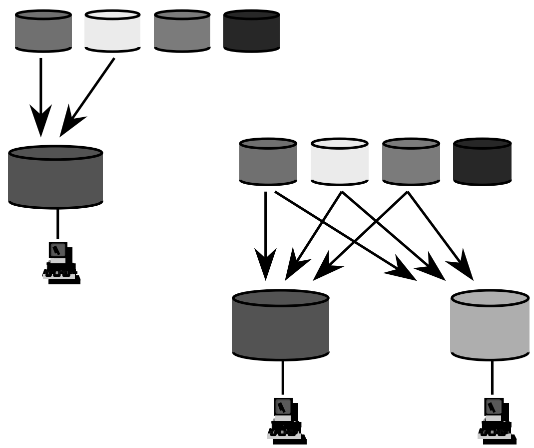
Data Marts in Practice



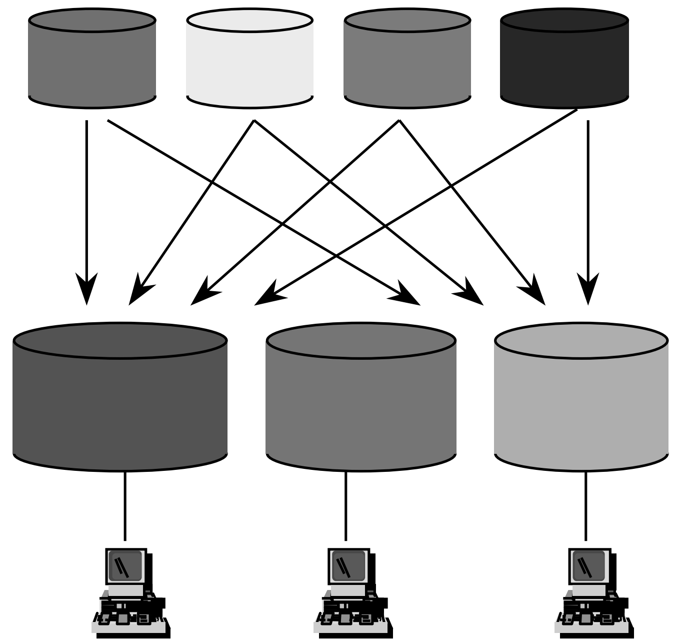
Danger Signs



Chaos Again!



You spend millions of dollars to recreate your problem!!



Why Data Marts Fail: Technical

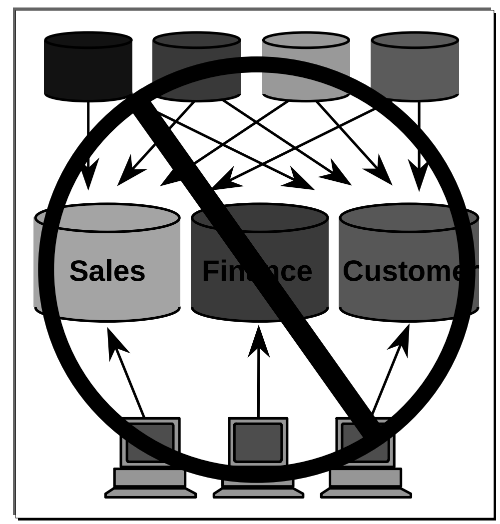
- In order to build, you need to know the questions - and the answers
- Little to no Data Transformation
  - Dirty Data is the biggest challenge
  - How do you know how dirty your data is?
- Usually rely on tools to hide the problems, until it's too late
- Architecture does not support long term goals
- Limit risk by Ignoring the Future

Why Data Marts Fail: Business

- Data Marts treat warehousing as a technical problem rather than a business solution
- Diverts resources to solving “point” solutions, not the foundation for information
- ROI is too low to justify expenditure
  - How much return do you need for a $1 Million dollar expenditure? In how long?

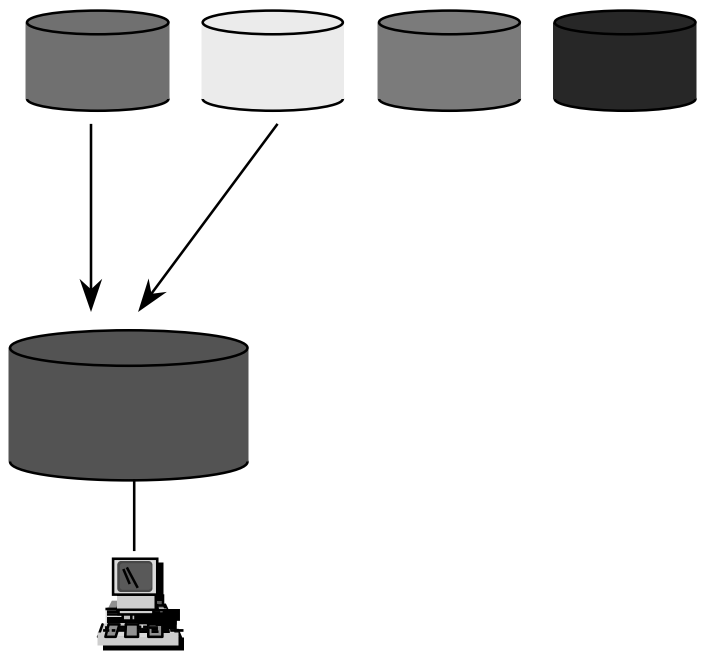
Top 10 Complaints on Data Marts

1. Performance
2. Too many data marts
3. Users want more access
4. Hard to find skilled personnel
5. Reconciling inconsistencies
6. Tools too difficult
7. Must customize tools
8. Incompatible tools
9. Expectations too high
10. Demand doubles in first year

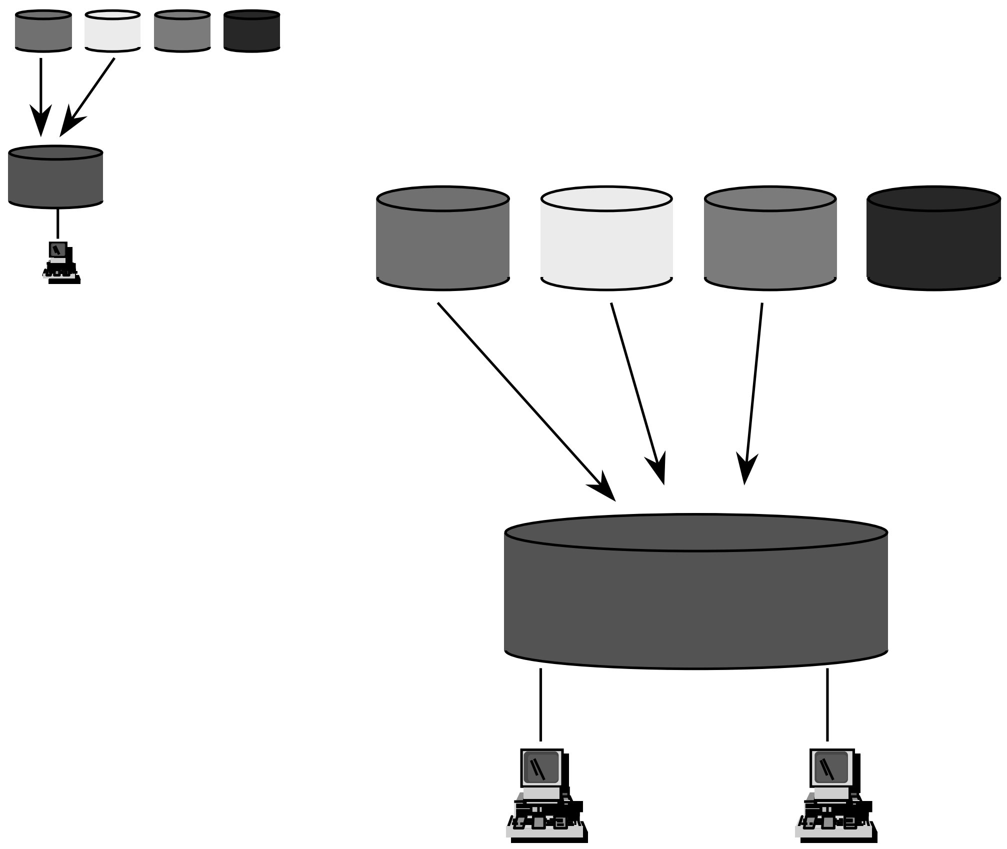


Source: InformationWeek November 11, 1996

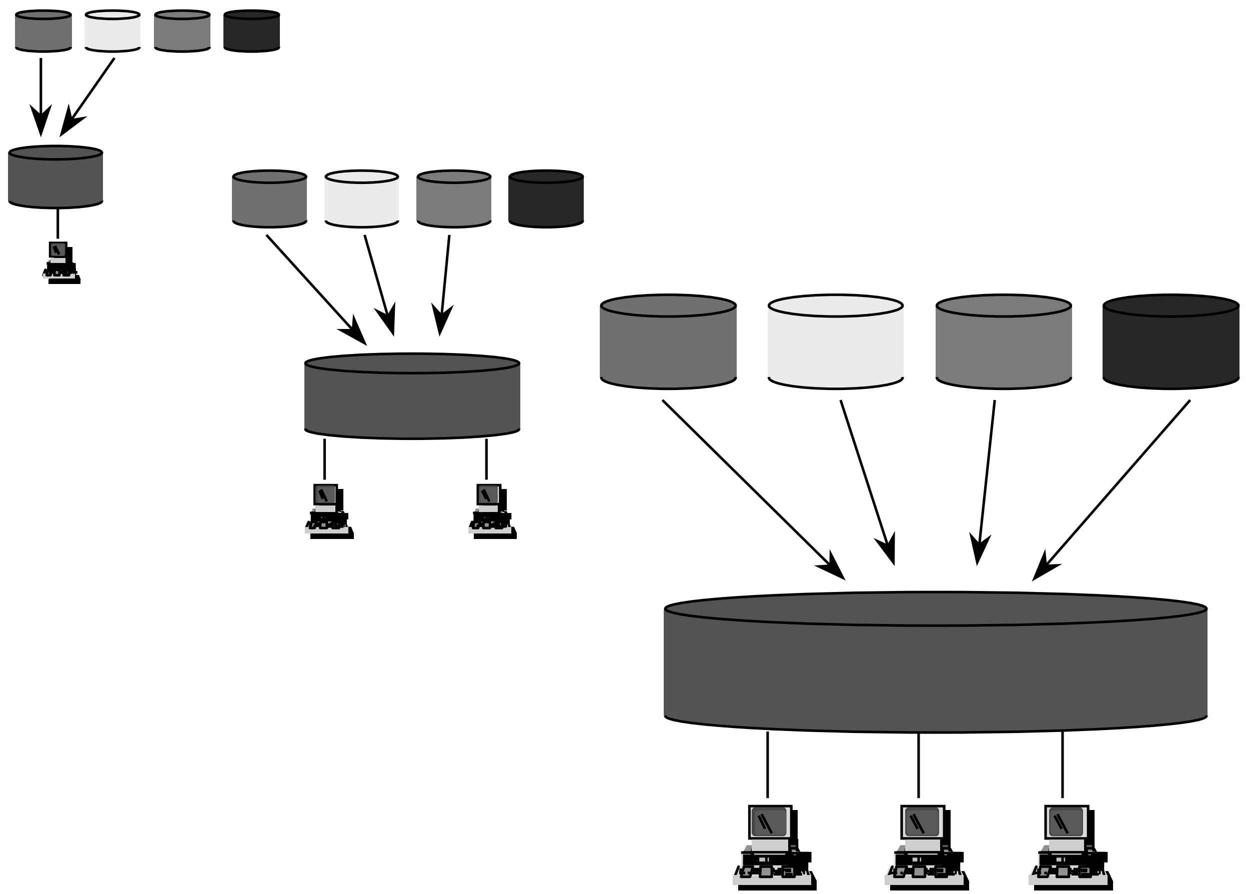
Laying a Winning Foundation



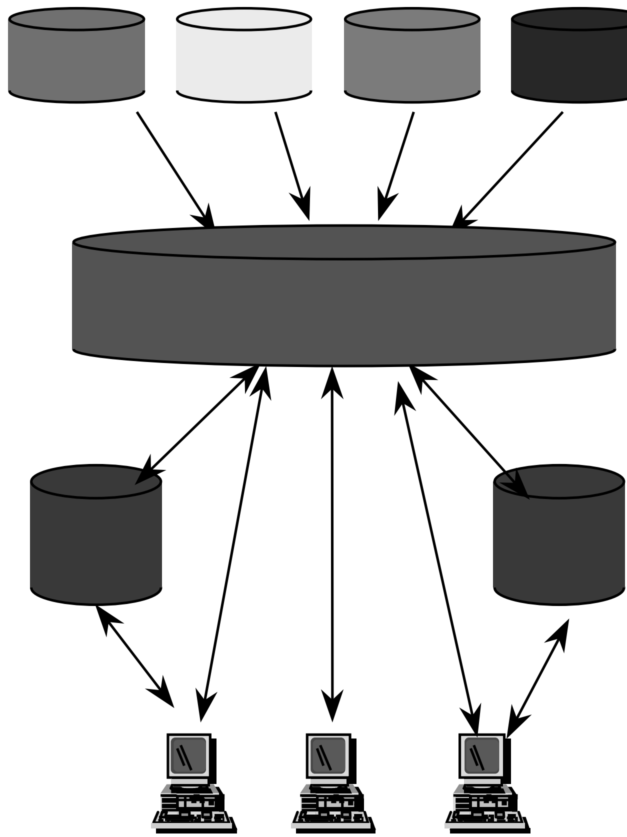
Avoiding the Fall



Success for Years!



A True Data Warehouse!

