# The Architecture of Transaction Processing Systems

Chapter 23

## Evolution of Transaction Processing Systems

- The basic components of a transaction processing system can be found in single user systems.
- The evolution of these systems provides a convenient framework for introducing their various features.

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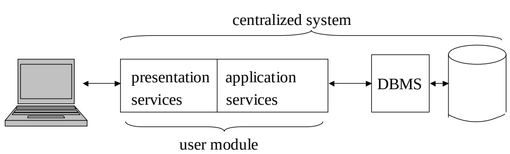
## Single-User System




- *Presentation Services* - displays forms, handles flow of information to/from screen
- *Application Services* - implements user request, interacts with DBMS
- ACID properties automatic (isolation is trivial) or not required (this is not really an enterprise)

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## Centralized Multi-User System

- Dumb terminals connected to mainframe
  - Application and presentation services on mainframe
- ACID properties required
  - Isolation: DBMS sees an interleaved schedule
  - Atomicity and durability: system supports a major enterprise
- Transaction abstraction, implemented by DBMS, provides ACID properties

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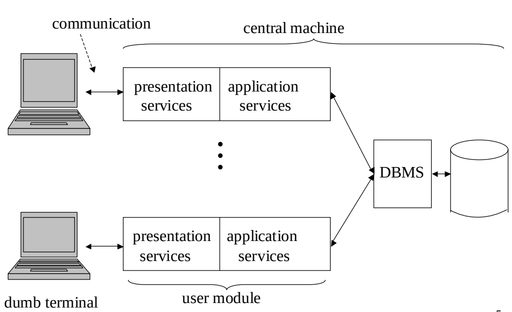
## Centralized Multi-User System

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## Transaction Processing in a Distributed System

- Decreased cost of hardware and communication make it possible to distribute components of transaction processing system
  - Dumb terminal replaced by computers
- Client/server organization generally used

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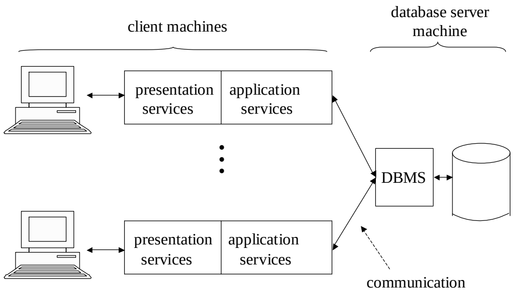
## Two-Tiered Model of TPS

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## Use of Stored Procedures

- Advantages that result from having the database server export a stored procedure interface instead of an SQL interface
  - Security: procedures can be protected since they are maintained at the enterprise site
  - Network traffic reduced, response time reduced
  - Maintenance easier since newer versions don't have to be distributed to client sites
  - Authorization can be implemented at the procedure (rather than the statement) level
  - Procedures can be prepared in advance
  - Application services sees a higher level of abstraction, doesn't interact directly with database

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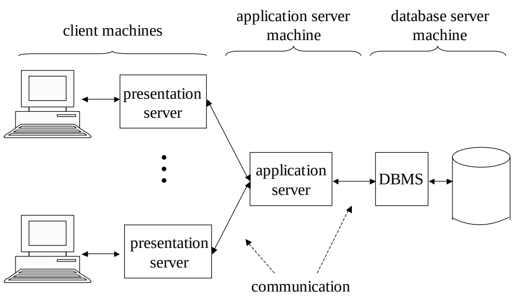
## Three-Tiered Model of TPS

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## Application Server

- Sets transaction boundaries
- Acts as a *workflow controller*: implements user request as a sequence of tasks
  - *e.g.*, registration = (check prerequisites, add student to course, bill student)
- Acts as a *router*
  - Distributed transactions involve multiple servers
  - Server classes are used for load balancing
- Since workflows might be time consuming and application server serves multiple clients, application server is often *multi-threaded*

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## Transaction Server

- Stored procedures off-loaded to separate (transaction) servers to reduce load on DBMS
- Transaction server located close to DBMS
  - Application server located close to clients
- Transaction server does bulk of data processing.
  - Transaction server might exist as a *server class*
    - Application server uses any available transaction server to execute a particular stored procedure; might do load balancing
    - Compare to application server which is multi-threaded

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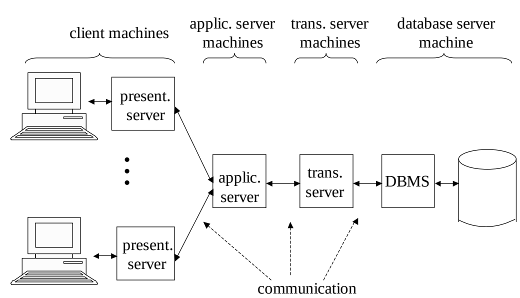
## Three-Tiered Model of TPS

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## Levels of Abstraction

- Presentation server implements the abstraction of the user interface
- Application server implements the abstraction of a user request
- Stored procedures (or transaction server) implement the abstraction of individual sub-tasks
- Database server implements the abstraction of the relational model

