ICS 321 Data Storage & Retrieval

# SQL in a Server Environment (i)

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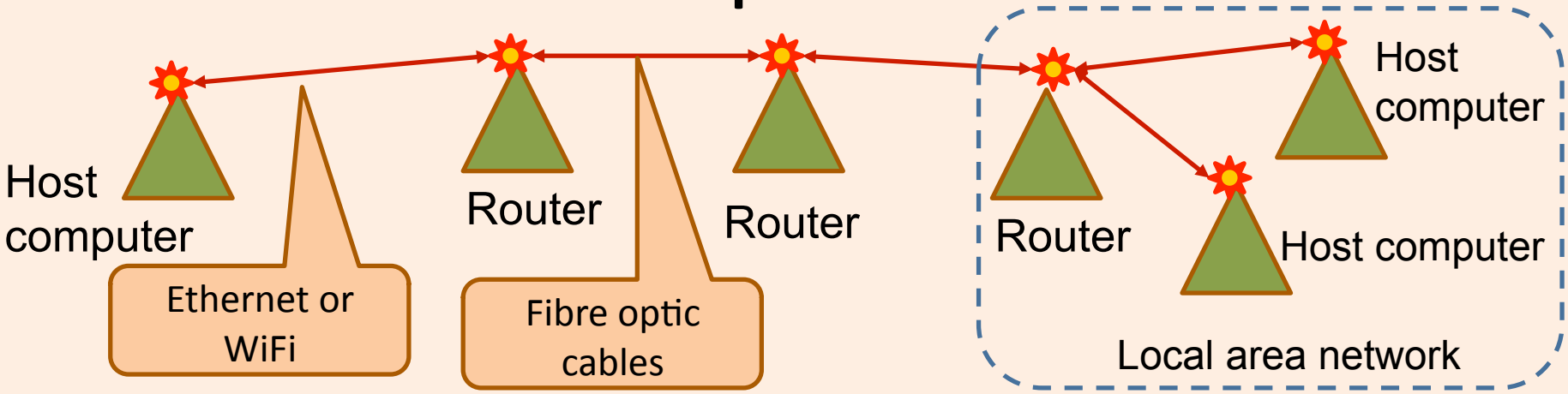
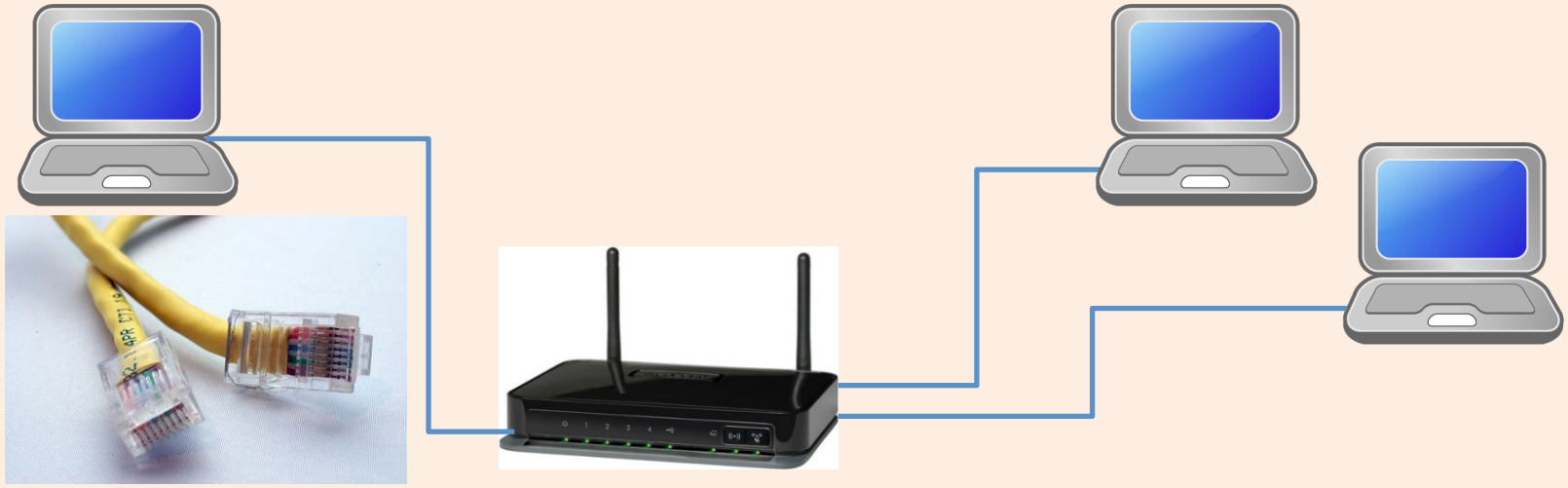
# Networking Primer

# Modern Computer Networks



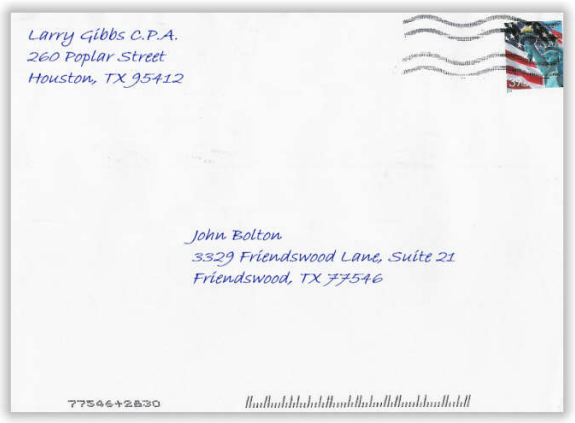

- Signaling technology can transmit complex sequences of bits - packets
- Each host or router obeys a set of rules for how to handle incoming/outgoing messages – communication protocols
- Communications can be multi-way
- Bandwidth: the number of bits that can be transferred per second (bps)
- Latency: the time it takes for a message to reach the destination after leaving the source