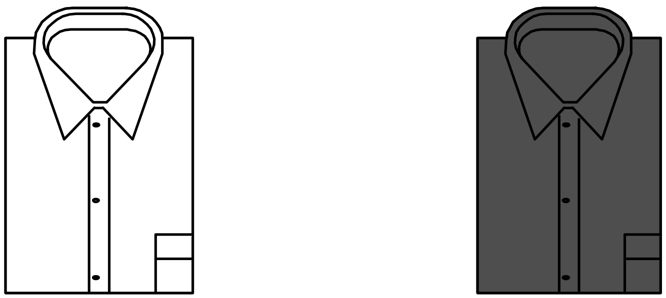


- ◆Single Transformation
- ◆Consistent Data
- ◆Cross function, Third Normal Form model
- ◆Data propagated from the Central warehouse
- ◆User access to Summary and Detail data

The Devil is in the Detail

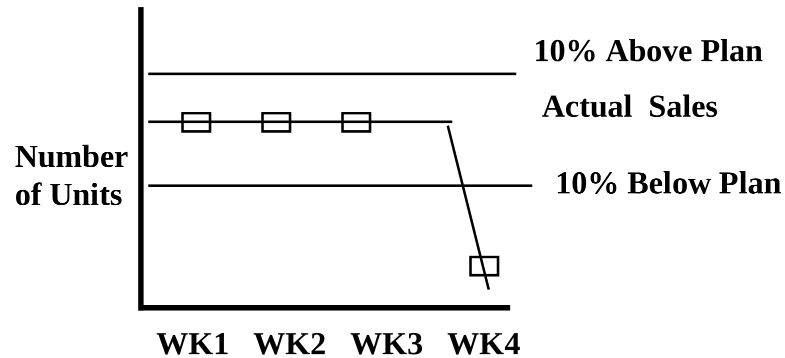
<u>Sales Analysis of Two Items in One Department/Class</u>

Department/Class = Men's / Dress Shirts



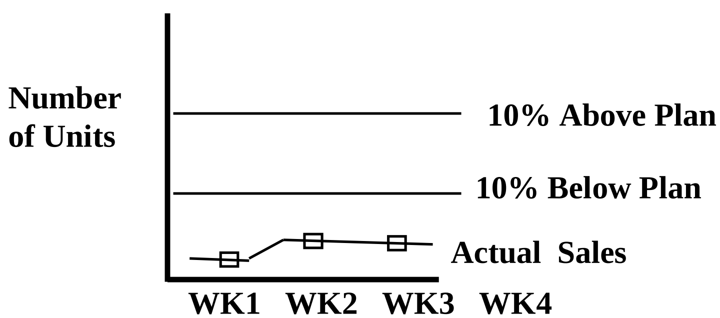
	Actual			TL
Units sold	**White Shirt**	**Blue Shirt**	**TL**	**Plan**
Week 1	3	7	10	10
Week 2	1	9	10	10
Week 3	3	7	10	10
Week 4	1	0	1	10

Summary Data Reporting - Men's / Dress Shirts

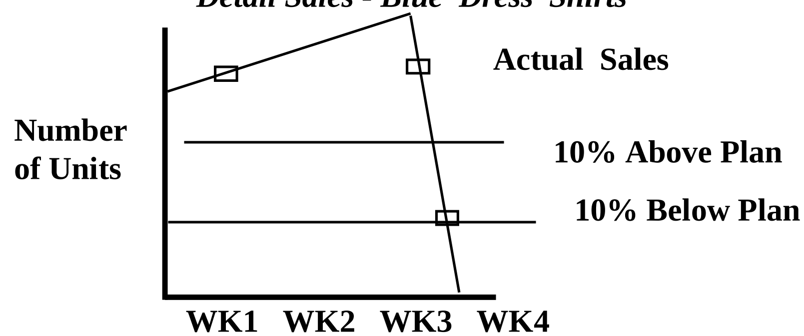


Summary Data Can Be Misleading . . .

Detail Sales - White Dress Shirts



Detail Sales - Blue Dress Shirts



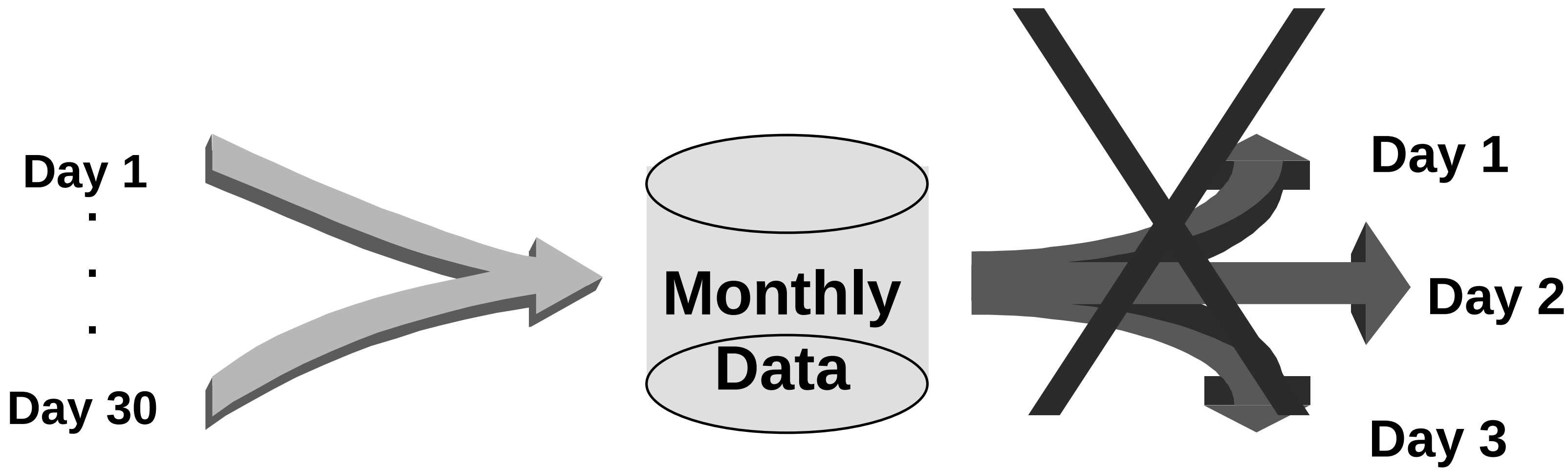
History of the Issues

- **Initial systems were meant to automate, *NOT* enhance the processes**
- **Operational systems captured and recorded "point in time" data, *NOT* historical data**
- **Data was then off-loaded to support *"decision support"* type questions**
- **Users demanded data at a *greater frequency* and/or *lower level of detail* across the business**
- **These user demands created *performance* problems**

Summarization: Get what we have FAST

- **Repetitive Queries**
- **Known Thought Process**
- **"80% of my users ask this"**
- **EIS Systems**
- **Provides a "Big Picture" View**
- **Only good if what you want is already summarized**
- **Application dependent, usually inflexible to business change**

Summary vs. Detail Data



You <u>can</u> create a summary from detail data...

but you <u>cannot</u> create detail data from a summary!

How Summary Falls Short

SCANNER DATA

CHECKOUT TRANSACTION NO.	ITEM NO.	QUANTITY SOLD
P K		
F K	F K	NN
1234001	1563	12
1234001	807	1
[redacted]		
1234001	149	4
. . .	. . .	. . .
. . .	. . .	. . .
1234005	402	3
[redacted]		
. . .	. . .	. . .
. . .	. . .	. . .
[redacted]		
1234027	807	3
. . .	. . .	. . .
. . .	. . .	. . .
1234046	177	6
1234046	807	1
[redacted]		
. . .	. . .	. . .
. . .	. . .	. . .
[redacted]		
1234639	177	1
. . .	. . .	. . .

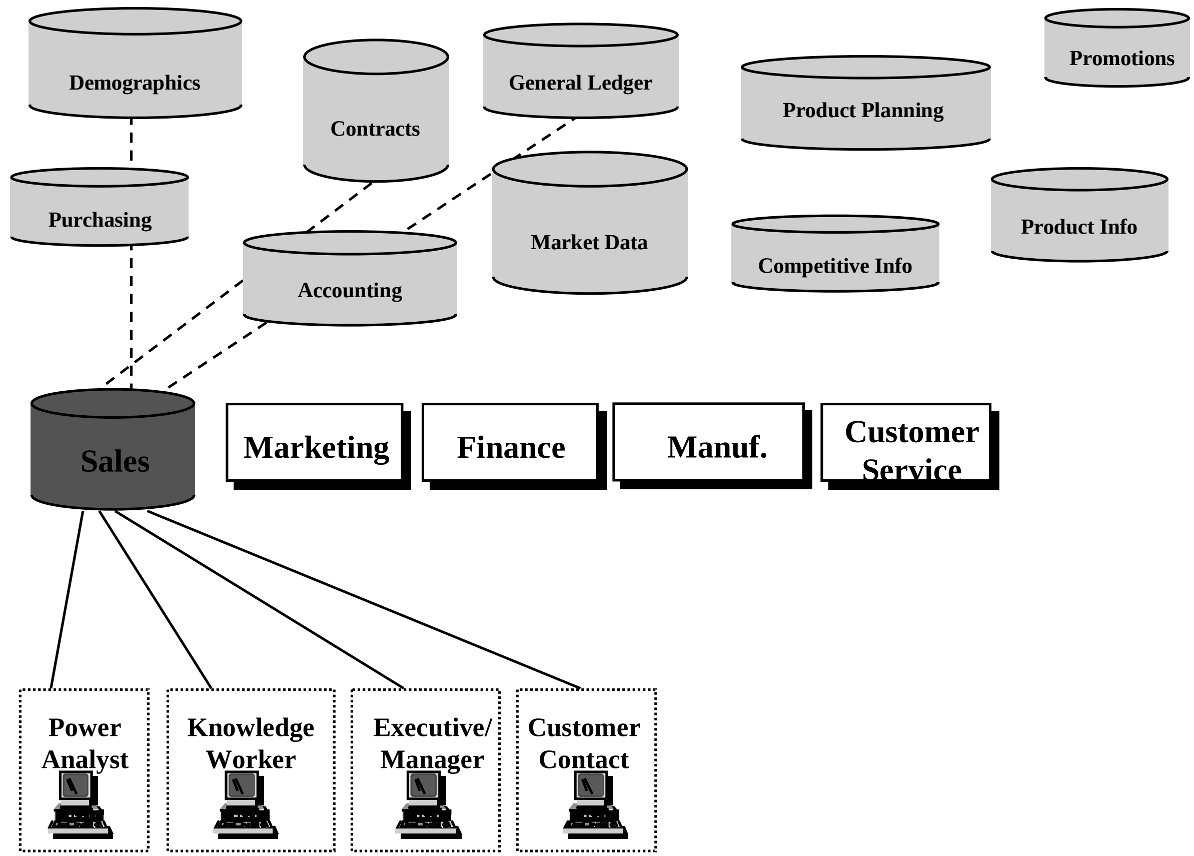
STORE ITEM <u>DAILY</u> SALES

STORE NO.	ITEM NO.	DATE	QUANTITY SOLD
P K			
F K			NN, DD
. . .	. . .	. . .	. . .
. . .	. . .	. . .	. . .
1	2	Jun 01	110
1	2	Jun 02	126
[redacted]			
1	2	Jun 04	144
1	2	Jun 05	102
1	2	Jun 06	344
1	2	Jun 07	410
. . .	. . .	. . .	. . .
. . .	. . .	. . .	. . .
2	2	Jun 01	50
2	2	Jun 02	47
[redacted]			
2	2	Jun 04	20
2	2	Jun 05	37
2	2	Jun 06	144
2	2	Jun 07	126
. . .	. . .	. . .	. . .
. . .	. . .	. . .	. . .

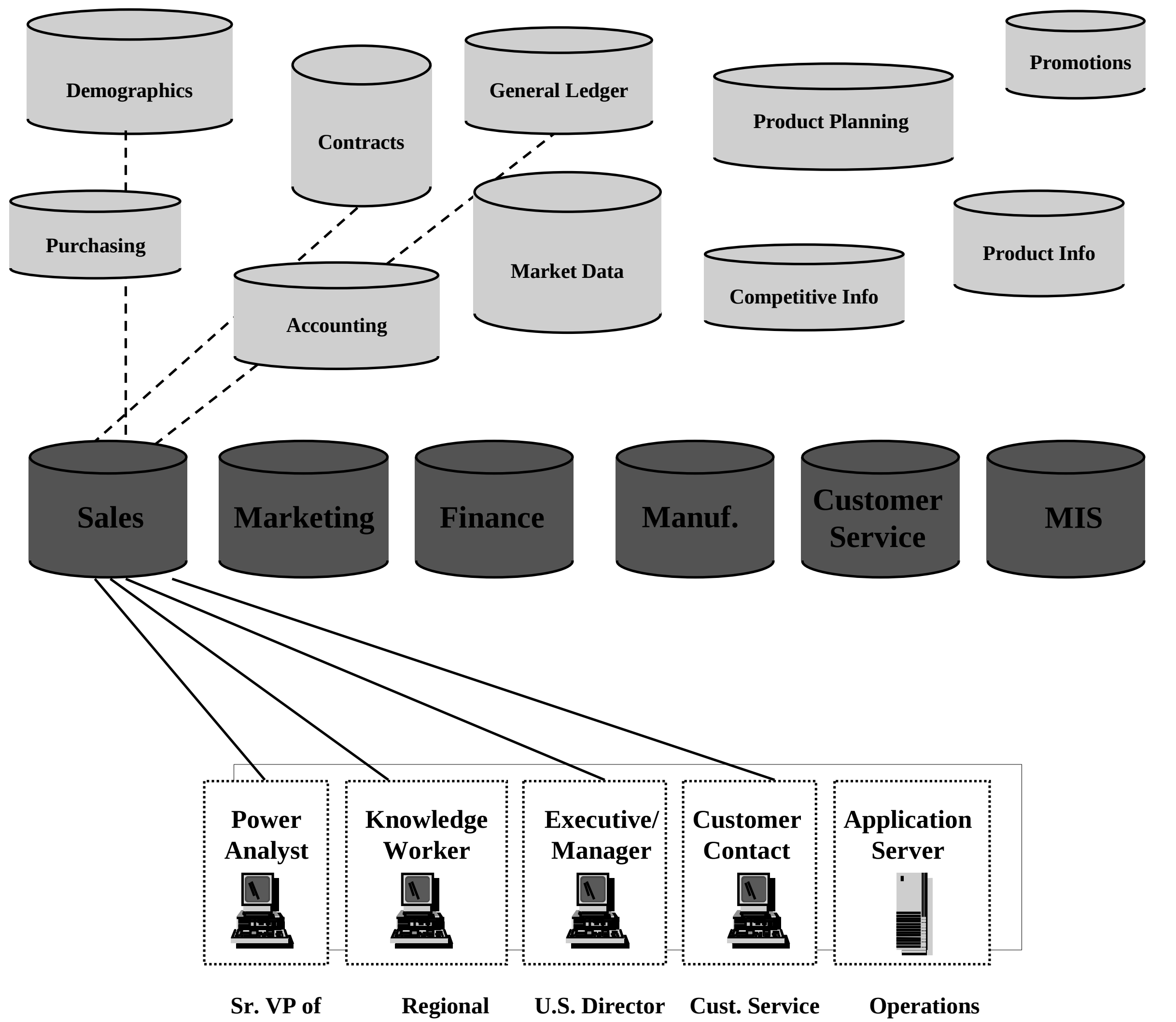
STORE ITEM <u>WEEKLY</u> SALES

STORE NO.	ITEM NO.	WEEK ENDING	QUANTITY SOLD
P K			
F K			NN, DD
. . .	. . .	. . .	. . .
[redacted]			
. . .	. . .	. . .	. . .
. . .	. . .	. . .	. . .
[redacted]			
. . .	. . .	. . .	. . .
. . .	. . .	. . .	. . .