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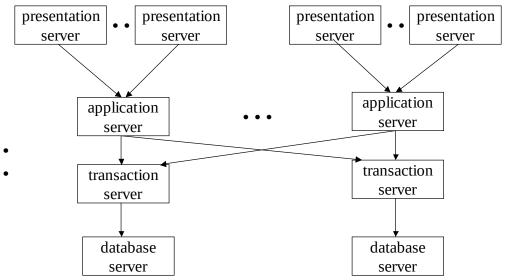
## Interconnection of Servers in Three-Tiered Model

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## Sessions and Context

- A *session* exists between two entities if they exchange messages while cooperating to perform some task
  - Each maintains some information describing the state of their participation in that task
  - State information is referred to as *context*

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## Communication in TPSs

- *Two-tiered model*:
  - Presentation/application server communicates with database server
- *Three-tiered model*:
  - Presentation server communicates with application server
  - Application server communicates with transaction/database server
- In each case, multiple messages have to be sent
  - Efficient and reliable communication essential
- Sessions are used to achieve these goals
  - Session set-up/take-down costly => session is long-term

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## Sessions

- Sessions established at different levels of abstraction:
  - Communication sessions (low level abstraction)
    - Context describes state of communication channel
  - Client/server sessions (high level abstraction)
    - Context used by server describes the client

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## Communication Sessions

- Context: sequence number, addressing information, encryption keys, …
- Overhead of session maintenance significant
  - Hence the number of sessions has to be limited
- Two-tiered model:
  - A client has a session with each database server it accesses
- Three-tiered model:
  - Each client has a session with its application server
  - Each application server *multiplexes* its connection to a database server over all transactions it supports

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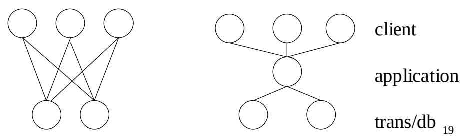
# Number of Sessions

- Let $n_1$ be the number of clients, $n_2$ the number of application servers, and $n_3$ the number of transaction/db servers
- Sessions, two-tier (worst case) = $n_1 * n_3$
- Sessions, three-tier (worst case) = $n_1 + n_2 * n_3$
- Since *n1* » *n2*, three-tiered model scales better

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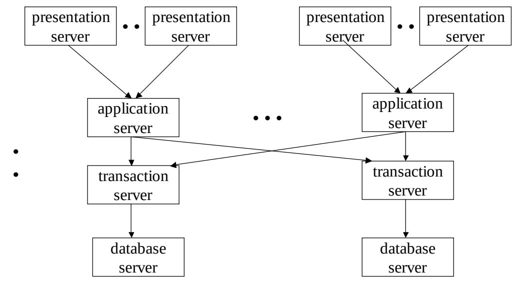
# Sessions in Three-Tiered Model

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# Client/Server Sessions

- Server context (describing client) has to be maintained by server in order to handle a sequence of client requests:
  - What has client bought so far?
  - What row was accessed last?
  - What is client authorized to do?

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# Client/Server Sessions

- Where is the server context stored?
  - At the server - but this does not accommodate:
    - Server classes: different server instances (e.g., transaction servers) may participate in a single session
    - Large number of clients maintaining long sessions: storage of context is a problem
  - In a central database - accessible to all servers in a server class
  - At the client - context passed back and forth with each request.
    - Context handle

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# Queued vs. Direct Transaction Processing

- *Direct*: Client waits until request is serviced. Service provided as quickly as possible and result is returned. Client and server are synchronized.
- *Queued*: Request enqueued and client continues execution. Server dequeues request at a later time and enqueues result. Client dequeues result later. Client and server unsynchronized.

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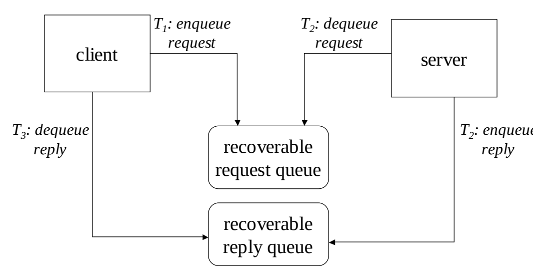
# Queued Transaction Processing

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## Queued Transaction Processing

- Three transactions on two recoverable queues
- **Advantages**:
  - Client can enter requests even if server is unavailable
  - Server can return results even if client is unavailable
  - Request will ultimately be served even if $T_2$ aborts (since queue is transactional)

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## Heterogeneous vs. Homogeneous TPSs

- *Homogeneous systems* are composed of HW and SW modules of a single vendor
  - Modules communicate through proprietary (often unpublished) interfaces
    - Hence, other vendor products cannot be included
  - Referred to as *TP-Lite* systems
- *Heterogeneous systems* are composed of HW and SW modules of different vendors
  - Modules communicate through standard, published interfaces
  - Referred to as *TP-Heavy* systems