# Local Area Networks

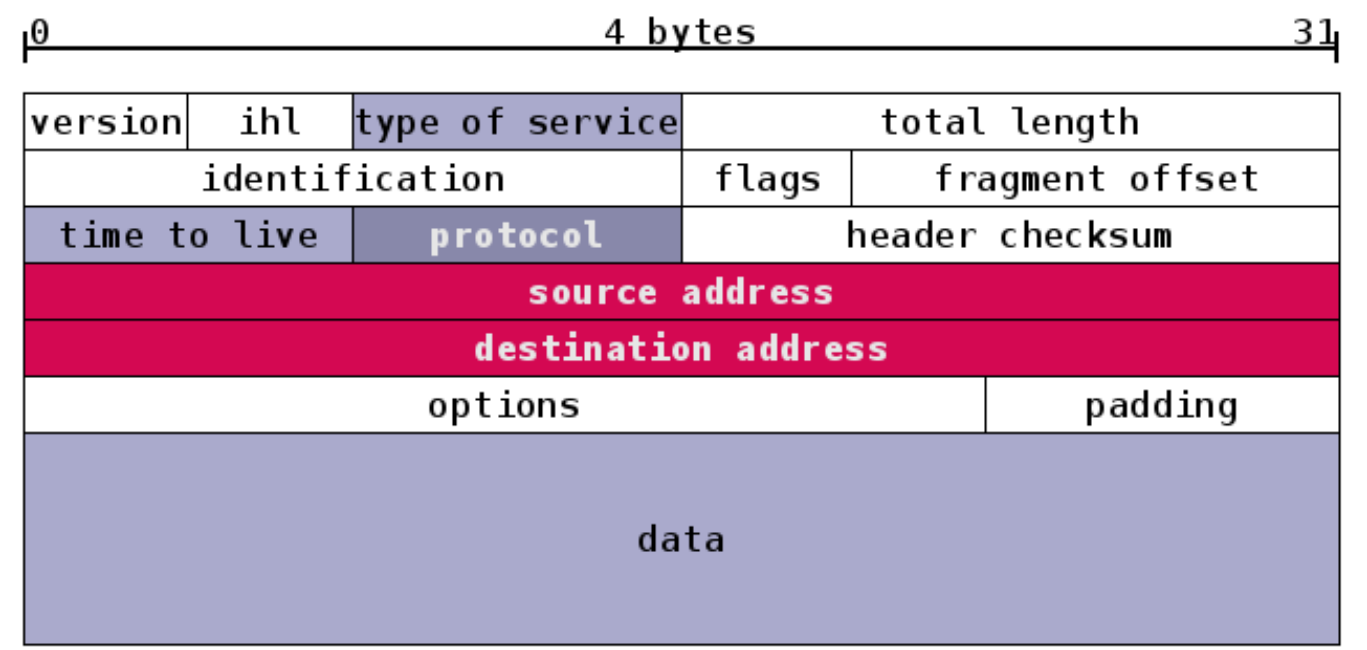


- Wired (UTP Cat5) or Wireless 802.11
- Connects hosts within a limited spatial region together to form a network
- All hosts within the network can “talk” to each other
- The network is often a shared medium: only one host can talk at one time and the rest listens.

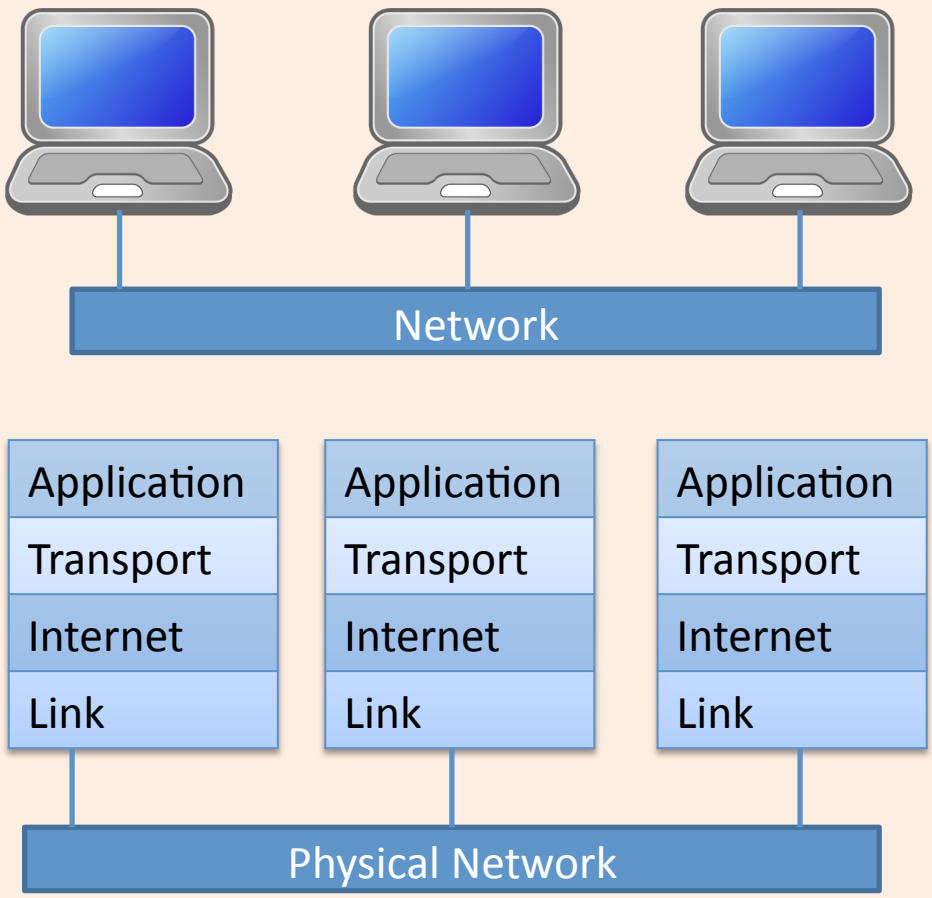
# Data Packet




- How messages are packaged for delivery on the network – like postal mail.
- Source and destination addresses

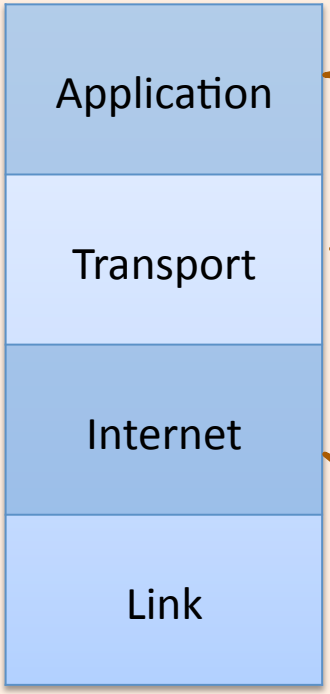


# Network Abstractions




- Network communications are conceived as layers of abstractions.
- Each layer plays a specific role and is relatively independent of other layers
- Each layer has its own packet format
- Packets from higher layers are embedded in packets of lower layers – "encapsulation"

# TCP/IP Four Layer Model



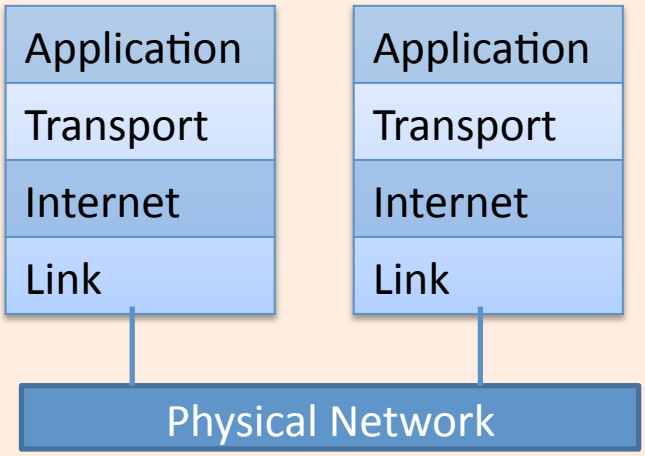

- Process to process: communicates data to other processes/applications on the same host or on other hosts
- Eg. SMTP, FTP, SSH, HTTP