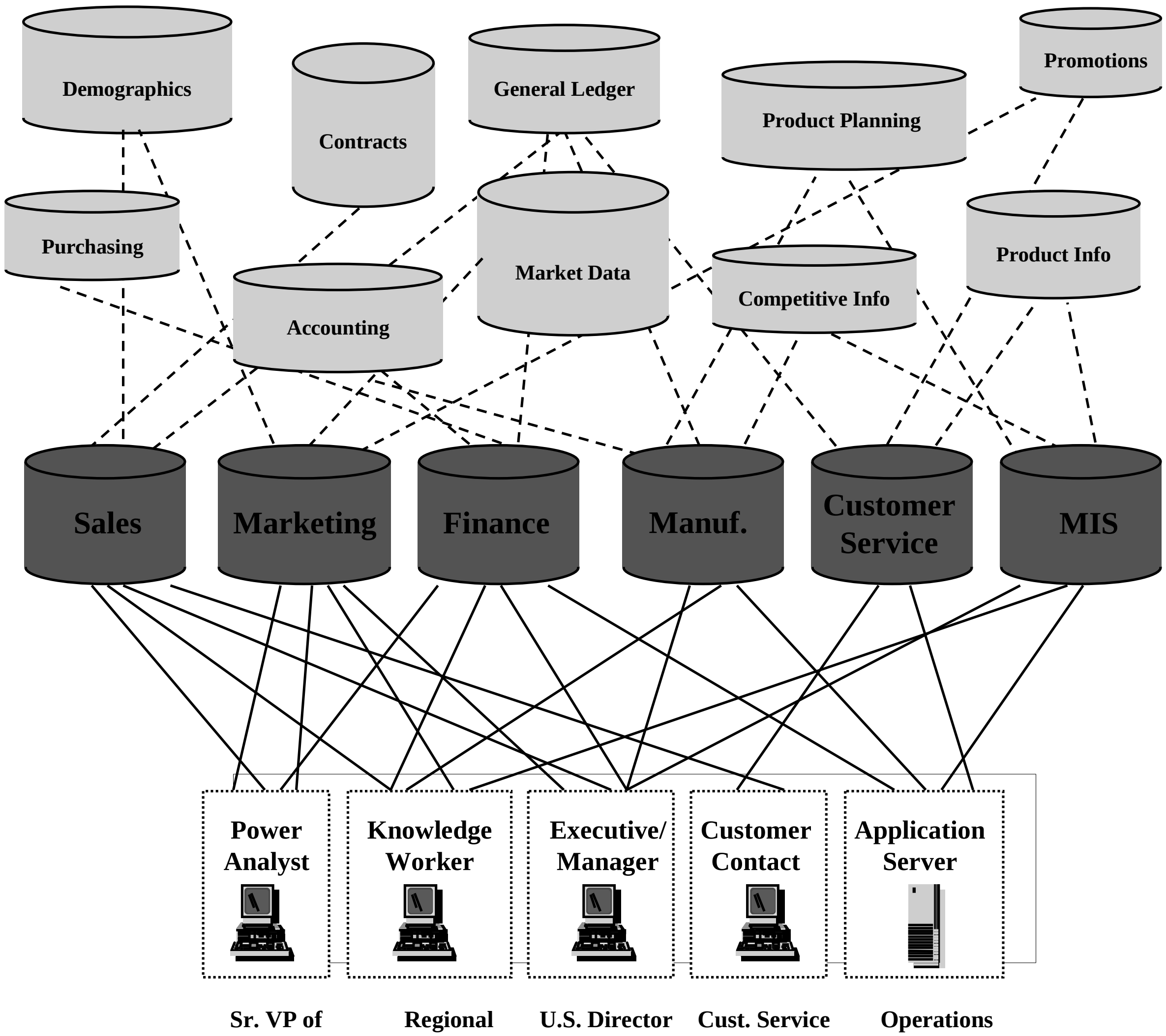
Today's Summary Systems....



Today’s Summary Systems...

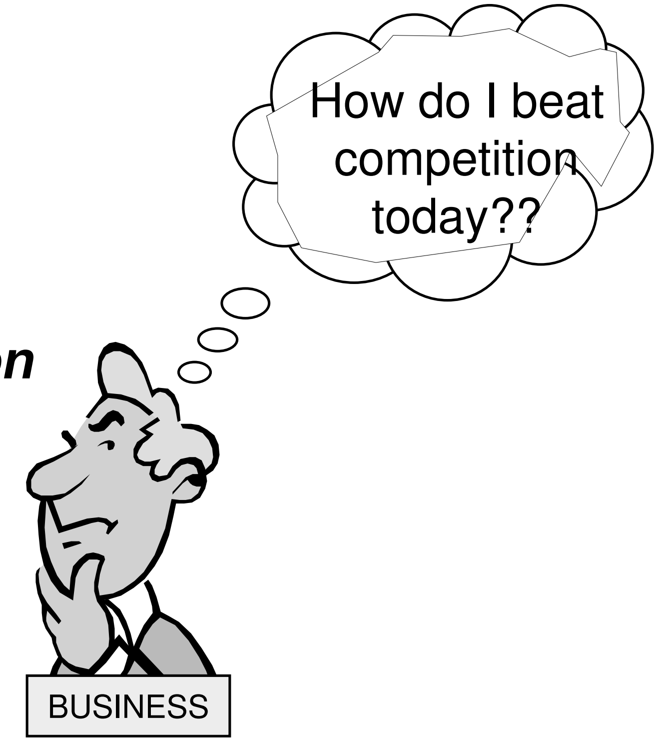


...Become Tomorrow’s Headaches



Constantly Changing Business Requirements

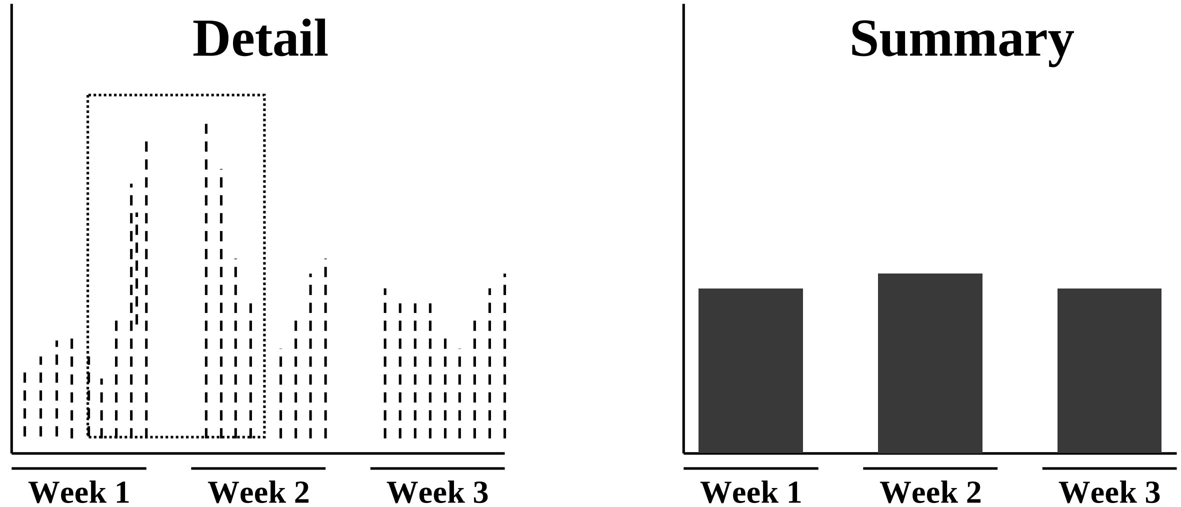
- ***Business requirements change***
- ***User demands change***
- ***The answer to 1 question drives 100's more***



The Only Constant is Change

"Administration of a data warehouse RDBMS will be a constant struggle to keep the system balanced in line with a partly unpredictable workload...the focus of users' queries within the database will constantly be changing."
-- Gartner Group

The Value of Detail Data - *Ask what you want !!!*



- **Example: A sales promotion is targeted for the fourth day of Week 1. The charts illustrate the sales results of weeks 1 through 3 utilizing both detail and summary data.**

Benefits of Detail Data

◆**Defines an Historical *Event***	**=** ***What ?***
◆**Has the Dimension of *Time***	**=** ***When ?***
◆**Event Contains Explicit/Implicit *Causal Data***	**=** ***Why ?***
◆**Has the Dimension of *Place or Geography***	**=** ***Where ?***
◆**Has Little, if any, Value When Viewed as an *Independent Event***	**=** ***What Else?***
◆**When Analyzed in Sets, It Predicts the *Future***	**=** ***What Next?***

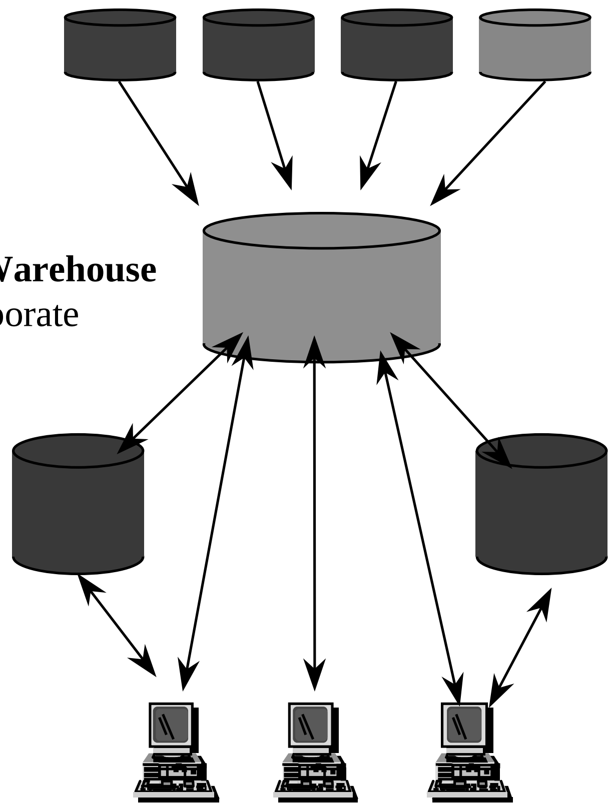
Pros and Cons

Summary	*Detail*
Limits Questions	**Full Analysis**
Application Specific	**Supports Many Applications**
High Performance	**Lower Performance**
High Maintenance	**Simple, Massive Updates**

Quick Implementation Tips

- **When possible, follow the *flow* of the data (Operational to Informational)**
- **Model the enterprise . . . *attack the core business***
- **Start with small subject area . . . *but detail data***
- **Provide new *functionality* to the end user**
- **Select next area to *expand* the model.**
- **If a benchmark is done . . . it should be with *detail data volumes and workloads* in mind.**
- **Track user queries and summarize as necessary from a *cost/benefit* standpoint**

Provide the Best of Both Worlds !



Transform **from Operational to Warehouse**

Tier 3: The Enterprise Warehouse
Emphasis on detail & corporate flexibility

Access **Tier 3 for "cross functional" processing & detail**

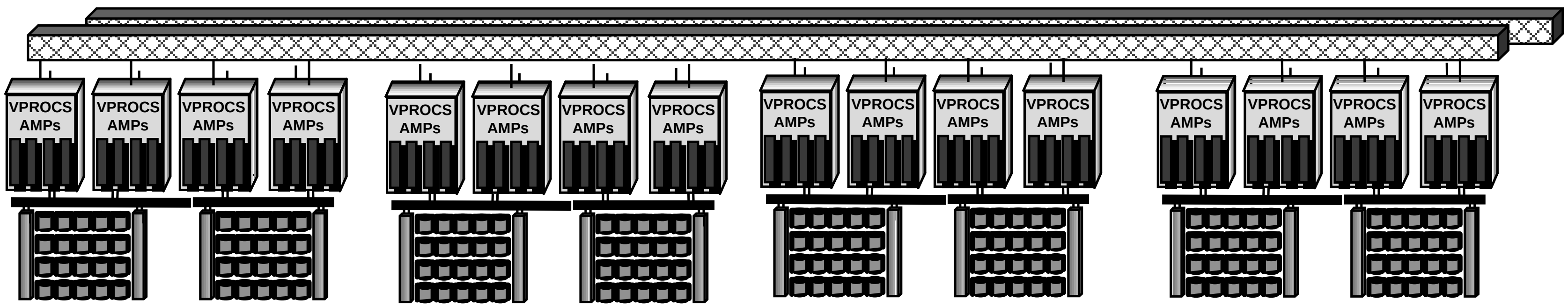
Propagate **from Tier 3 to Tier 2 for aggregate, specific query, and timely access**

Tier 2: The Data Mart
Emphasis on summary & functional specialization

Access **Tier 2 for function specific & less detail**

Tier 1: The Desktop
Suited to the individual

WORLDMARK 5100M CLUSTERS
(Maximum Theoretical 4096 SMP Nodes)



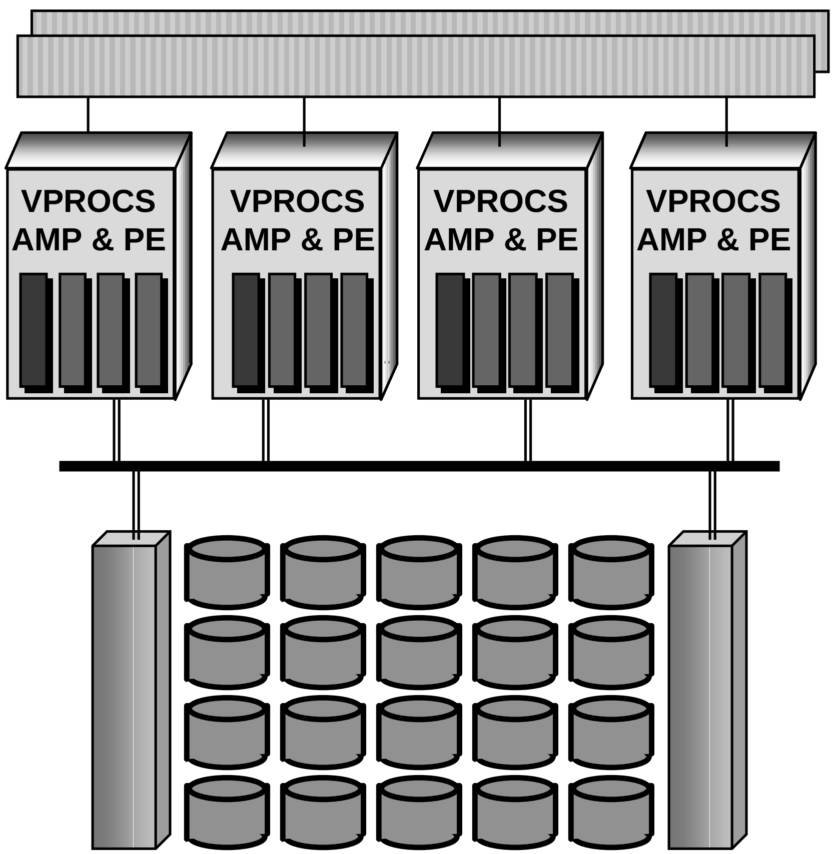
BYNET Interconnection Network

- Folded Banyan Network Topology

BYNET Builds upon the functionality of the YNET

- BackChannel Intelligence
  - Broadcast, Signaling, Merge
- Fault Tolerant
- Greater Scalability (20MB/s per Node)

CLIQUE



- SMP Nodes (32 Processors)
- BYNET Connected
- All nodes can access all disks
- Data Block Backup over BYNET
- All Memory as NVRAM
- Vproc Migration across DBS Reset
- Virtual PEs with Virtual AMPs or in separate nodes

Wal*Mart Case Study

- Wal*Mart: 2000+ Retail Stores
- SAM's Clubs 100+ Wholesalers Stores
- Old Retail Paradigm Problem
  - Wal*Mart
    - ➤Inventory Management
    - ➤Merchandise Accounts Payable
    - ➤Purchasing
    - ➤Supplier Promotions: National, Region, Store Level
  - Suppliers
    - ➤Accept Orders
    - ➤Promote Products
    - ➤Provide special Incentives
    - ➤Monitor and Track The Incentives
    - ➤Bill and Collect Receivables
    - ➤Estimate Retailer Demands

New (Just-In-Time) Retail Paradigm

- No More Deals.
- Shelf-Pass Through (POS Application)
  - One Unit Price
    - ➤Supplier Paid Once Week ACTUAL items sold
  - Wal*Mart Manager
    - ➤Daily Inventory Restock
    - ➤Supplier (sometimes Same Day) Ship to Wal*Mart
- Warehouse-Pass Through
  - Stock Smome Large Items
    - ➤Delivery May Come From Supplier
  - Distribution Center
    - ➤Supplier Trucks Merchandise Unloaded Directly onto Wal*Mart Trucks

Wal*Mart System

■ **5100M 96 Nodes;**	**24 TB Raw Disk;**
	700-1000 Pentium CPUs
■ **Number Rows**	**> 5 Billion**
■ **Historical Data**	**65 Weeks (5 Quarters)**
■ **New Daily Volume**	**Current Apps: 75 Million**
	New Apps: 100 Millions+
■ **Numbers Users**	**Thousands**
■ **Number Queries**	**60,000 Weeks**

Information as Strategic Weapon

- Daily Summary of all Sales Information
- Regional Analysis of all Stores in A logical Area
- Specific Product Sales
- Specific Supplies Sales
- Trend Analysis, etc.