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## Heterogeneous Systems

- Evolved from:
  - Need to integrate *legacy* modules produced by different vendors
  - Need to take advantage of products of many vendors
- *Middleware* is the software that integrates the components of a heterogeneous system and provides utility services
  - For example, supports communication (TCP/IP), security (Kerberos), global ACID properties, translation (JDBC)

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## Transaction Manager

- Middleware to support global atomicity of distributed transactions
  - Application invokes manager when transaction is initiated
  - Manager is informed each time a new server joins the transaction
  - Application invokes manager when transaction completes
  - Manager coordinates *atomic commit protocol* among servers to ensure global atomicity

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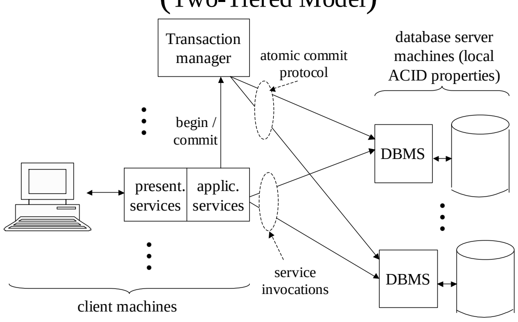
## Transaction Manager

(Two-Tiered Model)

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## TP Monitor

- A *TP Monitor* is a collection of middleware components that is useful in building hetereogeneous transaction processing systems
  - Includes transaction manager
  - Application independent services not usually provided by an operating system
- Layer of software between operating system and application
- Produces the abstraction of a (global) transaction

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# Layered Structure of a Transaction Processing System

Application level — *transactional API*

TP Monitor

Operating System

Physical Computer System

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# TP Monitor Services

- Communication services
  - Built on message passing facility of OS
  - Transactional peer-to-peer and/or remote procedure call
- ACID properties
  - Local isolation for a (non-db) server might be provided by a lock manager
    - Implements locks that an application can explicitly associate with instances of any resource
  - Local atomicity for a (non-db) server might be provided by a log manager
    - Implements a log that can be explicitly used by an application to store data that can be used to roll back changes to a resource
  - Global isolation and atomicity are provided by transaction manager

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# TP Monitor Services

- Routing and load balancing
  - TP monitor can use load balancing to route a request to the least loaded member of a server class
- Threading
  - Threads can be thought of as low cost processes
  - Useful in servers (*e.g.*, application server) that might be maintaining sessions for a large number of clients
  - TP monitor provides threads if OS does not

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# TP Monitor Services

- Recoverable queues
- Security services
  - Encryption, authentication, and authorization
- Miscellaneous servers
  - File server
  - Clock server

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# Communication Services

- Modules of a distributed transaction must communicate
- Message passing facility of underlying OS is
  - inconvenient to use, lacks type checking.
  - does not support transaction abstraction (atomicity)
    - Distributed transactions spread via messages => message passing facility can support mechanism to keep track of subtransactions
- TP monitor builds an enhanced communication facility on top of message passing facility of OS
  - Transactional remote procedure call
  - Transactional peer-to-peer communication
  - Event communication

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# Remote Procedure Call (RPC)

- Procedural interface
  - Convenient to use
  - Provides type checking
  - Naturally supports client/server model
- RPC extends procedural communication to distributed computations
- Deallocation of local variables limits ability to store context (*stateless*)
  - Context can be stored globally (*e.g.*, in database) or …
  - passed between caller and callee (*context handle*)

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## Remote Procedure Call

- **Asymmetric** : caller invokes, callee responds
- **Synchronous**: caller waits for callee
- **Location transparent**: caller cannot tell whether
  - Callee is local or remote
  - Callee has moved from one site to another

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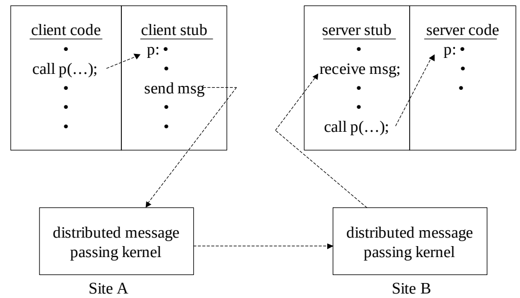
## RPC Implementation: Stubs

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## Stub Functions

- **Client stub**:
  - Locates server - sends globally unique name (character string) provided by application to *directory services*
  - Sets up connection to server
  - *Marshalls* arguments and procedure name
  - Sends invocation message (uses message passing)
- **Server stub**:
  - Unmarshalls arguments
  - Invokes procedure locally
  - Returns results

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## Connection Set-Up: IDL

- Server publishes its interface as a file written in **Interface Definition Language** (IDL). Specifies procedure names, arguments, etc
- IDL compiler produces header file and server-specific stubs
- Header file compiled with application code (type checking possible)
- Client stub linked to application

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## Connection Set-Up: Directory Services