- Host to host: communicates data to other host on the same network on on other networks
- Hides the topology of the network
- Flow control, error correction, connection control
- Eg. TCP, UDP

- Inter-network: communicates data to other networks
- Deals with addressing and routing of datagrams to next network
- Eg. IPv4, IPv6

- Transmit data to other network interfaces on the local network
- Eg. Ethernet, WiFi 802.11

# Link Layer



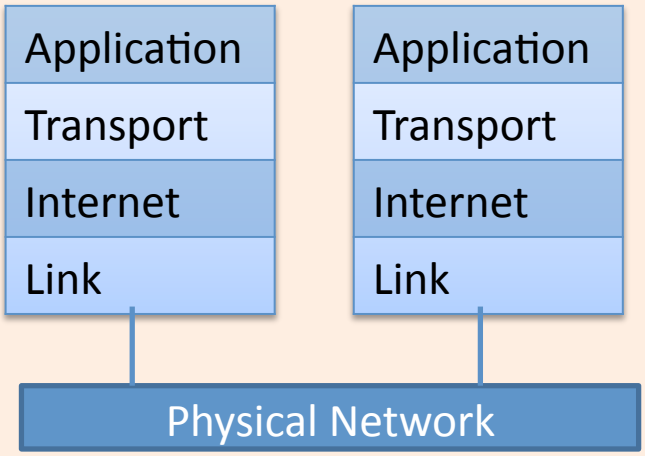

- Eg. Ethernet, WiFi 802.11
- A host can have multiple network interface cards (eg. Laptops typically have an ethernet interface and a WiFi interface)
- Each interface has a 48-bit physical address that is hardwired to the hardware

Data packet arrives from upper layer (Internet layer)

- If packet is too big, break packet into smaller fragments (`frames')
- Embed data packet in a link layer packet with link layer header, sequence number, error correction code etc.
- Link layer packets gets transmitted on physical link
- Link layer protocol governs how transmission over physical link is done. Eg. Carrier sense multiple access

Bottom-up process is similar on the receiving host

# Internet Layer




- Eg. IPv4
- Connects multiple networks together.
- Each network interface of a host is associated with an 32-bit IPv4 address
- IP address is not hardwired, but assigned in the software

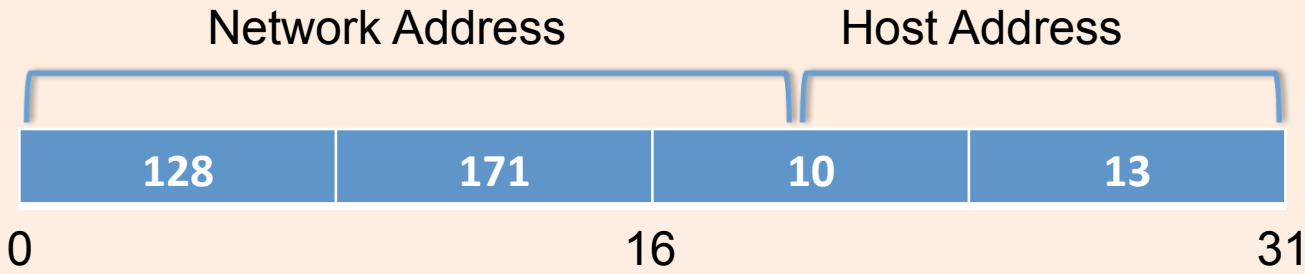
Data packet arrives from Transport layer

- Embed data packet in an IPv4 packet with IP header etc.
- Pass packet to Link layer

Data packet arrives from Link layer

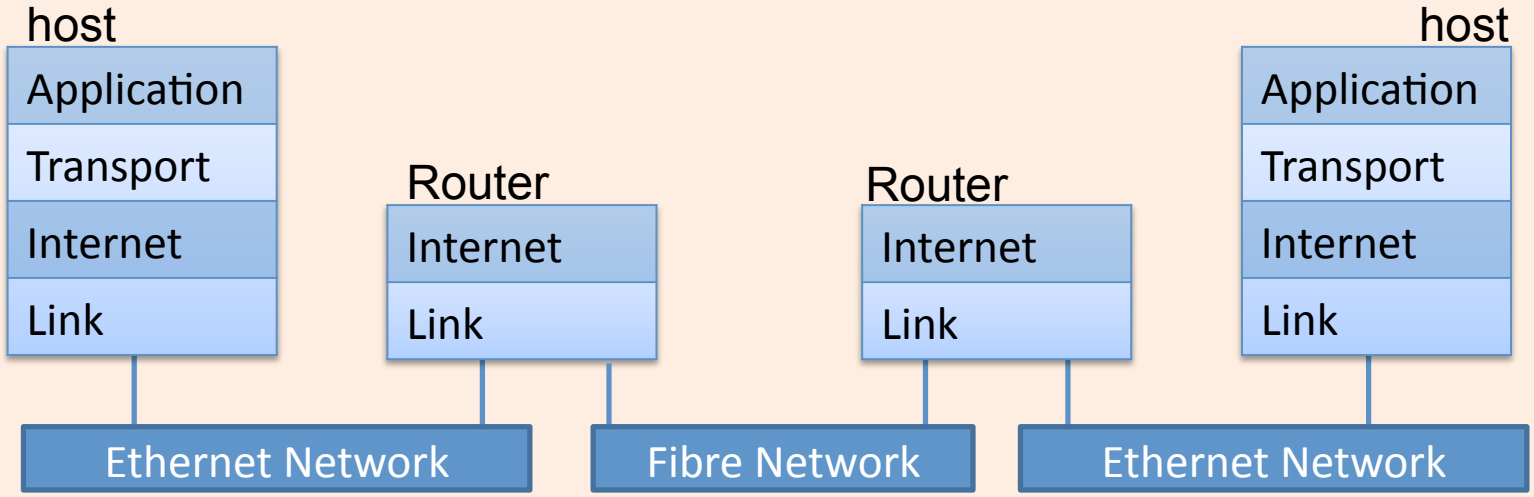
- Check IP header if packet destination is for this host. If yes, strip header and pass to Transport layer
- Otherwise forward packet (routing)

# IPv4 Addresses & Domain Name Service




- IP addresses are 32 bit numbers often written in 4 octets: 128.171.10.13
- Each address is also split into two parts
  - Prefix is the network address
  - Suffix is the host address within that network
- Domain Name Servers provide a service that translates more meaningful names to IP addresses
  - Uhunix.hawaii.edu = 128.171.24.197
  - www2.hawaii.edu = 128.171.224.150