- Wal*Mart Uses Information when Negotitaing with
  - Suppliers
  - Advertisers
  - Etc

DATABASE SIZES

VERY LARGE DATABASES (VLDB) SCALAR DATA

- **Terabyte (10**12) Wal*Mart (24TB)**

VLDB MULTIMEDIA DATA

- **Petabyte (10**15) Geographic Information Systems**
- **Exabyte (10**18) National Medical**
- **Zettabyte (10**21) Weather Images**
- **Zottabyte (10**24) Intelligence Agency (Video)**

IBM: Itty Bitty Machines

Object/Relational Evolution

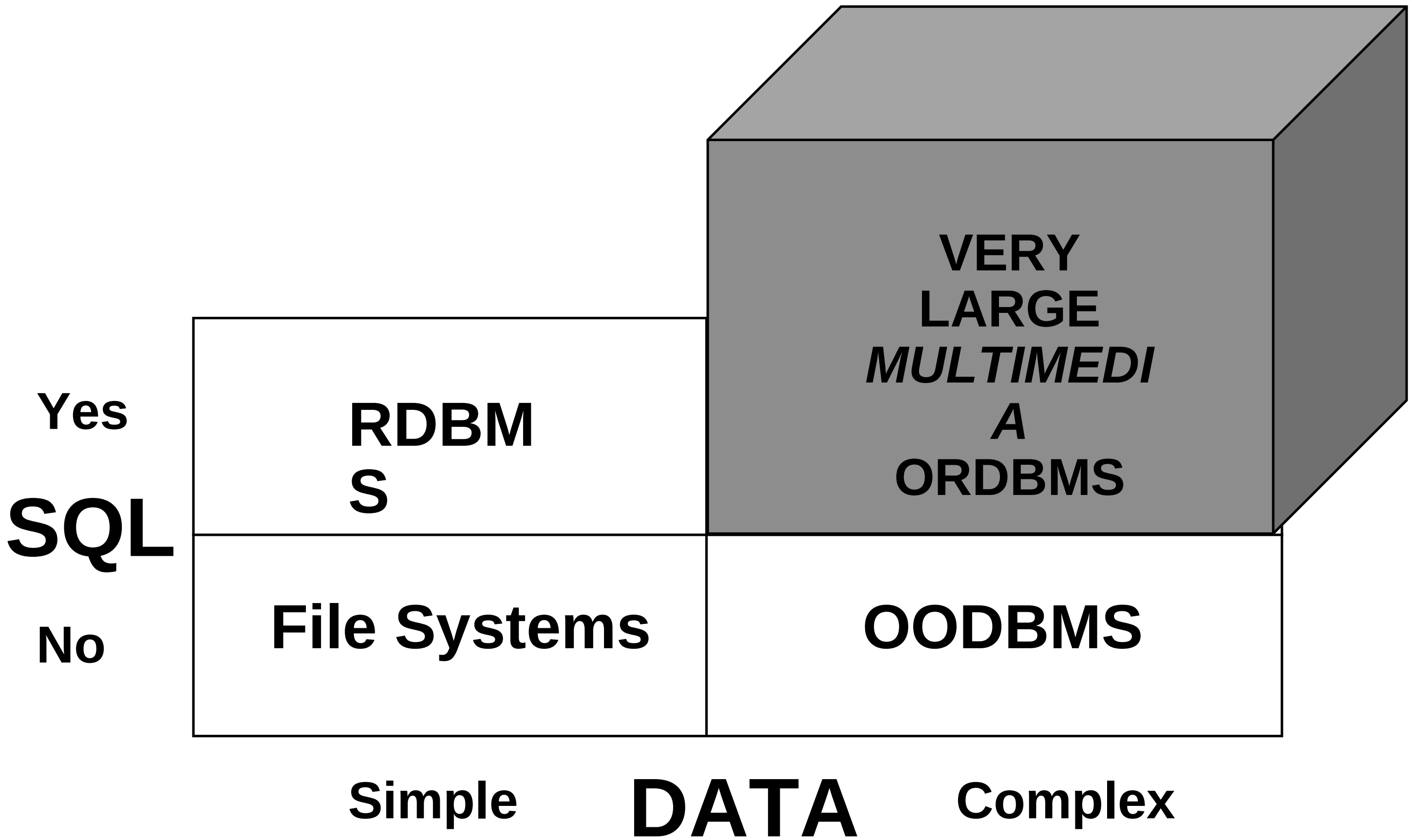
- Object/Relational (O/R) Databases
  - ➤User-Defined Types (UDTs)
  - ➤User-Defined Functions (UDFs)
- OQL (OODBMS)
  - ➤OODBMS Vendors Re-Inventing Themselves
- SQL3 (RDBMS)
  - ➤ Informix: DataBlades
  - ➤ Oracle: Cartridges
  - ➤ IBM: Extenders
  - ➤ Teradata: UDF Libraries
- Universal Server:
  - One Database for: OLTP, OLCP, DSS, UDF Execution
- Tight/Loose Integration
- Very Large (Petabyte) Database

Object-Relational: Paradigm Shift?

- Object/Relational DBMSs: The Next Great Wave
  - by Michael Stonebraker (Informix CTO)

SQL	Simple DATA	Complex DATA
Yes	RDBMS	ORDBMS
No	File Systems	OODBMS

Teradata Multimedia Object-Relational



Three Waves Of Multimedia Products

MULTIMEDIA Applications

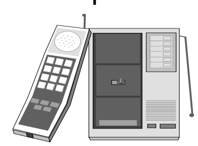
T O D A Y

Wave 1: Multimedia Communications

Wave 2: Content Storage & Retrieval

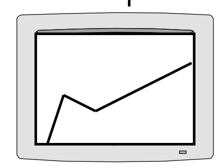
Wave 3: Content Analysis

Video Conference



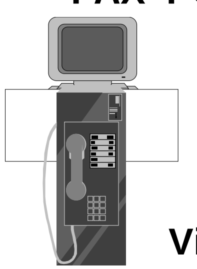
Audio/Video

Stock Analysis



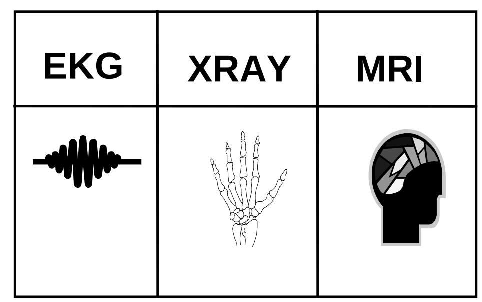
T O M O R R O W

FAX PCs



Videophones

Multimedia On-Line



Medical Records

Wave(2): Medical Query

SELECT * FROM PatientInfo WHERE (Age >37);

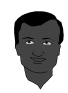
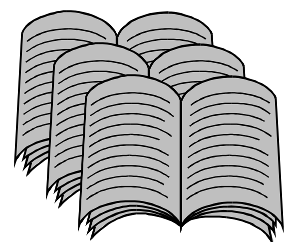
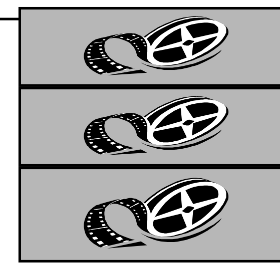
ID	NAME	GENDER	FACE	AGE	ADDRESS
7	Clinton, Bill	Male		50	1600 Pennsylvania Washington, D.C.
19	Riordan, Jeff	Male		65	13 San Vicente Brentwood, CA
23	Carino, Viviana	Female		40	9718 E. Naomi Ave Arcadia, CA

Image Column

Wave(2): Financial Query

SELECT * FROM StockInfo
WHERE Price / Earnings <= .5;

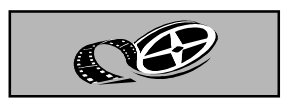
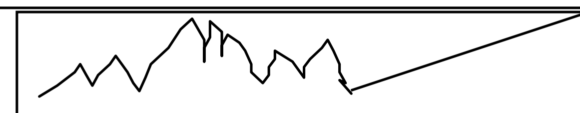
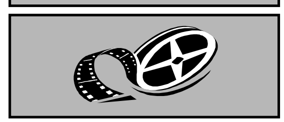
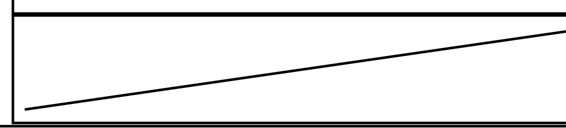
Stock	Price	Earnings	Reports	Video
InternetWare	10	100		
GreatSoftWare	25	50		
MultimediaSoft	20	45		

Database Query with a multimedia answer

Wave(3) Financial Time-Series

(UDFs In: Projection & Predicate)

```
SELECT Stock, Price, Video, PlotDailyValues(History)
FROM    StockHistory
WHERE  MovingAverage (History, 30) /
          LastPrice (History) < .8;
```

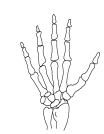
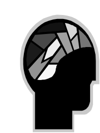
Stock	Price	Video	PlotDailyValues
CarinoSoft	100		
SterlingWare	300		

Wave(3) Medical Content-Analysis

Predicate: Wave(2) & Wave(3)

Find male patients over 30 years old whose MRI show a potential Tumor.

```
SELECT   *   FROM  PatientTable
WHERE    (Age > 30) and (Gender = 'Male')
AND      FindTumor (MRI) > 0.8;
```

NAME	AGE	GENDER	LAST DATE	EKG	X-RAY	MRI
JUAN	50	MALE	1/1/2000			

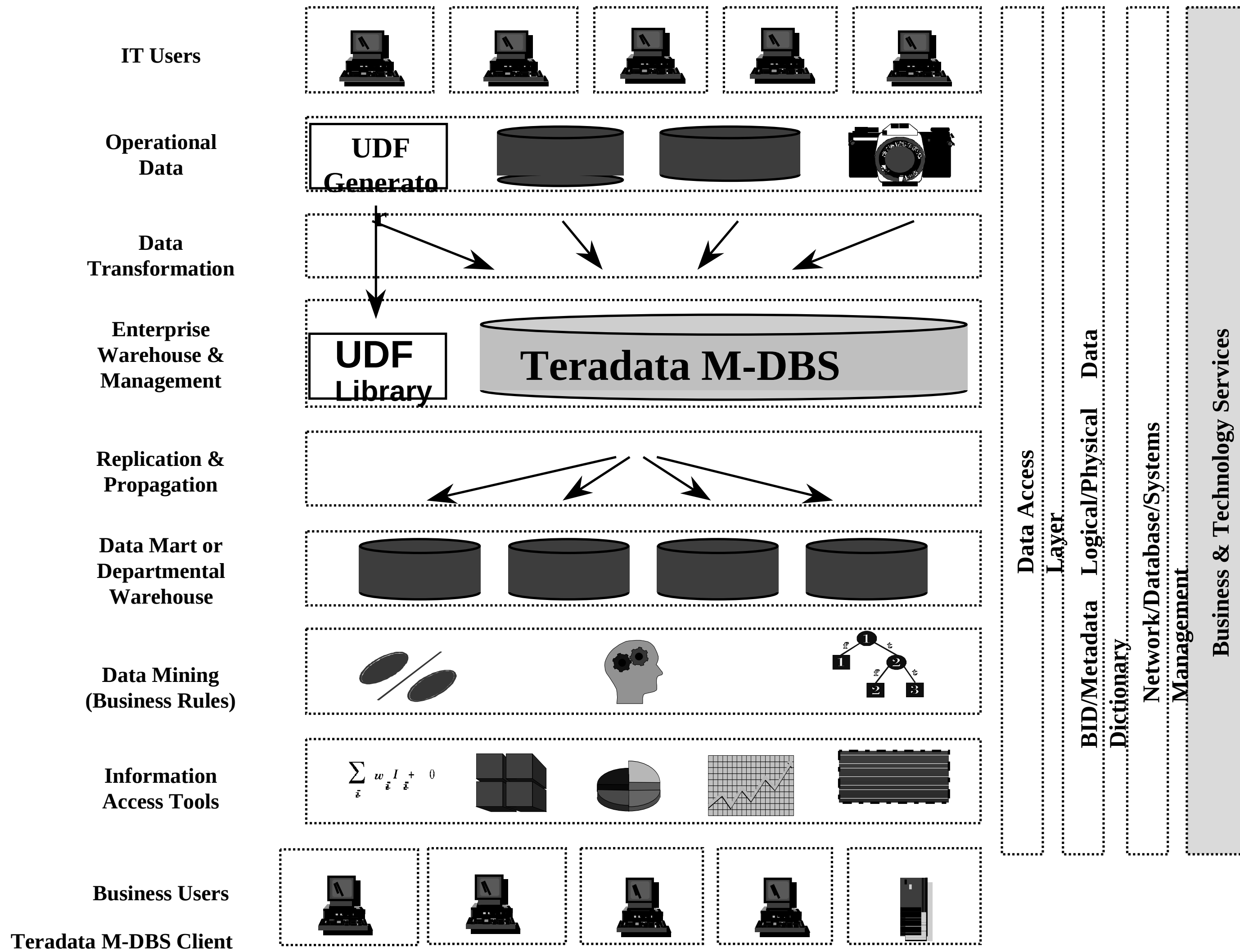
M-DBS SQL/C++: UDT/UDF Definition

SQL3 (ANSI X3H2) Database Language SQL 199X:

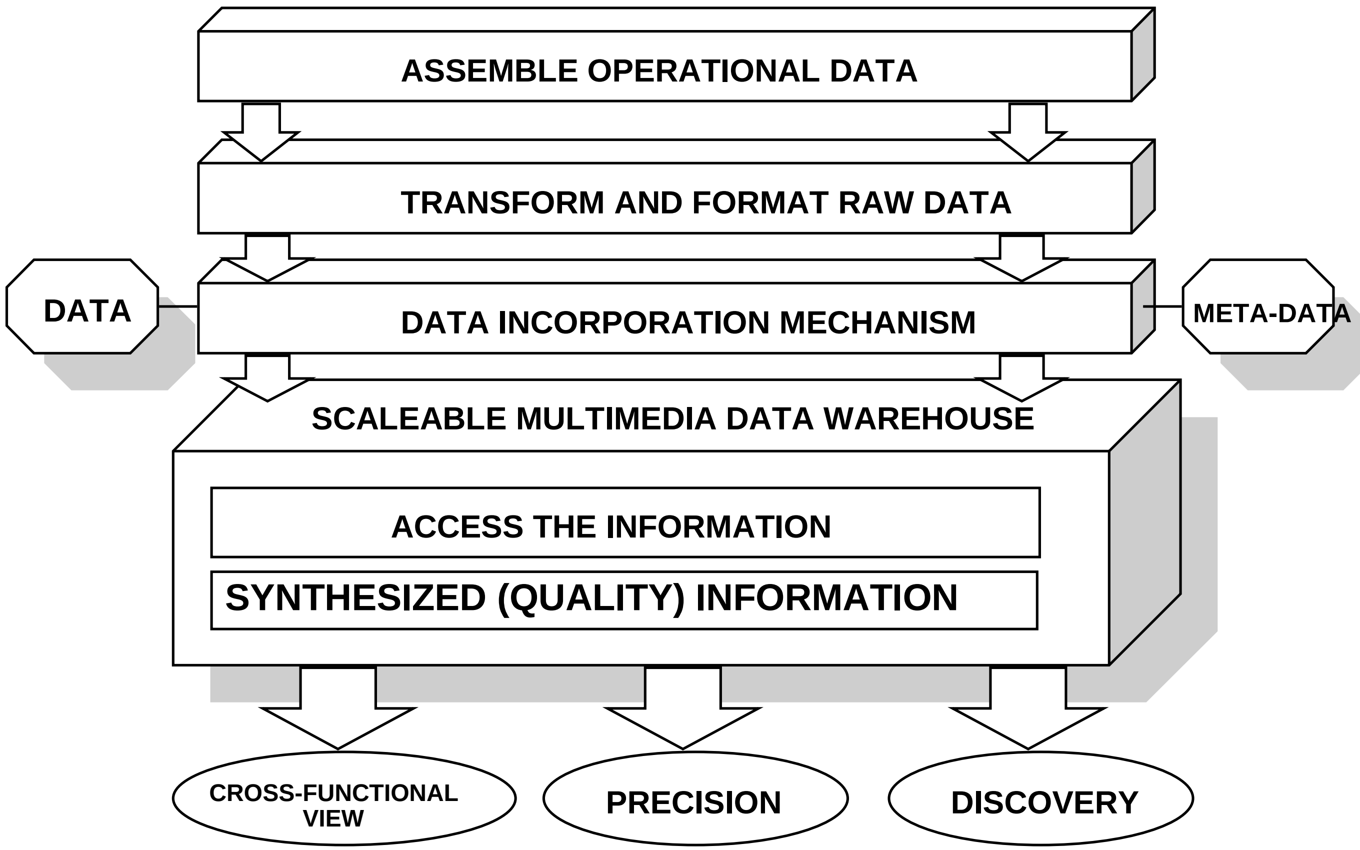
Framework, Foundation, CLI, Persistent Storage Module (PSM), Transaction, Temporal & Object

```
CREATE VALUE TYPE MRI ODBCTYPE -8000;
CREATE FUNCTION  FindTumor (MRI &) RETURNS FLOAT ..;
CREATE FUNCTION  LateralView (MRI &) RETURNS MRI ..;
CLASS MRI
{          // UDT TYPE DEFINITION
PUBLIC: FLOAT FindTumor (MRI &);    // PREDICATE UDF
            MRI&    LateralView (MRI & );  // PROJECTION UDF
}
FLOAT FindTumor (MRI &m)
{          // UDF FUNCTION CODE: GOES HERE        };
```

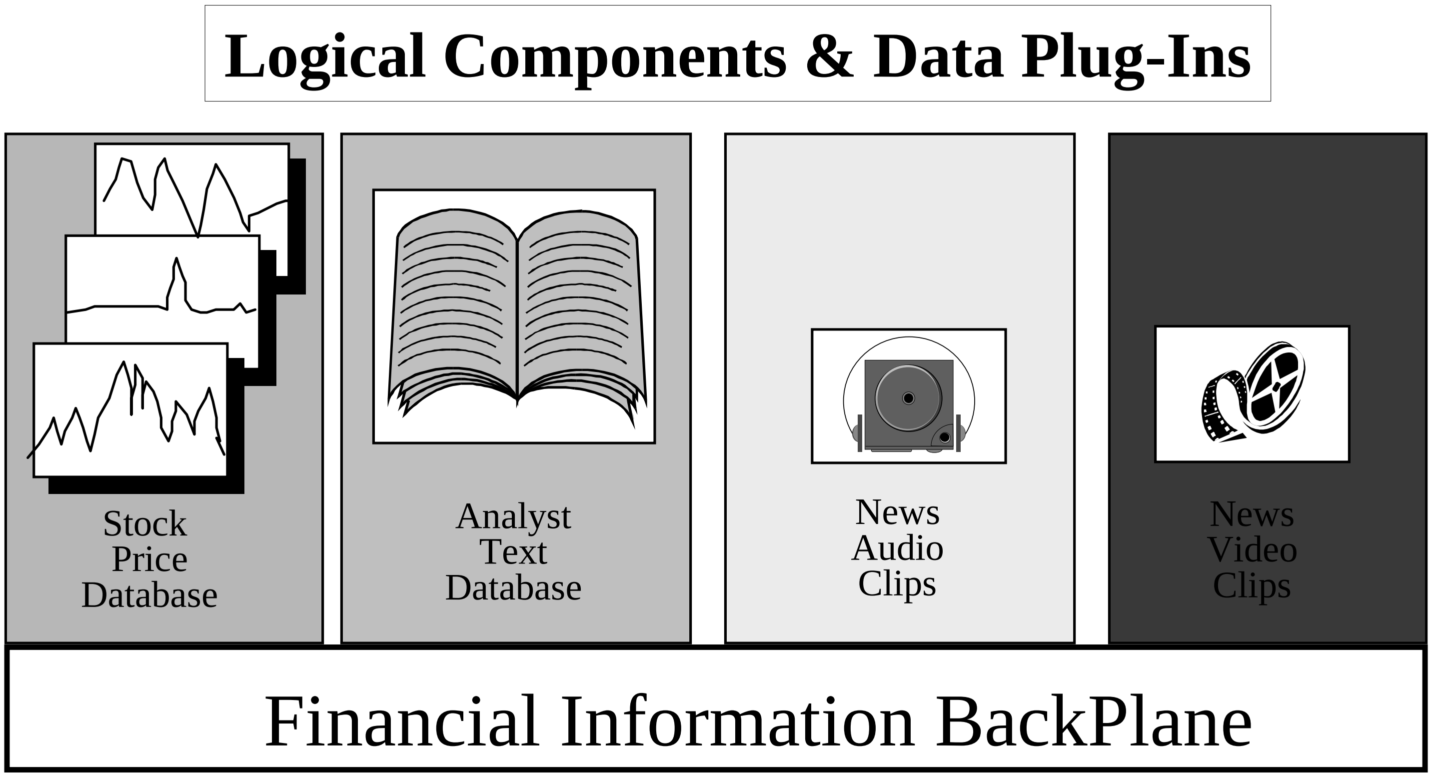
The Scalable Multimedia Data Warehouse Architecture



Data Warehouse Concept



Financial Services - Visionary Applications



- Content-Analysis and Information Correlation
- Historical Information, Patterns and ...

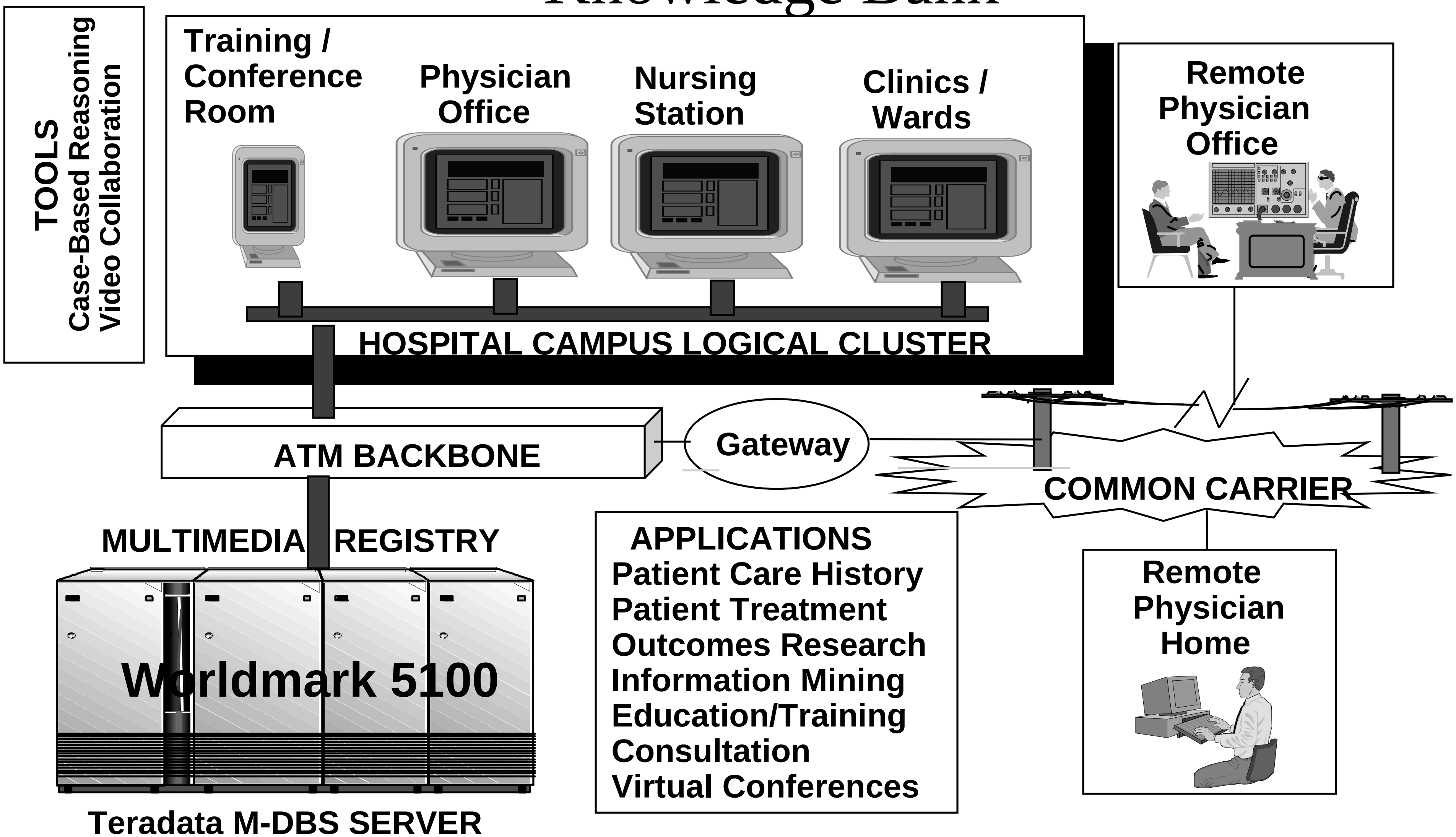
Healthcare Information System (Big Picture Application & Solution)

- National Institute of Standards and Technology (NIST)
  - Advanced Technology Program
- National Medical Practice Knowledge Bank
  - Multimedia Registry (the database)
- Five-Year Program : Develop Knowledge Bank
- Joint Venture Members
  - Allegheny Health Education & Research Foundation
  - NCR Human Interface Technology Center
  - NCR Parallel Systems (Teradata)
  - AT&T Business Markets Division
  - AT&T Solutions

Knowledge Bank Highlights

- "New" Medical Information Access Paradigm
  - Business Process Re-Engineering
  - Cultural Change
- System Integration of New Technology
  - Long-Run Test of System Integration
- Content-Analysis: Object (e.g., MRI)
- Video Challenge (CMU R&D)
  - Capture; Digitize; Compress; Edit; Index; Segment; and Analyze Content
- First End-To-End Demonstration 1997