- Interface does not specify the location of server that supports it.
  - Server might move
  - Interface might be supported by server class
- **Directory (Name) Services** provides run-time rendezvous.
  - Server registers its globally unique name, net address, interfaces it supports, protocols it uses, etc.
  - Client stub sends server name or interface identity
  - Directory service responds with address, protocol

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## RPC: Failures

- Component failures (communication lines, computers) are expected
- Service can often be provided despite failures
- **Example**: no response to invocation message
  - Possible reasons: communication slow, message lost, server crashed, server slow
  - Possible actions: resend message, contact different server, abort client, continue to wait
  - **Problem**: different actions appropriate to different failures

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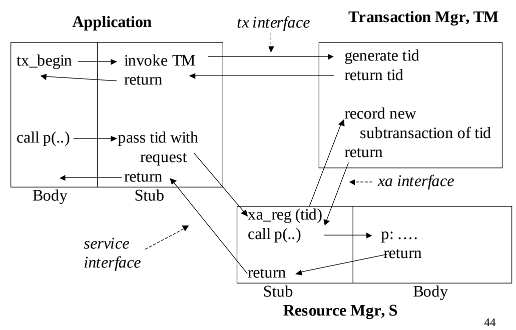
## Transactional RPC and Global Atomicity

- Client executes *tx_begin* to initiate transaction
  - Client stub calls transaction manager (TM)
  - TM returns transaction id (*tid*)
- **Transactional RPC** (TRPC):
  - Client stub appends *tid* to each call to server
  - Server stub informs TM when it is called for first time
    - Server has joined the client's transaction.
- Client commits by executing *tx_commit*
  - Client stub calls TM
  - TM coordinates *atomic commit protocol* among servers to ensure global atomicity

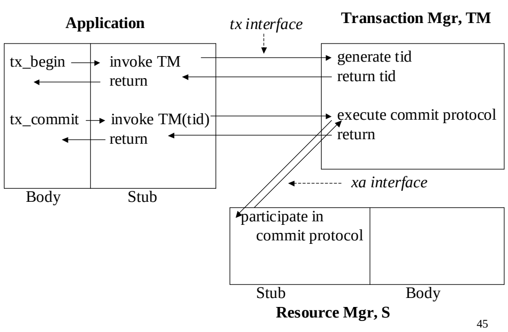


## Transaction Manager and TRPC






## Transaction Manager and Atomic Commit Protocol






## TRPC and Failure

- Stubs must guarantee *exactly once semantics* in handling failures. Either:
  - called procedure executed exactly once and transaction can continue, or
  - called procedure does not execute and transaction aborts
- Suppose called procedure makes a (nested) call to another server and then crashes.
  - *Orphan* is left in system when transaction aborted
  - Orphan elimination algorithm required



## Peer-To-Peer Communication

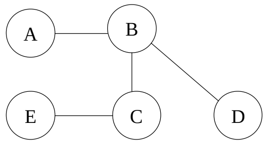
- **Symmetri**c: Once a connection is established communicants are equal (peers) - both can execute send/receive. If requestor is part of a transaction, requestee joins the transaction
- **Asynchronous**: Sender continues executing after send; arbitrary patterns (streams) of messages possible; communication more flexible, complex, and error prone than RPC
- **Not location transparent**



## Peer-To-Peer Communication

- Connection can be *half duplex* (only one peer is in send mode at a time) or *full duplex* (both can send simultaneously)
- Communication is *stateful*: each peer can maintain context over duration of exchange.
  - Each message received can be interpreted with respect to that context

## Peer-To-Peer Communication




- A module can have multiple connections concurrently
  - Each connection associated with transaction that created it
  - A new instance of  called program is created when a connection is established
  - The connections associated with a particular transaction form an acyclic graph
  - All nodes of graph coequal (no root as in RPC)

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## Peer-To-Peer and Commit

- **Problems:**
  - Coequal status: Since there is no root (as in RPC) who initiates the commit?
  - Asynchronous: How can initiator of commit be sure that all nodes have completed their computations? (This is not a problem with RPC.)

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## Solution: Syncpoints in Half Duplex Systems

- One node, *A*, initiates commit. It does this when
  - it completes its computation and
  - all its connections are in send mode.
- *A* declares a *syncpoint* and waits for protocol to complete.
- TP monitor sends syncpoint message to all neighbors, *B*.

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## Syncpoint Protocol (con't)

- When *B* completes its computation and all its connections (other than connection to *A*) are in send mode, *B* declares syncpoint and waits.
- TP monitor sends syncpoint message to all *B*'s neighbors (other than *A*).
- When syncpoint message reaches all nodes, all computation is complete and all have agreed to commit.

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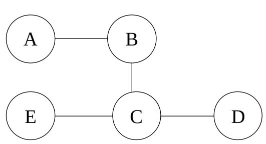
## Syncpoint Error




- **Problem**: Two nodes, all of whose connections are in send mode, initiate commit concurrently
- **Result**: Protocol does not terminate. First node to receive two syncpoint messages cannot declare a syncpoint

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## Handling Exceptional Situations

- With TRPC and peer-to-peer communication, a server services requests and is idle when no request is pending.
- **Problem**: Sometimes a server needs an interrupt mechanism to inform it of exceptional events that require immediate response even if it is busy.