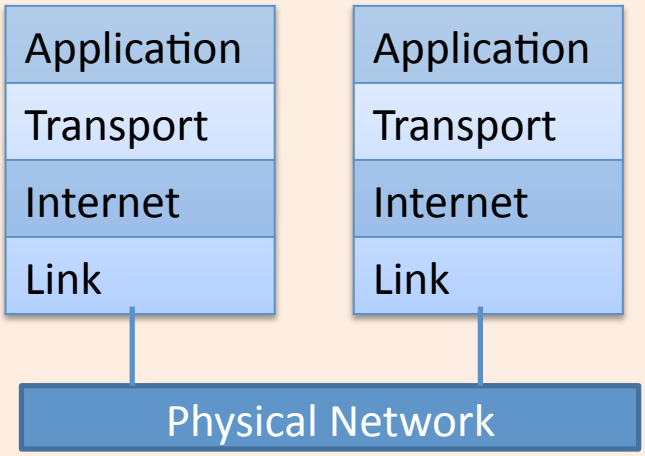
# IPv4 & Inter-network Routing




For routers

- Examine destination IP address
- Look up routing tables to determine outgoing network
- Pass packet to link layer of that outgoing network
- Best effort delivery – no guarantees!

# Transport Layer

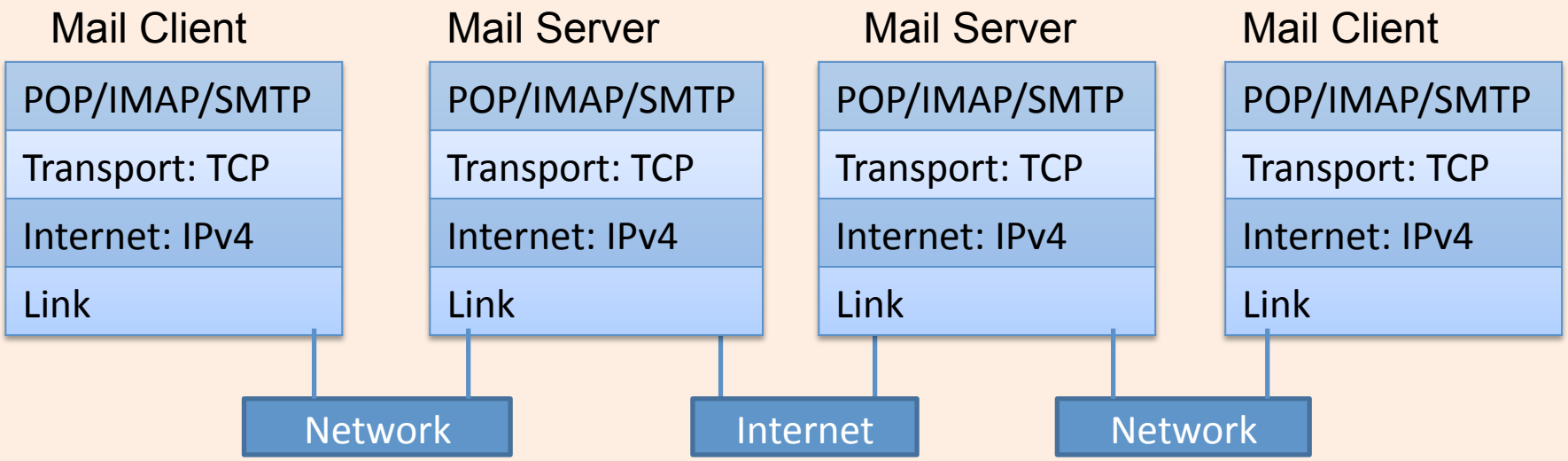



- Eg. TCP (connection-oriented), UDP
- End-to-end message transfer between hosts applications
- Each application on a host is associated with a port number
- IP address + port number will identify an application end-point

TCP provides a reliable communication channel between two host applications by addressing several issues

- Data packets arriving out of order
- Data packets are corrupted
- Same packets arriving more than once
- Some packets are lost/discarded
- Traffic congestion control

# Applications: Email



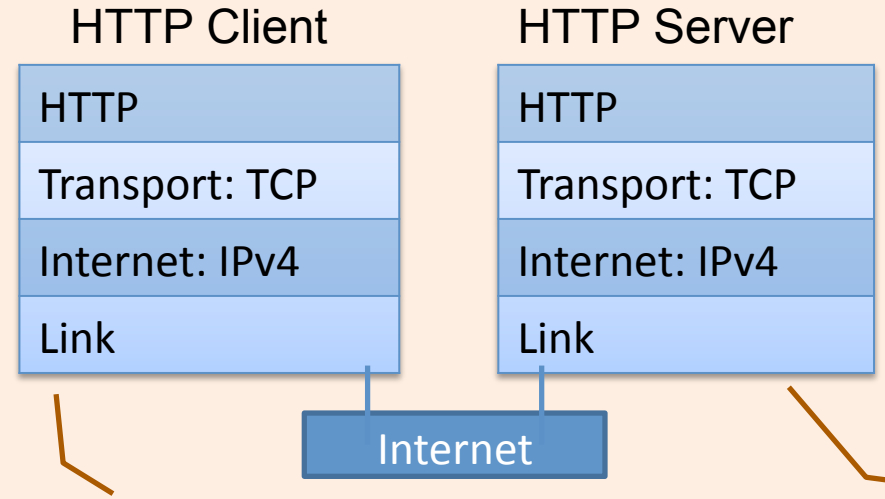

- Your email client program downloads incoming emails from mail server (imap.gmail.com pop.gmail.com)
- Outgoing emails are sent to mail server (smtp.gmail.com)
- Mail servers handle the routing of emails using SMTP protocol which operates on port 25 or 587
  - Lookup IP address of destination hostname in the email address using DNS
  - Relaying email as packets to that IP address

# Sample Email Header

Delivered-To: strev@guhrelay.hawaii.edu
Received: by 10.58.145.6 with SMTP id sq6csp687725veb; Mon, 3 Sep 2012
20:39:01 -0700 (PDT)
Received: by 10.68.129.38 with SMTP id nt6mr43102232pbb.76.1346729940698; Mon,
03 Sep 2012 20:39:00 -0700 (PDT)
Return-Path: <postmaster@laulima.hawaii.edu>
Received: from mta11.its.hawaii.edu (mta11.its.hawaii.edu.[128.171.224.147])
by mx.google.com with ESMTPS id px6si25354378pbc.214.2012.09.03.20.38.53
(version=TLSv1/SSLv3 cipher=RC4-MD5); Mon, 03 Sep 2012 20:39:00 -0700 (PDT)
Received-SPF: pass (google.com: domain of postmaster@laulima.hawaii.edu
designates 128.171.224.58 as permitted sender) client-ip=128.171.224.58;
Authentication-Results: mx.google.com; spf=pass (google.com: domain of
postmaster@laulima.hawaii.edu designates 128.171.224.58 as permitted sender)
smtp.mail=postmaster@laulima.hawaii.edu
MIME-version: 1.0
Content-type: multipart/mixed; boundary="Boundary_(ID_3RY8N2VbJHb4tH5siR1eww)"