Knowledge Bank



Multimedia Registry

TERADATA M-DBS DATABASE SERVER

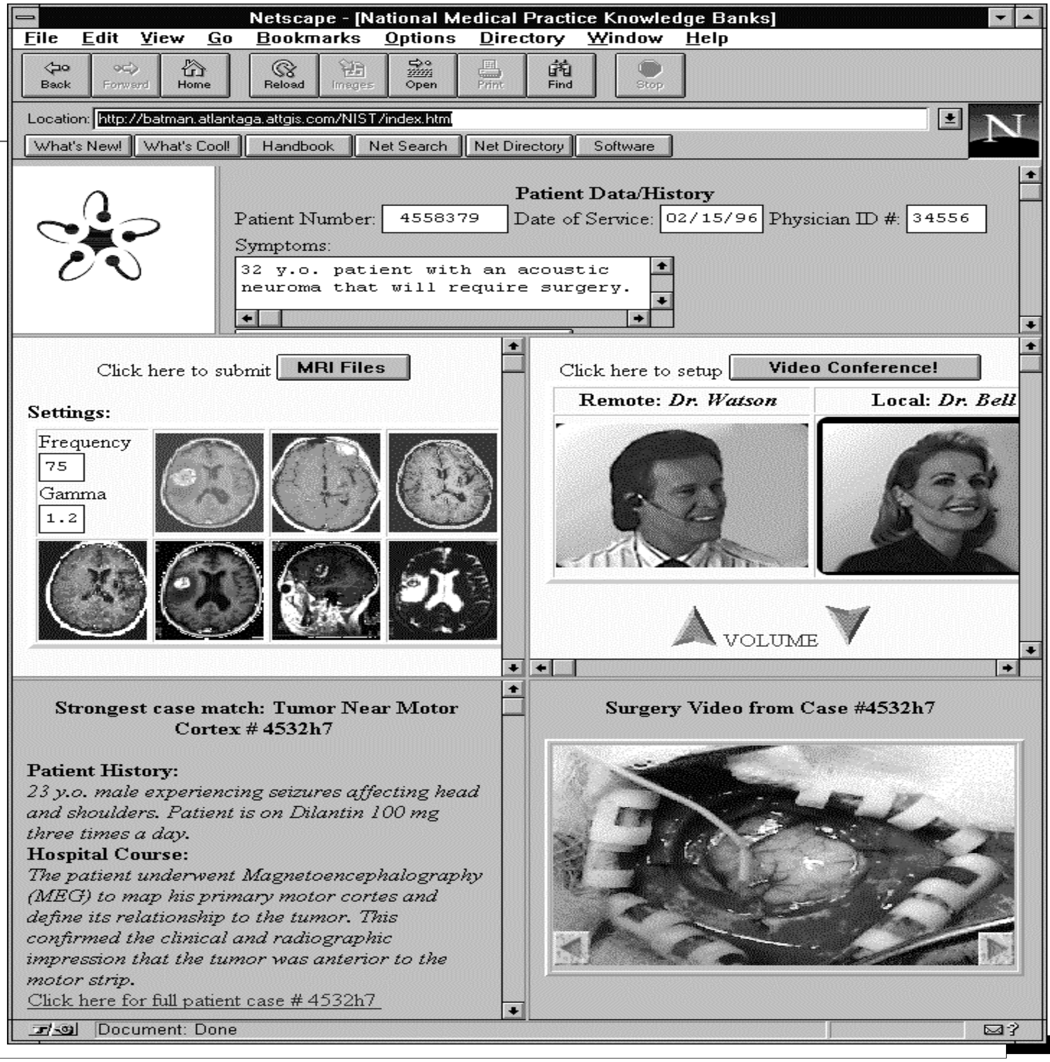
UDF LIBRARY

VIDEO INDEXING
VIDEO SEGMENTATION
VOICE-TO-TEXT
IMAGE FEATURE EXTRACTION

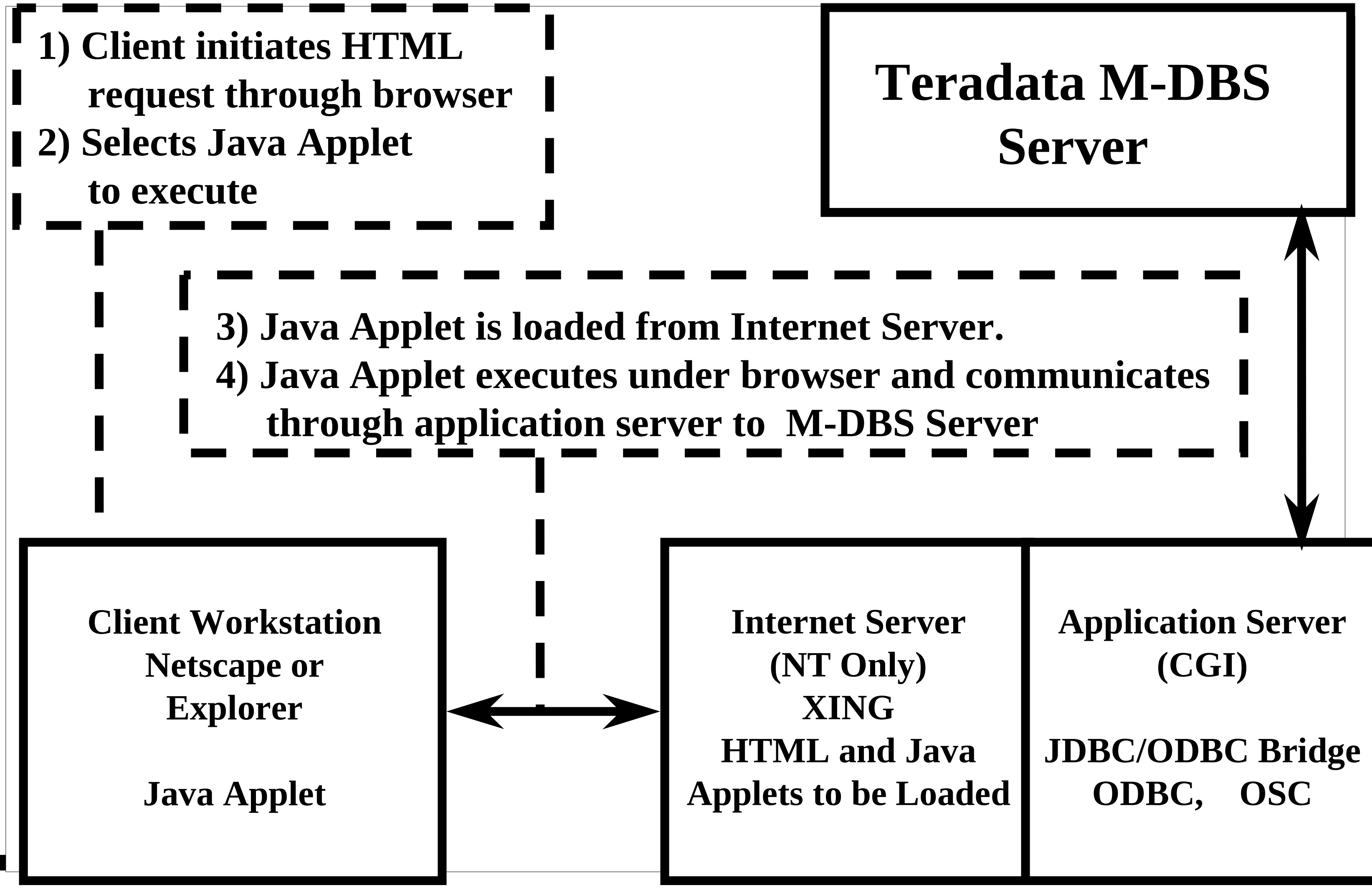
DATABASE TABLES

Patient Records, including ADT
Objects (e.g. MRI, CAT, EKG)
Video (Surgery, Interviews)
Critical Pathways

Web Browser Interface



WEB: Internet/Intranet/Extranet Datawarehouse 3-Tier Solution



Two-Pass Paradigm Concept

FIND A HOTEL/RESORT IN GRAND CANARY

```
SELECT Hotel Name, Rating, Movie
FROM    Hotel
WHERE Location = "GRAND CANARY"
AND      Rating >= 4
AND      Price BETWEEN 300 AND 2500;
```

Pass(1): Retrieve Tuples

HOTEL NAME	RATING	MOVIE
Nevada	4	
Condado Beach	4	
El Conquistador	5	

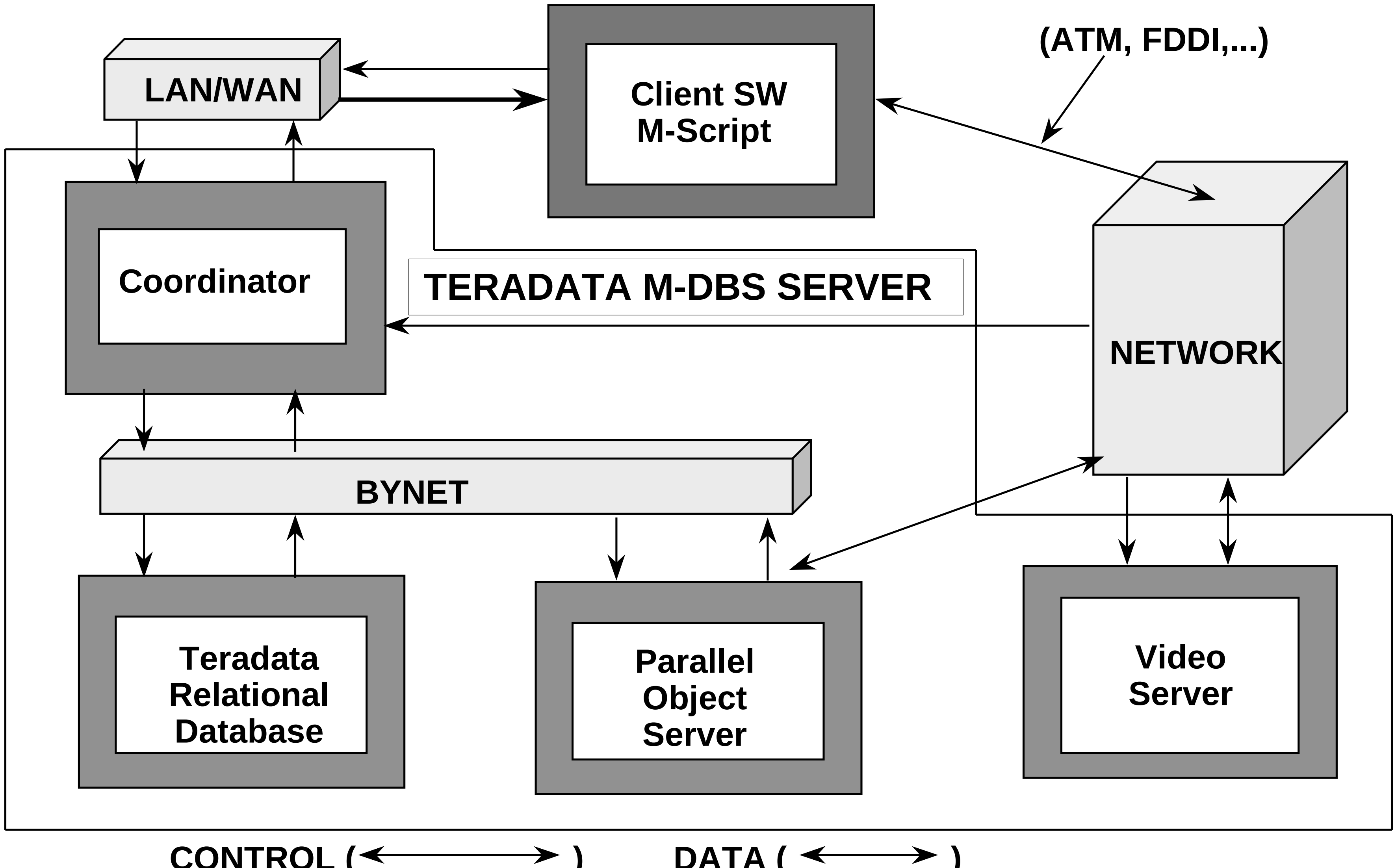
PASS(1) MOVIE OBJECT NOT SENT TO REQUESTING CLIENT

ICON REPRESENTING
MULTIMEDIA OBJECT LOCATOR (MOL)
M-DBS URL-like: Direct Object Access

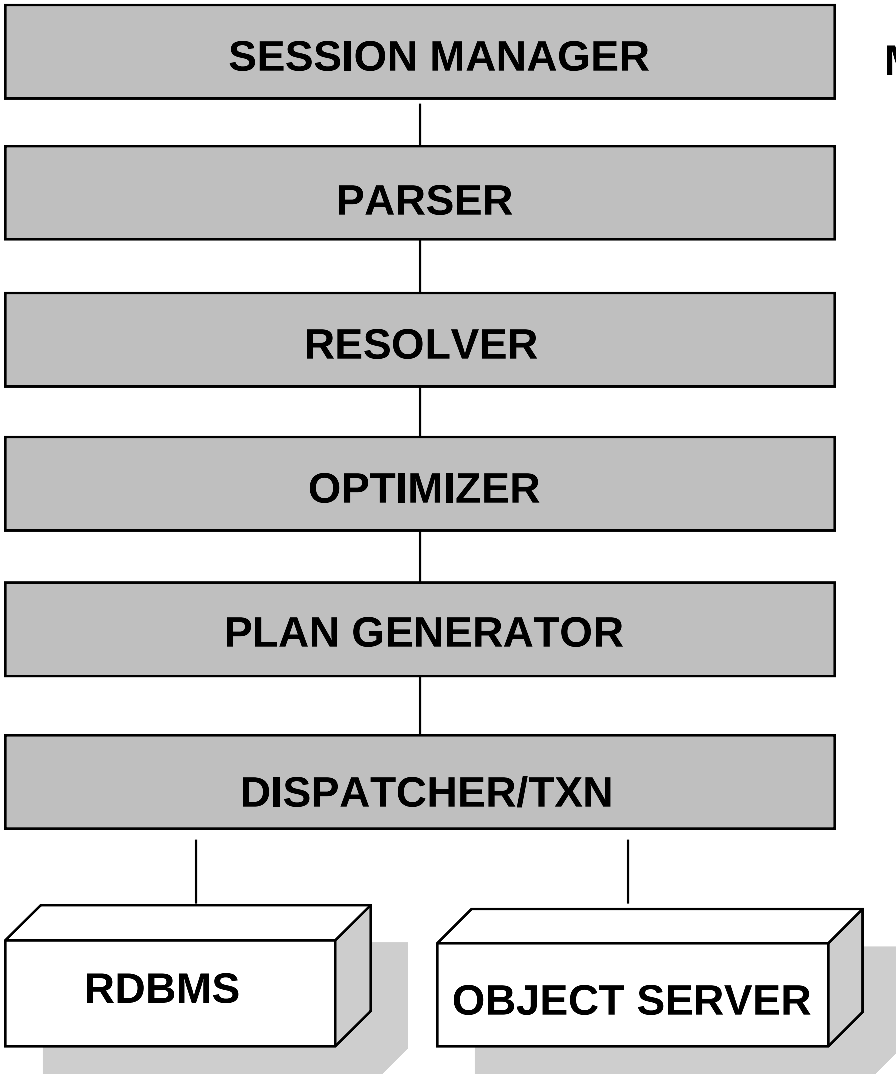
Pass(2): Hand “Click” On Specific Object