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# Example

- *M1* controls flow of chemicals into furnace
- *M2* monitors temperature
- *M1* must be informed when temperature reaches limit
- **Solution 1**: *M1 polls M2* periodically to check temperature
  - Wasteful if limit rarely reached, very wasteful if *M1* must respond fast (polling must be frequent)
- **Solution 2**: *M2 interrupts M1* when limit reached

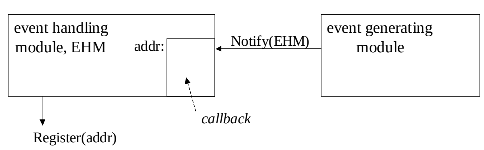


# Event Communication

- Event handling module *registers* address of its event handling routine with TP monitor using event API
  - Handler operates as an interrupt routine
- Event generating module recognizes event and *notifies* event handling module using event API
- TP monitor interrupts event handling module and causes it to execute handling routine



# Event Communication




- If event generating module recognizes event in the context of a transaction, T, execution of handler is part of T
- **Problem**: event generating module must know the identity of event handling module

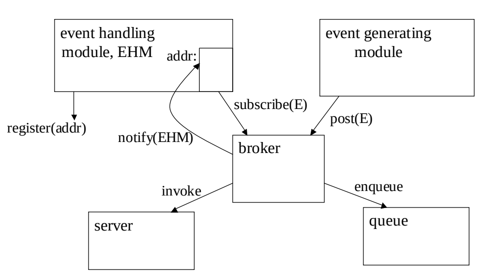


# Event Broker

- **Solution**: Use broker as an intermediary:
  - Events are named (*E*)
  - Event handling module *registers* handler with the TP monitor and *subscribes* to *E* by calling the broker with E as a parameter
  - Event generating module *posts E* to the broker when it occurs.
  - Broker *notifies* event handler
  - If recognition of *E* in generating module is part of a transaction, execution of handler is also



# Event Broker




- Broker can cause alternate actions in addition to notifying handler



# Storage Architecture

- Much of this chapter deals with various architectures for increasing performance
- One performance bottleneck we have not yet discussed is disk I/0
- It is hard to get throughput of thousands of transactions per second when each disk access requires a time measured in thousandths of a second

## Disk Cache

- The DBMS maintains a disk cache in main memory
  - Recently accessed disk pages are kept in the cache and if at some later time a transaction accesses that page, it can access the cached version
  - Many designers try to obtain over 90% hit rate in the cache
  - Many cache sizes are in the tens of gigabytes
  - We discuss caches in detail in Chapter 9

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## RAID Systems

- A RAID (Redundant Array of Independent Disks) consists of a set of disks configured to look like a single disk with increased throughput and reliability
  - Increased throughput is obtained by striping or partitioning each file over a number of disks, thus decreasing the time to access that file
  - Increased reliability is obtained by storing the data redundantly, for example using parity bits

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## RAID Systems (continued)

- We discuss RAID systems in detail in Chapter 9
- Here we point out that a number of RAID levels have been defined, depending on the type of striping and redundancy used
- The levels usually recommended for transaction processing systems are
  - Level 5: Block-level striping of both data and parity
  - Level 10: A striped array of mirrored disks

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## NAS and SAN

- In a NAS (Network Attached Storage) a file server, sometimes called an appliance, is directly connected to the same network as the application server and other servers
  - The files on the appliance can be shared by all the servers

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## NAS and SAN (continued)

- In a SAN (Storage Attached Network) a server connects to its storage devices over a separate high speed network
  - The network operates at about the same speed as the bus on which a disk might connected to the server
  - The server accesses the storage devices using the same commands and at the same speed as if it were connected on a bus

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## NAS and SAN (continued)

- Both NAS and SAN can scale to more storage devices than if those devices were connected directly to the server
- SANs are usually considered preferable for high performance transaction processing systems because the DBMS can access the storage devices directly instead of having to go through a server.

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## Transaction Processing on the Internet

- The growth of the Internet has stimulated the development of many Internet services involving transaction processing
  - Often with throughput requirements of thousands of transactions per second

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## C2B and B2B Services

- C2B (Customer-to-Business) services
  - Usually involve people interacting with the system through their browsers
- B2B (Business-to-Business) services
  - Usually fully automated
  - Programs on one business's Web site communicates with programs on another business's Web site

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## Front-End and Back-End Services

- Front-end services refers to the interface a service offers to customers and businesses
  - How it is described to users
  - How it is invoked
- Back-end services refers to how that service is actually implemented

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## Front-End and Back-End Services (continued)

- Next we discuss architectures for C2B systems in which the front-end services are provided by a browser and the back-end services can be implemented as discussed earlier in the chapter
- Then we discuss how back-end services can be implemented by commercial Web application servers
- These same back-end implementations can be used for B2B services using a different front-end
  - We discuss B2B front-end services in Chapter 28