Received: from pmx11.its.hawaii.edu (pmx11.its.hawaii.edu [128.171.224.58]) by
mta11.its.hawaii.edu (Sun Java(tm) System Messaging Server 6.3-11.01 (built
Feb 12 2010; 32bit)) with ESMTP id <0M9T0071I3GJ4F40@mta11.its.hawaii.edu>;
Mon, 03 Sep 2012 17:38:45 -1000 (HST)
Received: from kuhi.its.hawaii.edu (kuhi.its.hawaii.edu [128.171.25.223]) by
pmx11.its.hawaii.edu (Postfix) with ESMTP id E587118C023; Mon, 03 Sep 2012
17:38:42 -1000 (HST)
Received: from sak24.its.hawaii.edu (sak24.its.hawaii.edu [128.171.225.199])
by kuhi.its.hawaii.edu (8.12.10/8.12.6) with ESMTP id q843ccvH023430; Mon, 03
Sep 2012 17:38:38 -1000 (HST)
Date: Mon, 03 Sep 2012 17:38:33 -1000 (HST)
From: Dennis Streveler <strev@hawaii.edu>
Cc: "strev@hawaii.edu" <strev@hawaii.edu>
Message-id: <112987554.2310.1346729913602.JavaMail.sakai@sak24.its.hawaii.edu>
Subject: ICS 101 Help: Tuesday lecture -- Everything you THOUGHT you knew
about NETWORKS and then some
X-Mailer: sakai-mailsender

# Applications: HTTP



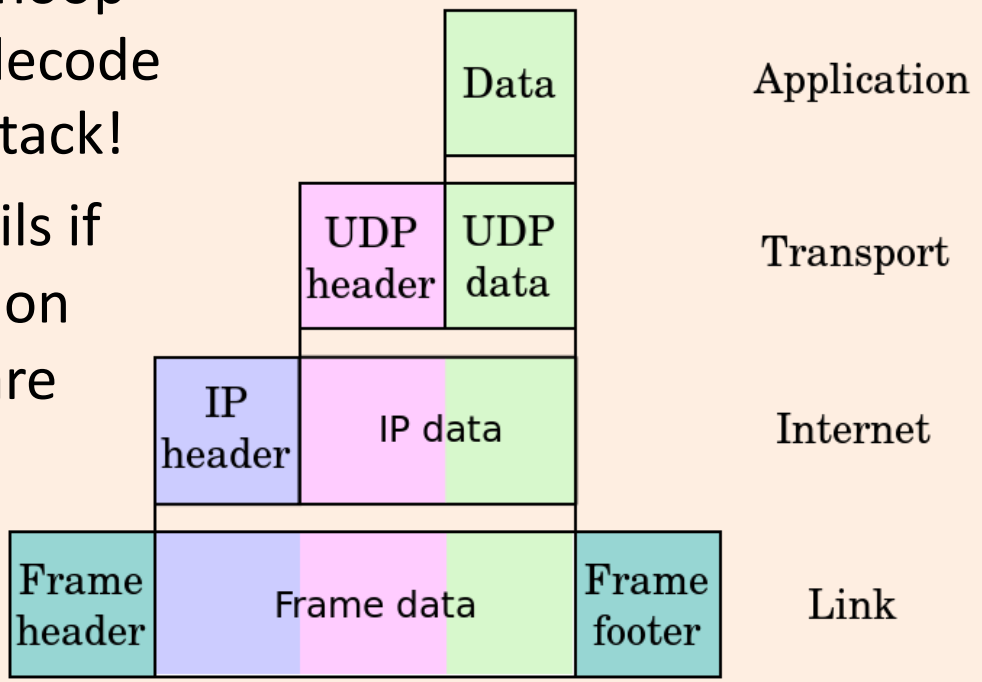

- Hyper-Text Transfer Protocol (port 80)
- Request-response protocol
- When http://www2.hawaii.edu/~lipyeow/index.html is entered into a web browser (http client)

```
GET /~lipyeow/index.html HTTP/1.1
host: www2.hawaii.edu
```

```
HTTP/1.1 200 OK
Date: Sun, 02 Sep 2012 00:35:40 GMT
Server: Apache
Last-Modified: Tue, 21 Aug 2012 01:27:18 GMT
ETag: "7d3e8-2950-4c7bc86e86980"
Accept-Ranges: bytes
Content-Length: 10576
Content-Type: text/html
<!DOCTYPE HTML PUBLIC "-//W3C//DTD HTML 4.0 Transitional//EN"> <HTML> ...
```

# Internet Security

- All data transmitted on the network using the protocols described thus far are in plaintext
- Anyone with access to the physical network link can snoop on the bit sequences and decode according to the protocol stack!
- Anyone can read your emails if he/she has access to a link on which your email packets are transmitted
- Use encrypted connections eg. SSL/TLS