HOTEL NAME	RATING	MOVIE
El Conquistador	5	

Framework & Architecture



Coordinator



MANAGES CLIENT SESSIONS

PARSES QUERY

BINDS VALUES USING GLOBAL DD

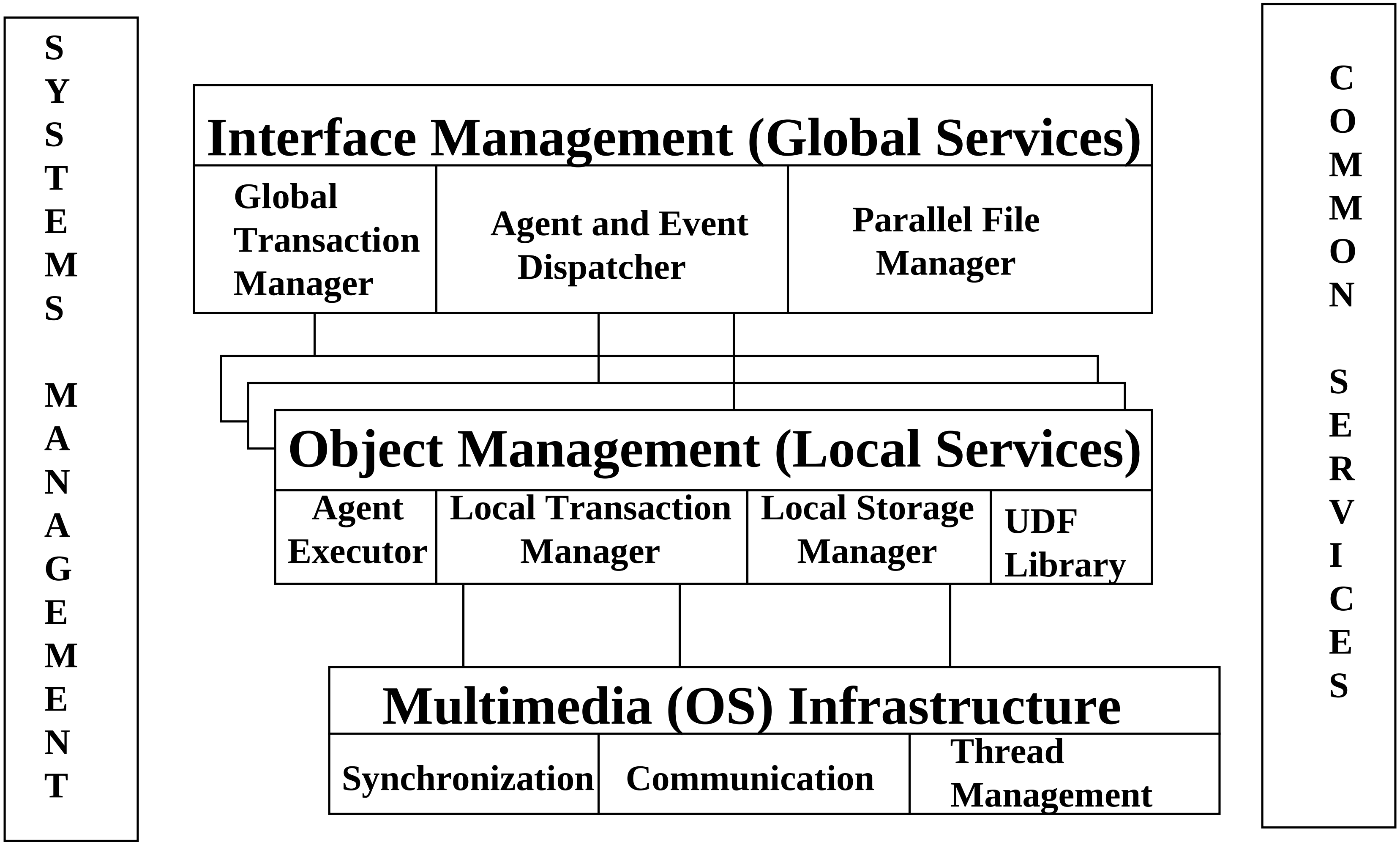
GENERATES A BETTER PLAN

CONVERTS PLAN INTO M-STEPS

SEND PLAN TO EXECUTE

RELATIONAL & OBJECT SERVERS

Parallel Object Server Architecture

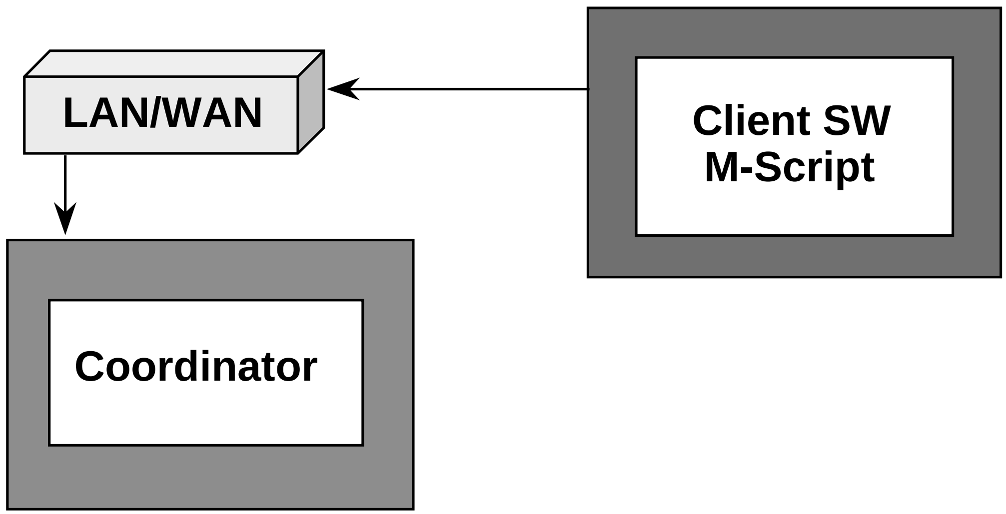


Execution Flow (Request)

Client SW
M-Script

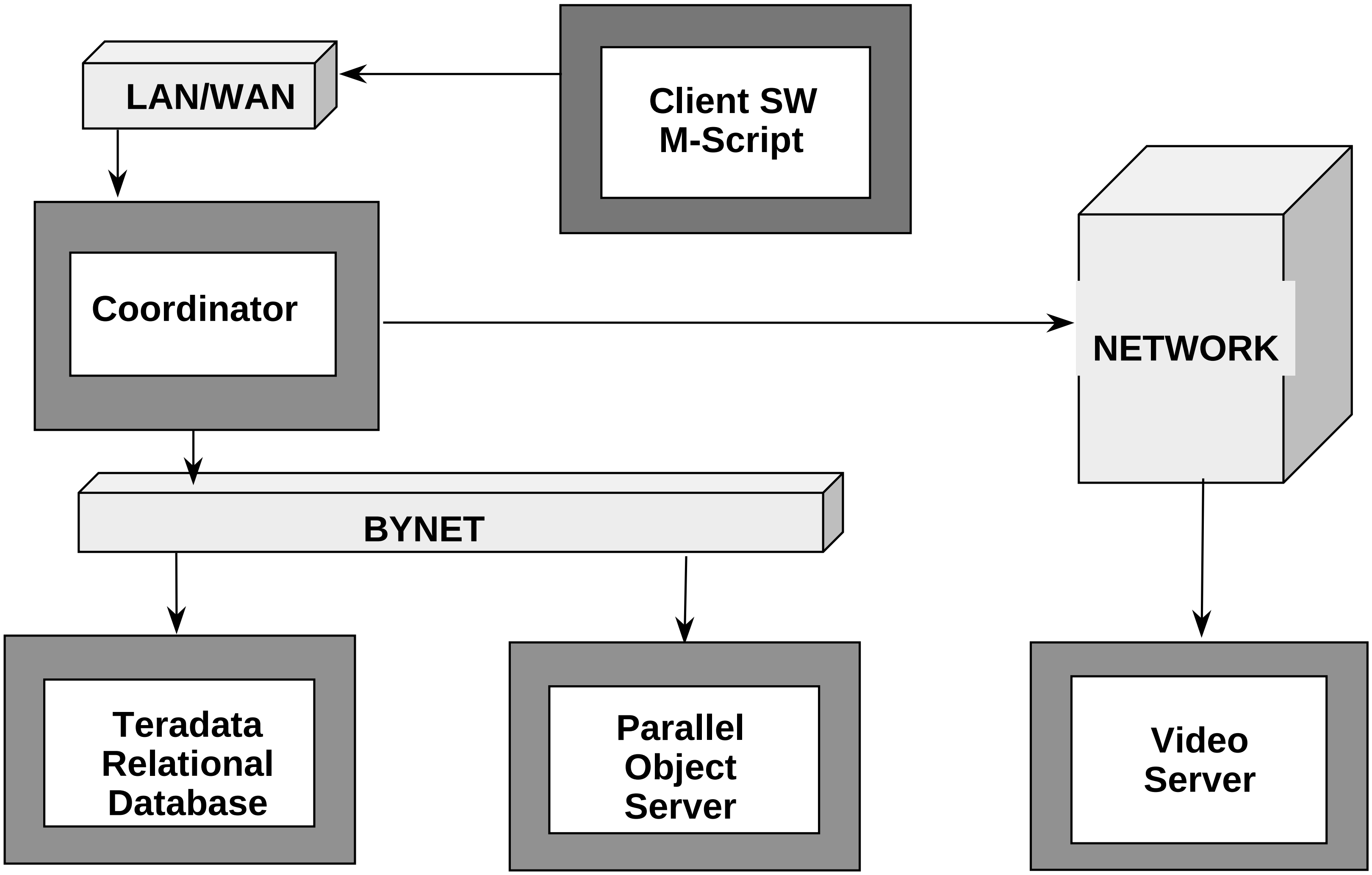
```
SELECT Stock, Price, Video, PlotDailyValues(History)
FROM    StockHistory
WHERE  MovingAverage (History, 30) /
        LastPrice (History) < .8;
```

Pass(1): Execution Flow

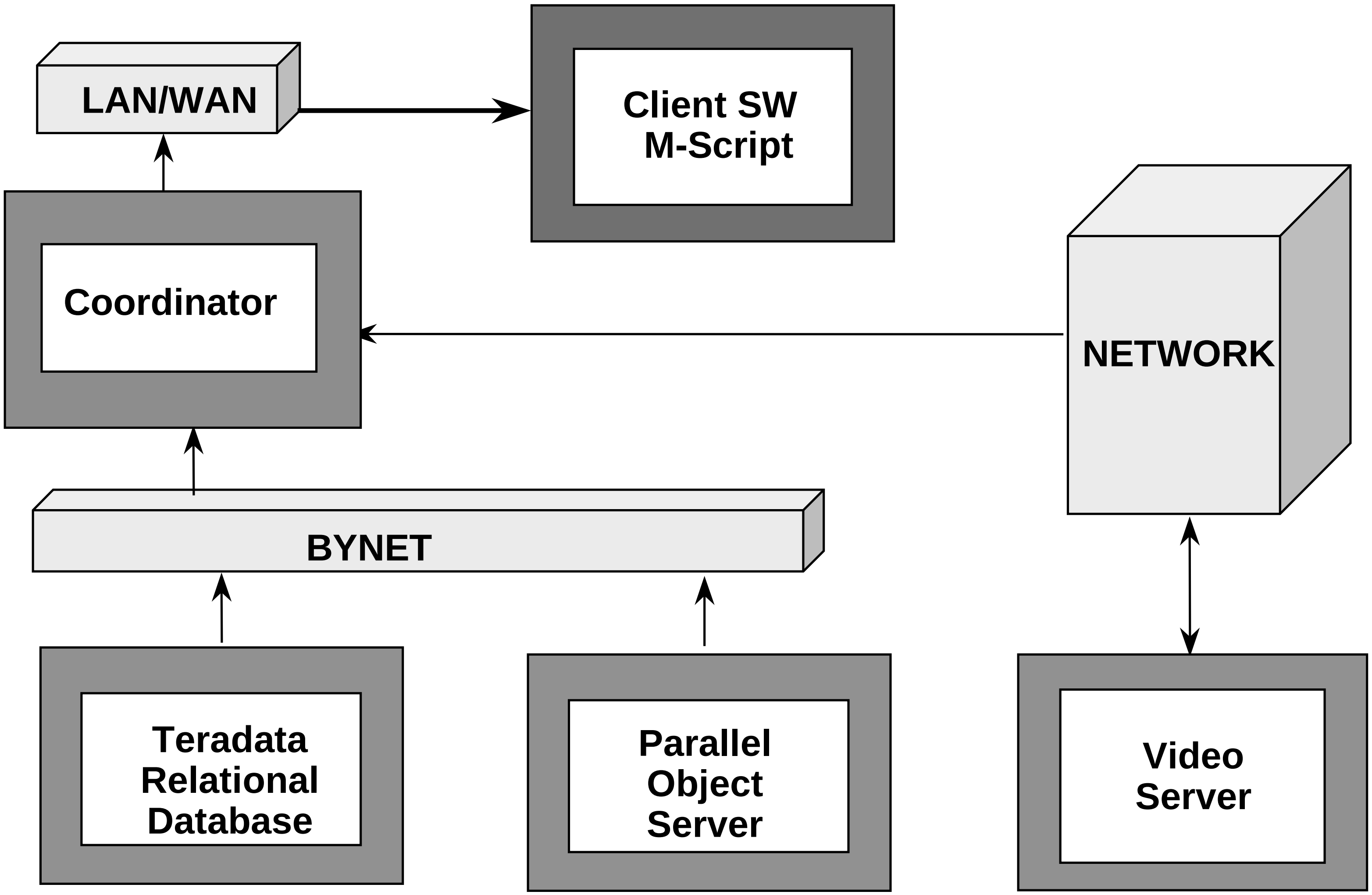


- **Coordinator**
  - **Establishes Session**
  - **Generates M-STEP Query Execution Plan**
  - **Dispatches Plan to RDBMS & Object Servers**