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## C2B Transaction Processing on the Internet

- Common information interchange method
  - Browser requests information from server
  - Server sends to browser HTML page and possibly one or more Java programs called applets
  - User interacts with page and Java programs and sends information back to server
  - Java servlet on server reads information from user, processes it, perhaps accesses a database, and sends new page back to browser

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## C2B Transaction Processing on the Internet (continued)

- Servlets have a lifetime that extends beyond one user
  - When it is started, it creates a number of threads
  - These threads are assigned dynamically to each request
- Servlets provide API for maintaining context
  - Context information is stored in file on Web server that is accessed through a *session number*
    - *Cookies*: servlet places session number in a cookie file in browser; subsequent servlets can access cookie
    - *Hidden fields in HTML*: servlet places session number in hidden field in HTML document it sends to browser; hidden field is not displayed but is returned with HTML document
    - *Appended field to HTTP return address*: session number is appended to HTTP return address and can be accessed by next servlet

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## Architectures for Transaction Processing on the Internet

- Browser plays the role of presentation server and application server
  - Java applet on browser implements the transaction and accesses database using JDBC
- Browser plays the role of presentation server, and servlet program on server plays the role of application server
  - Servlet program implements the transaction and accesses database using JDBC

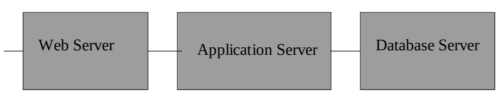


## Architectures for Transaction Processing on the Internet

- Many high throughput applications require a three- or four-tiered architecture
  - After getting inputs from browser, the servlet program initiates the transaction on the application server, which is not connected to the Internet
    - Application server might be separated from the Web server by a firewall
  - From the TP system's viewpoint, the browser and servlet program together are acting as the presentation server



## Architecture of a Web Transaction Processing System




| | | |
|---|---|---|
| Interacts with client | Executes the application | Hosts the database |
| Java servlet receives messages and calls program on application server | The application might be a transaction program that implements the business rules of the Web service | |



## Web Server

- HTTP Interface to Web
  - Java **servlet** on Web server interacts with *client*'s browser using HTTP messages and then initiates programs on the application server



## Web Application Server

- A Web application server is a set of tools and modules for building and executing transaction processing systems for the Web
  - Including the application server tier of the system
- Name is confusing because *application server* is the name usually given to the middle tier in an transaction processing system



## Web Application Servers (continued)

- Most Web application servers support the J2EE (Java 2 Enterprise Edition) standards
  - Or Microsoft .NET
- We discuss J2EE
  - J2EE One language, many platforms
    - A standard implemented by many vendors
  - .NET One platform, many languages
    - A set of products of Microsoft

## J2EE

- J2EE defines a set of services and classes particularly oriented toward transaction-oriented Web services
  - – Java servlets
  - – Enterprise Java beans

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## Enterprise Java Beans

- Java classes that implement the business methods of an enterprise
- Execute within an infrastructure of services provided by the Web application server
  - – Supports transactions, persistence, concurrency, authorization, etc.
  - – Implements declarative transaction semantics
    - The bean programmer can just declare that a particular method is to be a transaction and does not have to specify the *begin* and *commit* commands
  - – Bean programmer can focus on business methods of the enterprise rather on details of system implementation

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## Entity Beans

- An **entity bean** represents a persistent business object whose state is stored in the database
  - – Each entity bean corresponds to a database table
  - – Each instance of that bean corresponds to a row in that table.

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## Example of an Entity Bean

- – An entity bean called Account, which corresponds to a database table Account
  - Each instance of that bean corresponds to a row in that table
- – Account has fields that include AccountId and Balance
  - AccountId is the primary key
  - Every entity bean has a *FindByPrimaryKey* method that can be used to find the bean based on its primary key
- – Account has other methods that might include *Deposit* and *Withdraw*

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## Persistence of Entity Beans

- Any changes to the bean are *persistent* in that those changes are propagated to the corresponding database items
- This persistence can be managed either manually by the bean itself using standard JDBC statements or automatically by the system (as described later)
- The system can also automatically manage the authorization and transactional properties of the bean (as described later)

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## Session Bean

- A **session bean** represents a client performing interactions within a session using the business methods of the enterprise
  - – A session is a sequence of interactions by a user to accomplish some objective. For example, a session might include selecting items from a catalog and then purchasing them.
- The session bean retains its state during all the interactions of the session
  - – Stateless session beans also exist

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## Example of a Session Bean

- ShoppingCart provides the services of adding items to a “shopping cart” and then purchasing the selected items
  - Methods include *AddItemToShoppingCart* and *Checkout*
  - ShoppingCart maintains state during all the interactions of a session
    - It remembers what items are in the shopping cart

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## Session Beans and Entity Beans

- Session beans can call methods in entity beans
  - The *Checkout* method of the ShoppingCart session bean calls appropriate methods in the Customer, Order, and Shipping entity beans to record the order in the database