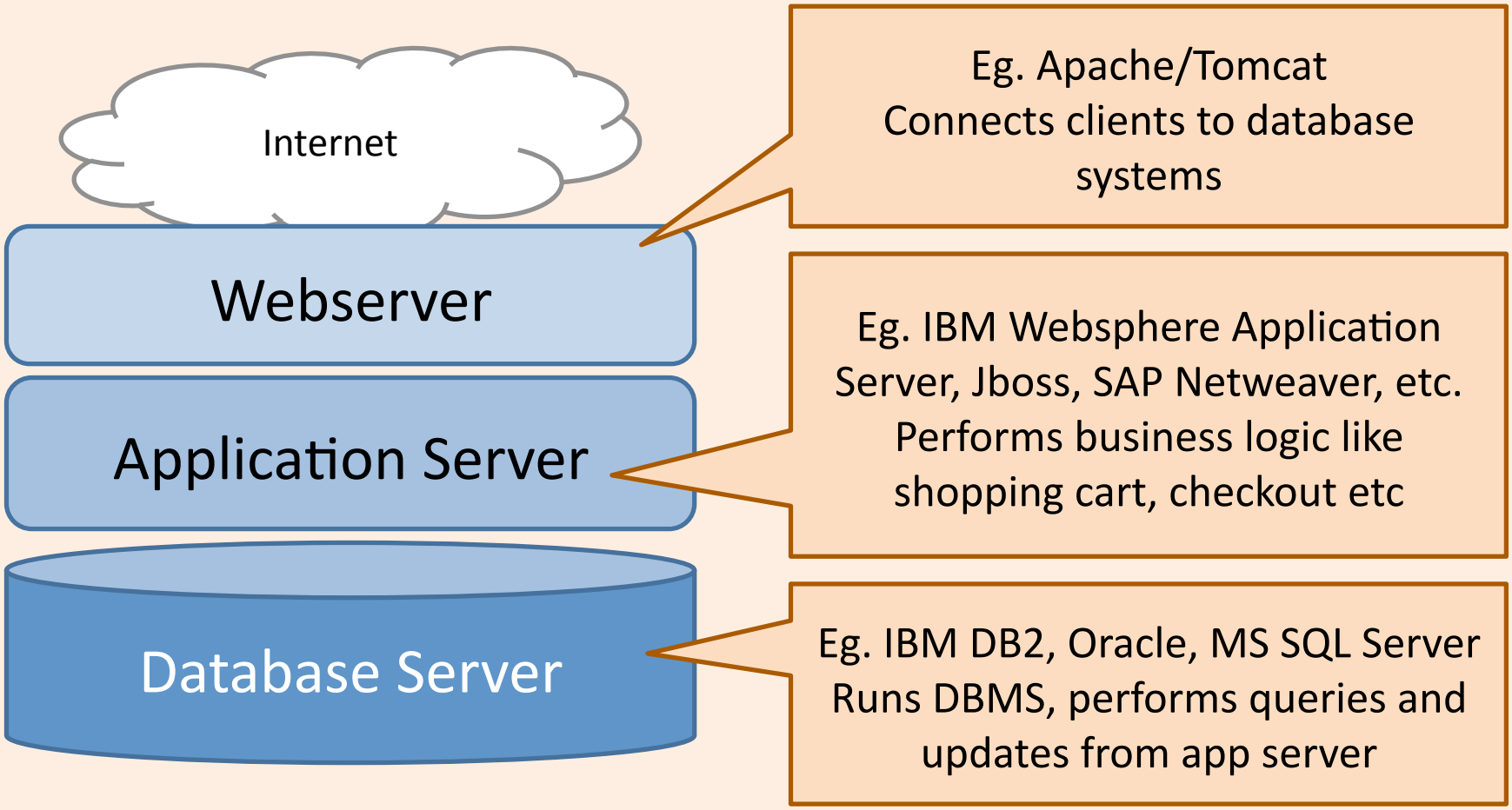
ICS 321 Data Storage & Retrieval

# SQL in a Server Environment

# How do database-backed applications work ?

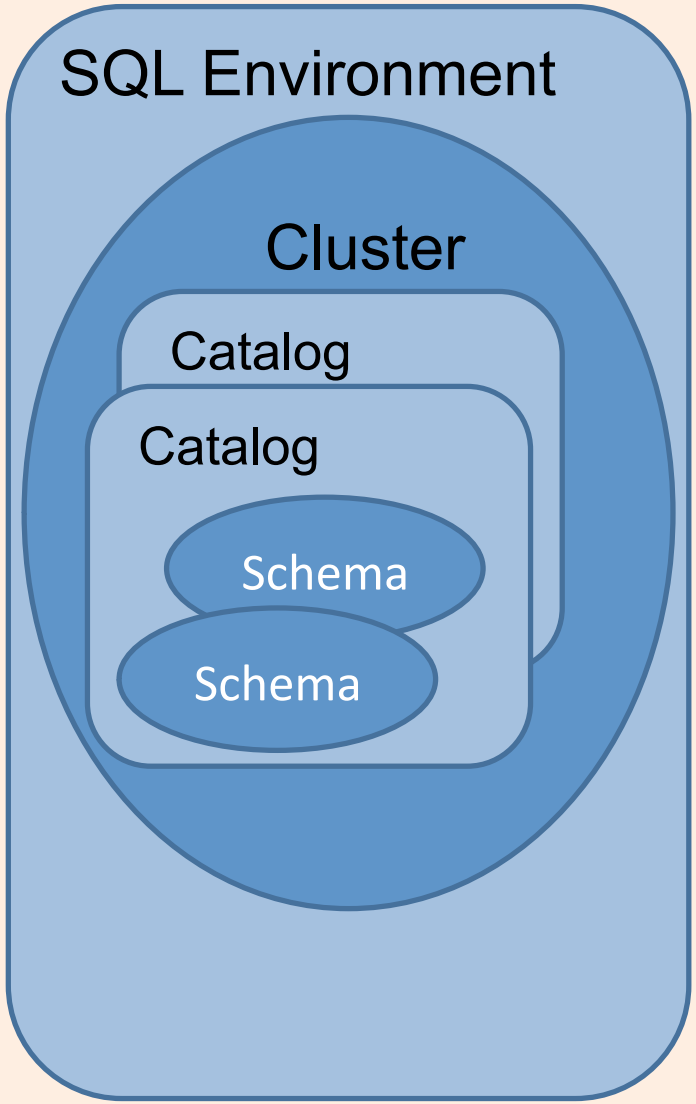
- Programming perspective – How do I program such applications?
  - SQL environment
  - Programming language environment (eg. Java)
  - Web-based applications ?
- Systems perspective – How do I setup the system(s)?
  - Is application program on the same machine as DBMS?
  - How does application program "talk" to the DBMS server ?

# Three Tier Architecture



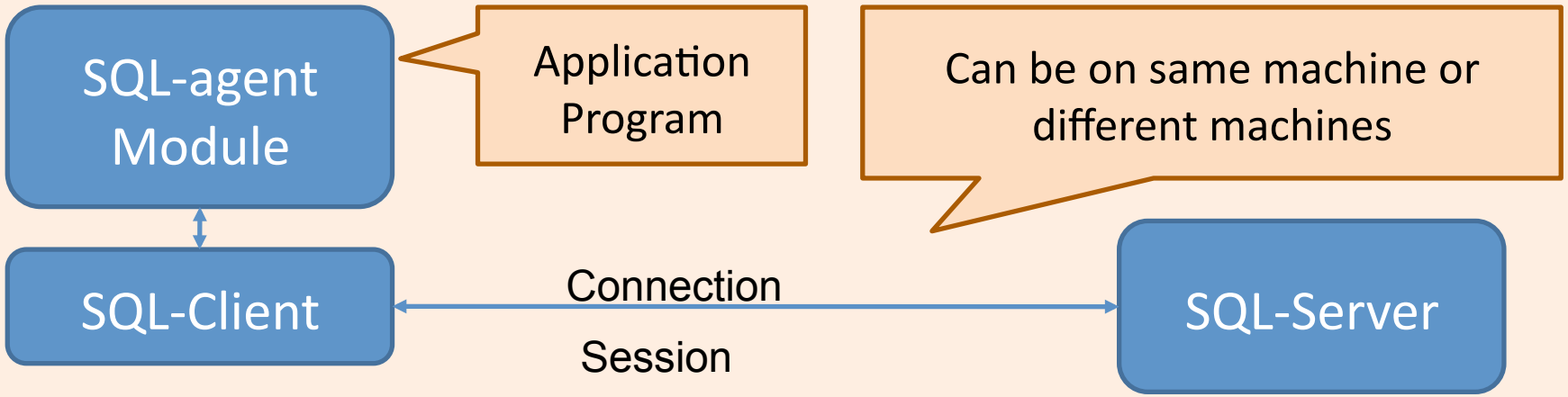

- Commonly used in large internet enterprises

# SQL Environment




- Schemas : tables, views, assertions, triggers
  - CREATE SCHEMA <schema name>
  - Your login id is your default schema
  - SET SCHEMA <schema>
  - A fully qualified table name is <schema>.<table>
- Catalogs : collection of schemas
  - Corresponds to “databases” in DB2
- Clusters : collection of catalogs
  - Corresponds to “database instance” in DB2