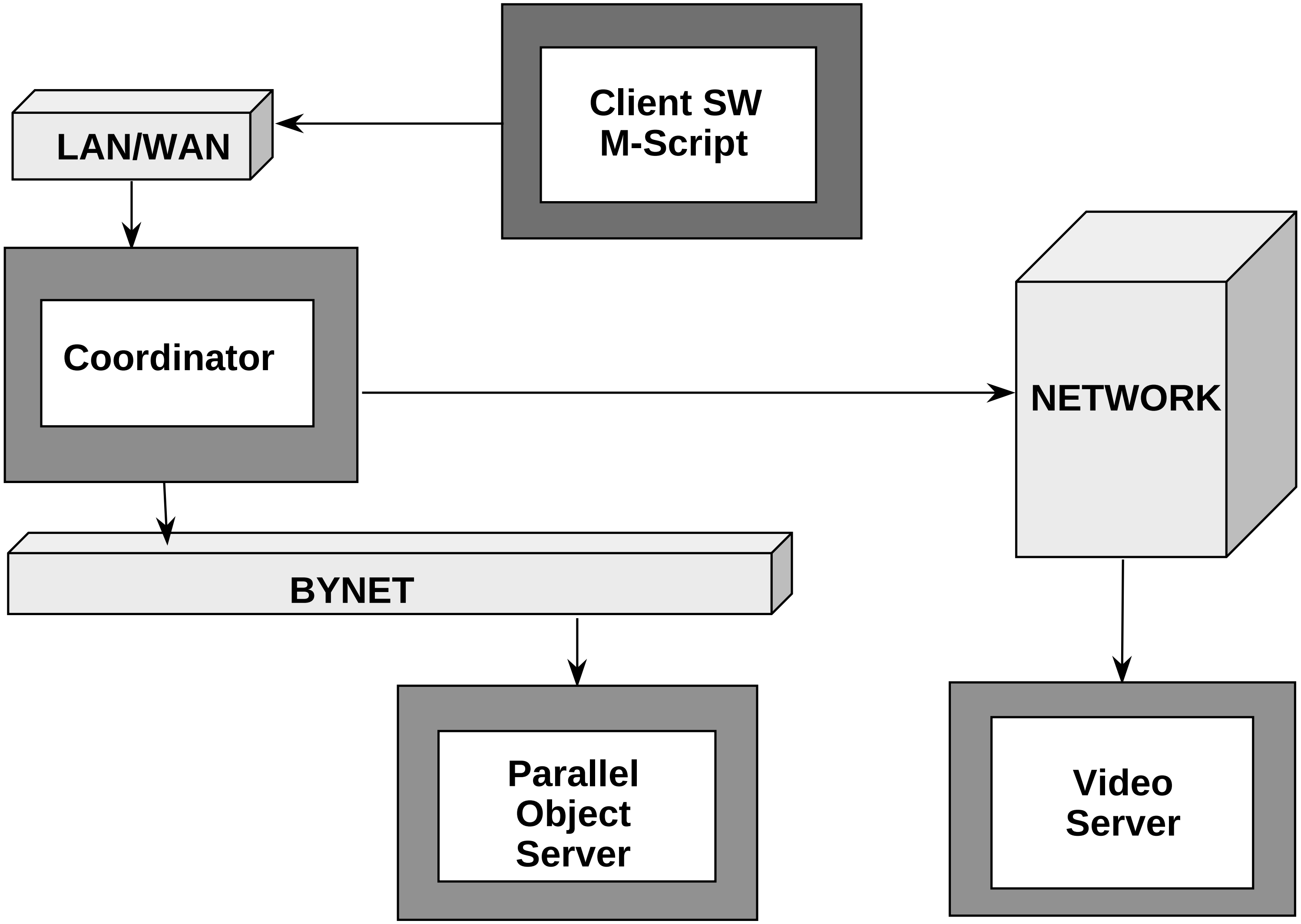
Pass(1): Execution Flow



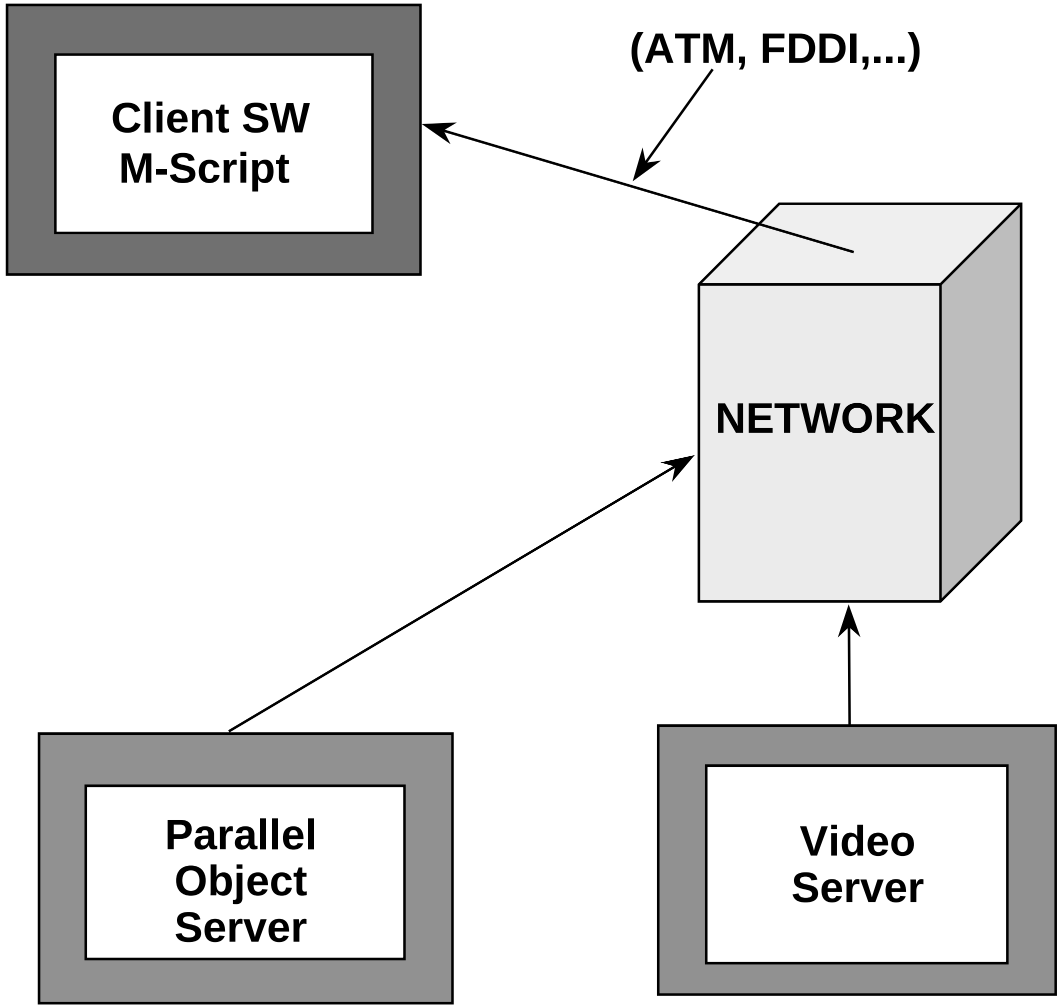
Pass(1): Data Flow (Response)



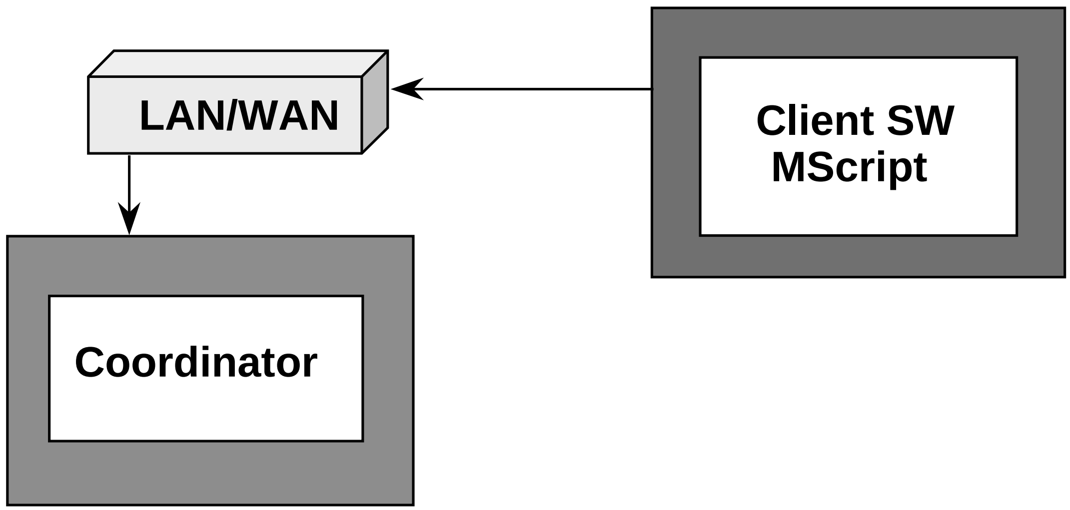
Pass(2): Object Retrieval



Pass(2): Object Retrieval



End Transaction



Open Database Connectivity (ODBC)

- Microsoft ODBC
  - Defacto Call-Level Interface Standard
- Expect Microsoft ODBC to be Dominant
- Let Microsoft Find Application Partners
- Key ODBC Issue:
  - Missing Real ADT Support
  - LONGVARBINARY (NOT ADT)
- Teradata M-DBS
  - ODBC 2.5 + M-DBS ADT Extensions + OSC
  - ODBC 3.0 has CLOBs, BLOBs
    - NOT ADT (e.g. OBJECT SUPPORT)
  - ODBC 3.5 Locators

OSC Transport Connections

- Object Server Connectivity (OSC)
  - Manages Diverse Networks (100BaseT, ATM ..)
  - Protocol Independence, Initially TCP/IP
- Primary Network - usually low legacy bandwidth (10BaseT, 100BaseT)
- Secondary Network - higher bandwidth (e.g. ATM)
- Primary & Secondary connections CAN use same network
- Mechanism to manage (Not R1.1):
  - Quality of Service (QoS)
  - Minimize "expensive" usage-based network access

Register Utility

- Legacy (SQL2) Applications
- Register Utility
  - Add ADT/UDFs To Existing Tables
  - Provide Views For Legacy Applications
  - Preserve SQL2 Applications
  - Legacy SQL2 Updates (CAVEAT EMPTOR)
  - Provide SQL2 Functionality to M-DBS
  - Philosophy: Preserve Legacy Programs.
    - No Need To Rewrite

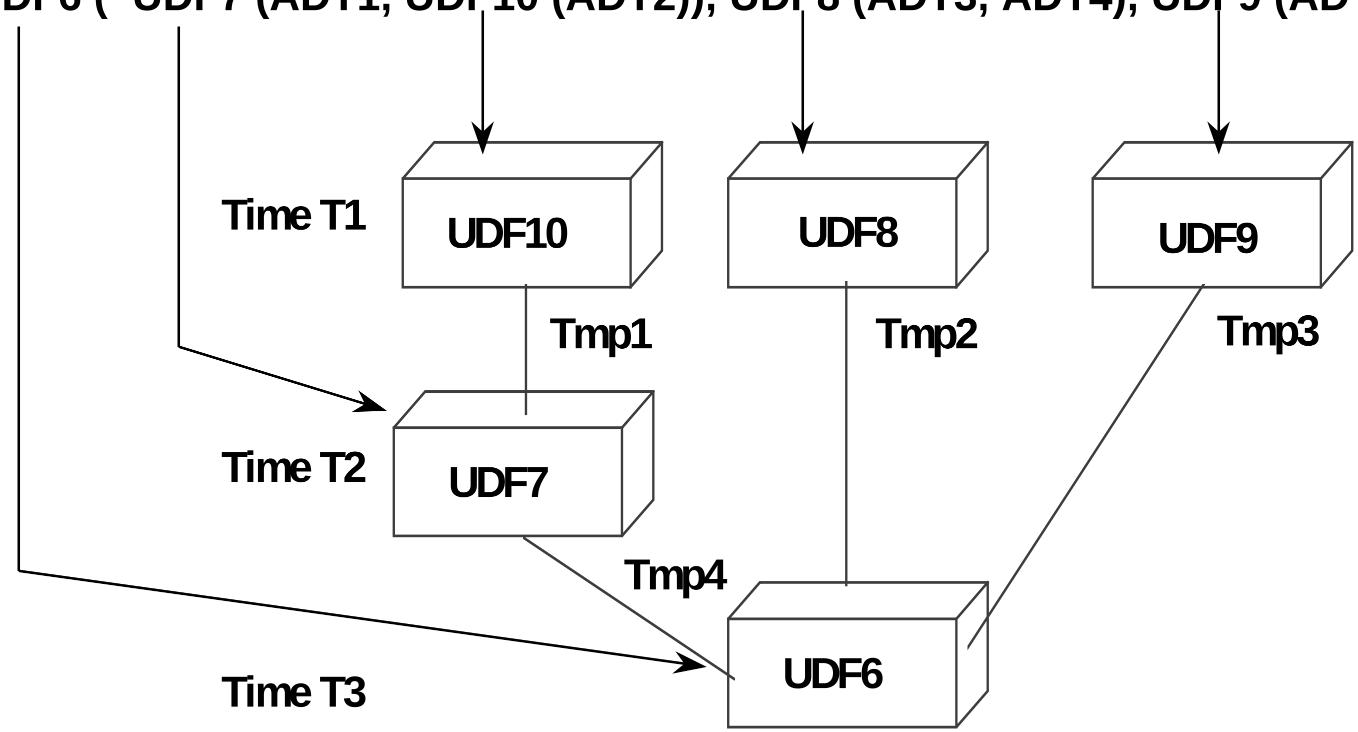
UDF Usage & Optimization

- **Applications Expertise Migrate Into Database**
  - **UDF Libraries, DataBlades, Extenders, Cartridges**
  - **Existing Legacy Application Re-write**
- **Some OR/DBMS MPP UDF Issues (Ph.d Thesis Topics?)**
  - **Projection UDF: Execute Pass(1) or Pass(2)**
  - **Predicate UDFs:**
    - **UDF1(UDT1) ^ UDF2(UDT2) ^ UDF3(UDT3)**
      - **ORDER, LOCATION, STRATEGY (Migrating Tuple)**
    - **UDF (UDT1, UDT2): Remote Access vs Copy/Move Object**
    - **Pipelining Values for Nested UDFs**
    - **Multi-Dimensional Indexes (Feature Extracts)**
  - **Parallel (Multimedia) Object Load (Organize & Load)**

PARALLEL PIPELING UDF EXECUTION

SELECT * FROM Patient WHERE

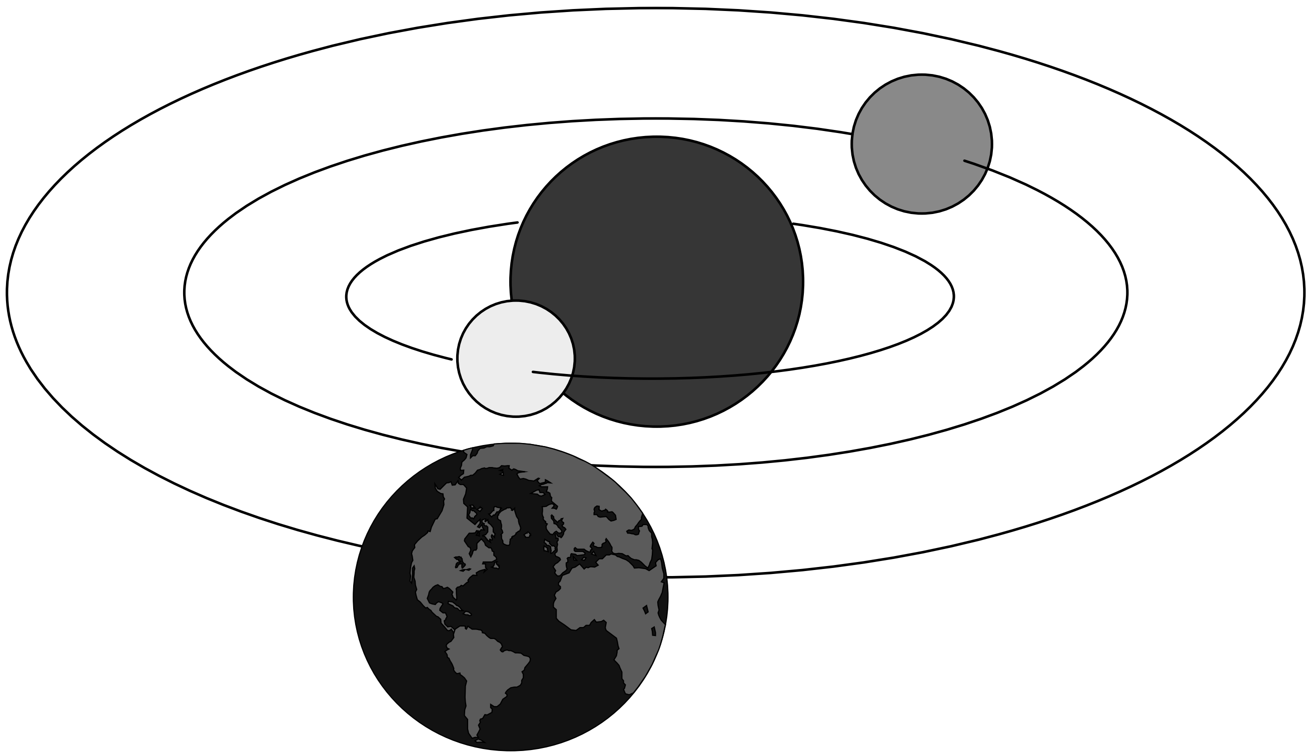
UDF6 (UDF7 (ADT1, UDF10 (ADT2)), UDF8 (ADT3, ADT4), UDF9 (ADT5, ADT1, ADT6));

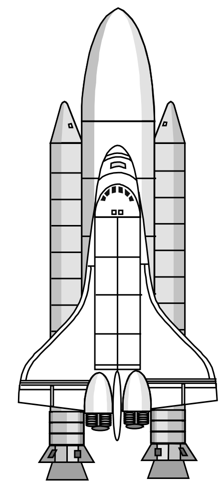


Conclusion

- Information Strategic Weapon
  - Central Data Warehouse
    - ➤ Cross-Functional Departmental Views
    - ➤ Design, Plan and Build For Growth
    - ➤ Avoid Data Mart Inexpen$ive Allure
    - ➤ Wal*Mart Case
- Scalable Multimedia Data Warehouse (DW)
  - (Multimedia) Object/Relational Evolution
  - Parallel Platform, OR/DBMS & Utilities
  - Special UDF Issues
  - Internet DW and Medical Knowledge Bank

Questions?





Felipe.Carino@ElSegundoCA.ncr.com
(310) 524-7026