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## Session Bean Transactions

- Session beans can be transactional
  - The transaction can be managed manually by the bean itself using standard JDBC or JTA (Java Transaction API) calls or automatically by the system (as described below)

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## Message-Driven Beans

- All of the communication so far is *synchronous*
  - A session bean calls an entity bean and waits for a reply
- Sometimes the sender of a message does not need to wait for a reply
  - Communication can be *asynchronous*
    - Thus increasing throughput
  - Message-driven beans are provided for this purpose
- A **message-driven bean** is like a session bean in that it implements the business methods of the enterprise
  - It is called when an asynchronous JMS message is placed on the message queue to which it is associated
  - Its *onMessage* method is called by the system to process the message

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## Example of a Message-Driven Bean

- When shopping cart C*heckout* method completes, it sends an asynchronous message to the shipping department to ship the purchased goods
- The shipping department maintains a message queue, *ShippingMessageQ,* and a message driven bean, ShippingMessageQListener, associated with that queue
- When a message is placed on the queue, the system selects an instance of the bean to process it and calls that bean’s *onMessage* method

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## Structure of an Enterprise Bean

- The bean class
  - Contains the implementations of the business methods of the enterprise
- A remote interface (also optionally a local interface)
  - Used by clients to access the bean class remotely, using RMI (or locally with the local interface)
    - Acts as a proxy for the bean class
  - Includes declarations of all the business methods
- A home interface (also optionally a local home interface)
  - Contains methods that control bean’s life cycle
    - Create, remove
  - Also finder methods(e.g. *FindByPrimaryKey*) methods

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## Structure of an Enterprise Bean (continued)

- A deployment descriptor
  - Declarative metadata for the bean
  - Describes persistence, transactional, and authorization properties



## Example of Deployment Descriptor

- The deployment descriptor for a banking application might say that
  - The *Withdraw* method of an Account entity bean
    - Is to be executed as a transaction
    - Can be executed either by the account owner or by a teller
  - The *Balance* field of the Account Bean
    - Has its persistence managed by the system
      - Any changes are automatically propagated to the DB
- Deployment descriptors are written in XML



## Portion of a Deployment Descriptor Describing Authorization

```
<method-permission>
   <role-name> teller </role-name>
   <method>
       <ejb-name> Account </ejb-name>
       <method-name> Withdraw </method-name>
   </method>
</method-permission>
```



## EJB Container

- Enterprise beans together with their deployment descriptors are encapsulated within an **EJB container** supplied by the Web application server
- The EJB container provides system-level support for the beans based on information in their deployment descriptors



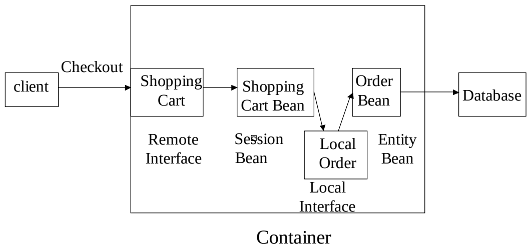
## EJB Container (continued)

- The EJB container provides this support by intervening before and after each bean method is called and performing whatever actions are necessary
  - When a method is called, the call goes to the similarly named interface method
  - The interface method performs whatever actions are necessary before and after calling the bean method



## EJB Container (continued)

- For example, if the deployment descriptor says the method is to run as a transaction
  - The interface method starts the transaction before calling the method
  - Commits the transaction when the method completes
- The EJB container supplies the code for the interface methods.




Remote and Local Interfaces Within a Container



# Persistence of Entity Beans

- Persistence of entity beans can be managed
  - Manually by the bean itself (bean-managed persistence) using standard JDBC statements
  - Automatically by the container (container-managed persistence, cmp)



# Example of Deployment Descriptor for Container Managed Persistence

<persistence-type> container </persistence-type>
<cmp-field>
<field-name> balance </field-name>
</cmp-field>



# Get and Set Methods

- The entity bean must contain declarations for *get* and *set* methods. For example

  *public abstract float getBalance( )*
  *public abstract void setBalance (float balance)*
- The container generates code for these methods
- A client of the bean, for example a session bean, can use
  - a finder method, for example, *FindByPrimaryKey(),* to find an entity bean and then
  - a *get* or *set* method to read or update specific fields of that bean.



# EJB QL Language

- The container will generate the code for the *FindByPrimaryKey()* method
- The container will also generate code for other finder methods described in the deployment descriptor
  - These methods are described in the deployment descriptor using the **EJB QL (EJB Query Language**)
  - EJB QL is used to find one or more entity beans based on criteria other than their primary key



# Example of EJB QL

```
<query>
  <query-method>
    <method-name>FindByName </method-name>
    <method-params>
      <method-param>string</method-param>
    </method-params>
  </query-method>
  <ejb-ql>
     SELECT OBJECT (A) FROM Account A WHERE A.Name = ?1
  </ejb-ql>
</query>
```

## Create and Remove Methods

- A client of an entity bean can use the create and remove methods in its home interface to create and remove instances of that entity (rows in the database table).