# Client-Server Model




- CONNECT TO <server> AS <connection name> AUTHORIZATION
- DISCONNECT/CONNECT RESET/TERMINATE
- Session – SQL operations performed while a connection is active

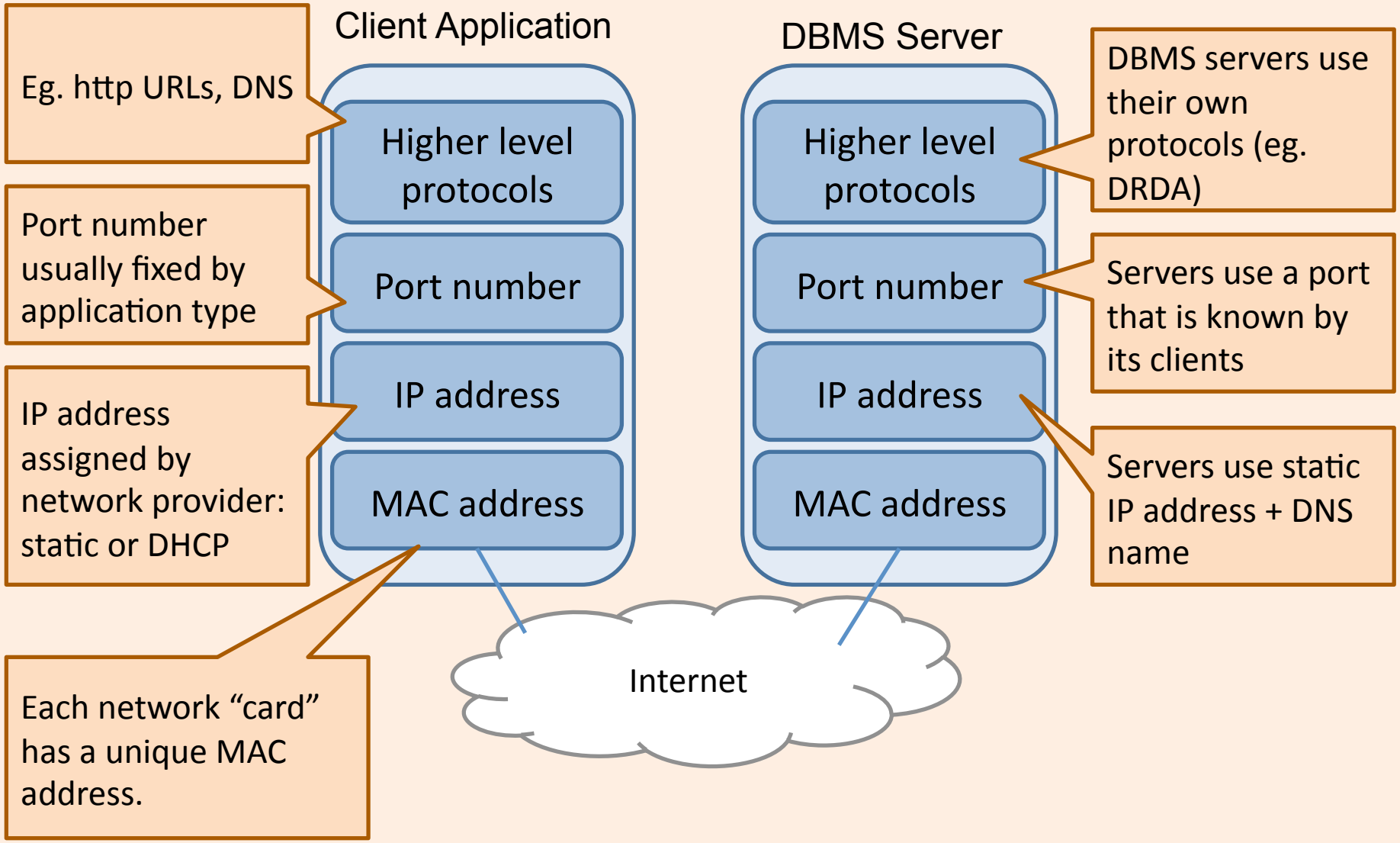
- Programming API
  - Generic SQL Interface
  - Embedded SQL in a host language
  - True Modules. Eg. Stored procedures.

# SQL & Other Programming Languages

Two extremes of the integration spectrum:

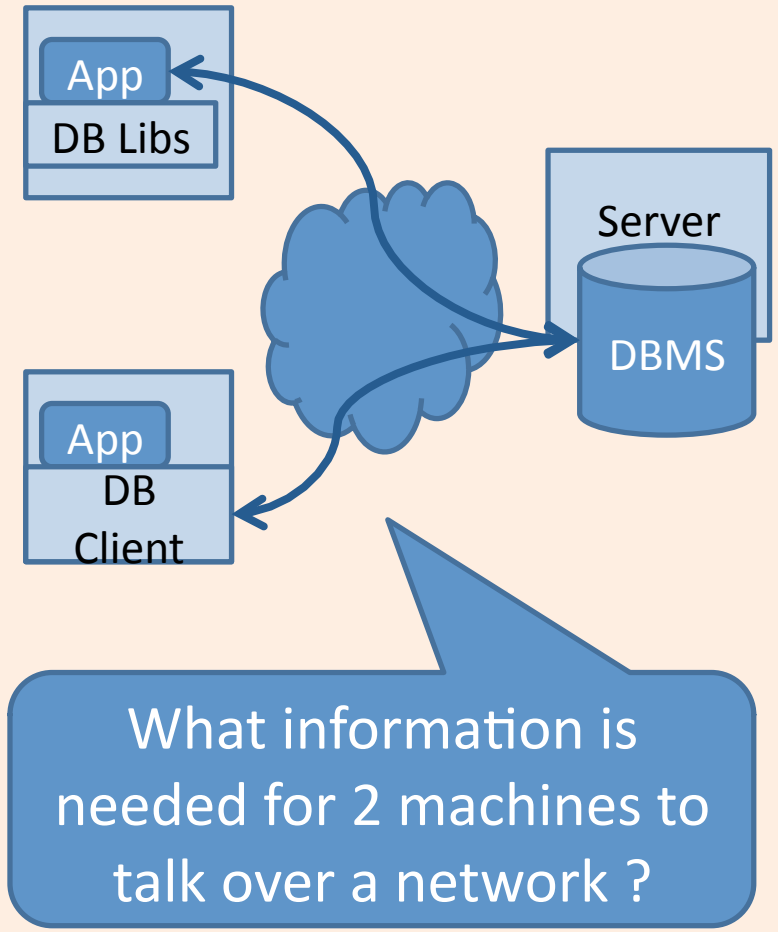
- Highly integrated eg. Microsoft linq
  - Compiler checking of database operations
- Loosely integrated eg. ODBC & JDBC
  - Provides a way to call SQL from host language
  - Host language compiler doesn't understand database operations.
- Requirements:
  - Perform DB operations from host language
  - DB operations need to access variables in host language