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## Container-Managed Relationships

- In addition to fields that represent data, entity beans can have fields that represent relationships
  - One-to-one, One-to-many, Many-to-many
  - As with other database applications, these relationships can be used to find entity beans based on their relationships to other beans.
- Example: there might be a many-to-many relationship, *Signers*, relating Account bean and BankCustomer bean
  - *Signers* specifies which customers can sign checks on which accounts

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## Container-Managed Relationships (continued)

- Relationships can be declared in the deployment descriptor to be container-managed
  - For a many-to-many relationship such as *Signers,* the container will automatically create a new table to manage the relationship
  - For a one-to-one relationship, the container will automatically generate a foreign key

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## Portion of Deployment Descriptor

```
<ejb-relation>
    <ejb-relation-name>Signers</ejb-relation-name>
     <ejb-relationship-role>
          <ejb-relationship-role-name>account-has-signers
                                                     </ejb-relationship-role-name>
           <multiplicity>many</multiplicity>
           <relationship-role-source>
                 <ejb-name>Account</ejb-name>
           </relationship-role-source>
           <cmr-field>
                  <cmr-field-name>Signers</cmr-field-name>
                   <cmr-field-type>java.util.collection</cmr-field-type>
            </cmr-field>
</ejb-relationship-role>
   ………… description of the other bean in the relation
</ejb-relation>
```

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## Get and Set Methods

- The entity bean must contain declarations for *get* and *set* methods for these relationship fields (as for other fields)
- For example

*public abstract collection getSigners( )*

*public abstract void setSigners (collection BankCustomers)*

- The EJB container will generate code for these methods

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## Transactions

- Transactions can be managed
  - Manually by the bean itself (bean-managed transactions) using standard JDBC or JTA calls
    - Bean programmer must provide statements to start and commit transactions
  - Automatically by the container (container-managed transactions)
    - Deployment descriptor contains declarative description of transaction attributes of each method

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## Transactions (continued)

- In container-managed transactions, the deployment descriptor must specify the transaction attributes of each method
- Attributes supported are
  - *Required*
  - *RequiresNew*
  - *Mandatory*
  - *NotSupported*
  - *Supports*
  - *Never*
- The semantics of these attributes are discussed in Chapter 22

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## Restrictions on Attributes

- For message-driven beans, only the *Required* and *NotSupported* attributes are allowed
  - If the bean has the *Required* attribute and aborts, the message is put back on the queue and the transaction will be called again
- For stateless session beans only *Requires, RequiresNew, Supports, Never*, and *NotSupported* are allowed
- For entity beans with container-managed persistence, only *Requires, RequiresNew*, and *Mandatory* are allowed.

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## Example of Deployment Descriptor

<container-transaction>
<method>
<ejb-name> ShoppingCart </ejbname>
<method-name> *Checkout* </method-name>
</method>
<trans-attribute> *Required* </trans-attribute>
</container-transaction>

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## Two-Phase Commit

- The container also contains a transaction manager, which will manage a two-phase commit procedure, for both container-managed and bean-managed transactions.

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## Concurrency of Entity Beans

- A number of concurrently executing clients might request access to the same entity bean and hence the same row of a database table
- If that bean has been declared transactional, the concurrency is controlled by the container
  - If not, each client gets its own copy of the entity bean and the concurrency is controlled by the DBMS
    - For session beans and message-driven beans with bean-managed concurrency the bean programmer can specify the isolation level within the code for the bean
- The default J2EE implementation of container-managed concurrency is that each client gets its own copy of the entity bean and the underlying DBMS manages the concurrency

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## Another Implementation of Container-Managed Concurrency

- Some vendors of Web application servers offer other alternatives, such as optimistic concurrency control
  - DBMS executes at READ COMMITTED
  - All writes are kept in the entity bean until the transaction requests to commit
    - The intentions list
  - The validation check verifies that no entity the transaction read has been updated *since the read took place*.
    - Not the same validation check performed by the optimistic control discussed earlier
      - In that control, the validation check verifies that no entity the transaction read has been updated *anywhere in its read phase*
    - Both implementation provide serializability

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## Reusability of Enterprise Beans

- Part of the vision underlying enterprise beans is that they would be reusable components
  - Sam’s Software Company sells a set of beans for shopping cart applications, including a ShoppingCartBean session bean
  - Joe’s Hardware Store buys the beans
    - Instead of using the standard ShoppingCartBean, Joe’s system uses a child of that bean, JoesShoppingCartBean that had been changed slightly to reflect Joe’s business rules
    - Joe also changes the deployment descriptor a bit

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## Reusability of Enterprise Beans continued

- The implementation of Joe’s system is considerably simplified
- Joe’s programmers need be concerned mainly with Joe’s business rules not with implementation details
- Joe’s shopping cart application will run on any system using any Web application server that supports J2EE
  - Provided it does not use any proprietary extensions to J2EE

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