# Networking Basics



# Remote Client Access

- Applications run on a machine that is separate from the DB server
- DBMS "thin" client
  - Libraries to link your app to
  - App needs to know how to talk to DBMS server via network
- DBMS "full" client layer
  - Need to pre-configure the thick client layer to talk to DBMS server
  - Your app talks to a DBMS client layer as if it is talking to the server



# Configuring DBMS Client Layer

- Tell the client where to find the server

```
db2 CATALOG TCPIP NODE mydbsrv
    REMOTE 123.3.4.12 SERVER 50001
```

- Tell the client where to find the server

```
db2 CATALOG DATABASE bookdb AS
    mybookdb AT NODE mydbsrv
```

Give a name for this node

Specify the IP address/ hostname and the port number of the DB server machine

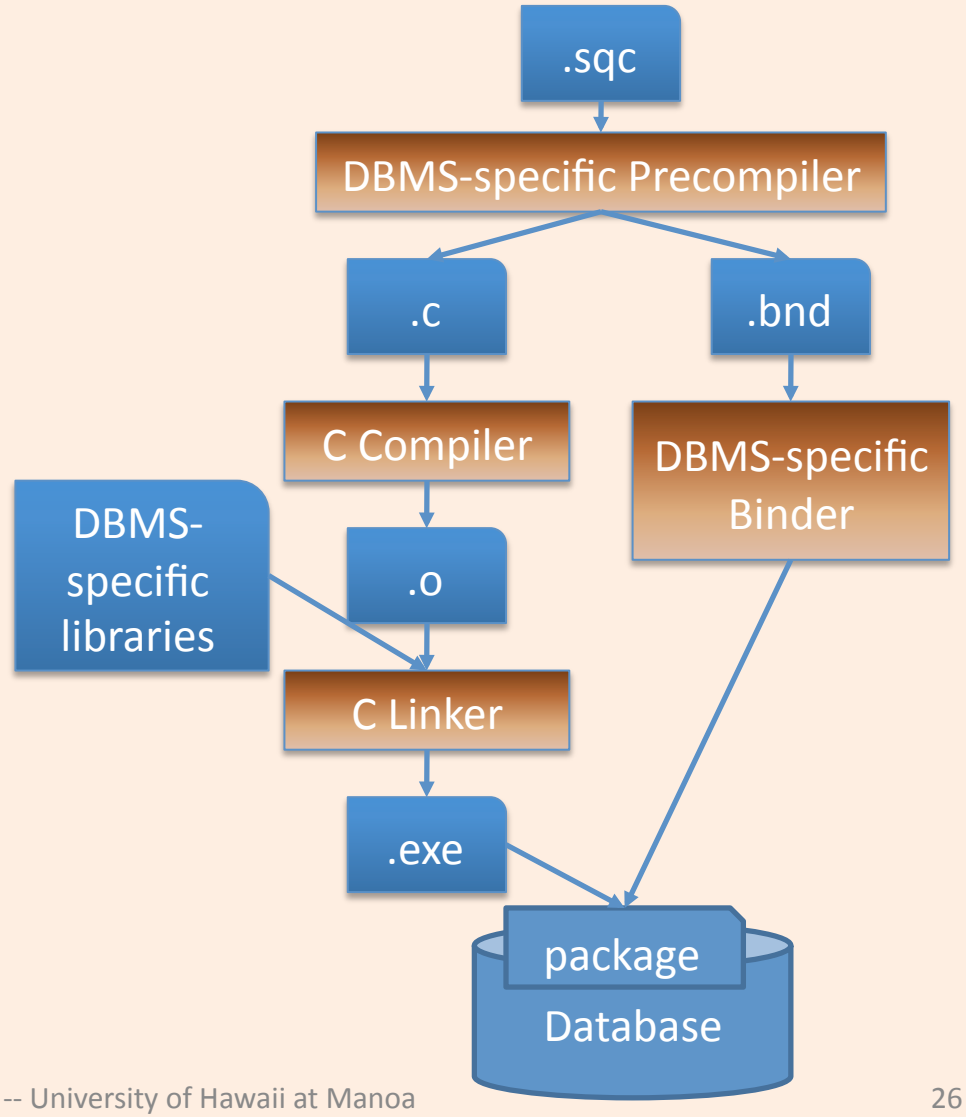
Specify the name of the database on the server

Give a local alias for the database

Specify the name of the node that is associated with this database

# Embedded SQL in C Programs

- DBMS-specific Preprocessor translates special macros to DB-specific function calls
- Pre-processor needs access to DBMS instance for validation.
- Executable needs to be bound to a specific database in a DBMS in order to execute



# Connecting SQL & Host Language

- Need a way for host language to get data from SQL environment
- Need a way to pass values from host language to SQL environment
- Shared variables
  - DECLARE SECTION
  - In SQL, refer using :Salary, :EmployeeNo

```
EXEC SQL BEGIN DECLARE SECTION;
char EmployeeNo[7];
char LastName[16];
double Salary;
short SalaryNI;
EXEC SQL END DECLARE SECTION;
```

# An Example of Embedded SQL C Program

```
#include <stdio.h>
#include <string.h>
#include <sql.h>
int main()
{
// Include The SQLCA Data Structure Variable
EXEC SQL INCLUDE SQLCA;

// Define The SQL Host Variables Needed
EXEC SQL BEGIN DECLARE SECTION;
char EmployeeNo[7];
char LastName[16];
double Salary;
short SalaryNI;
EXEC SQL END DECLARE SECTION;

// Connect To The Appropriate Database
EXEC SQL CONNECT TO SAMPLE USER
     db2admin USING ibmdb2;

// Declare A Static Cursor
EXEC SQL DECLARE C1 CURSOR FOR
SELECT EMPNO, LASTNAME, DOUBLE(SALARY)
FROM EMPLOYEE
WHERE JOB = 'DESIGNER';

// Open The Cursor
EXEC SQL OPEN C1;
```

# An Example of Embedded SQL C Program

```
// If The Cursor Was Opened Successfully,
while (sqlca.sqlcode == SQL_RC_OK)
{
    EXEC SQL FETCH C1 INTO :EmployeeNo,
            :LastName, :Salary, :SalaryNI;

    // Display The Record Retrieved
    if (sqlca.sqlcode == SQL_RC_OK)
    {
            printf("%-8s %-16s ", EmployeeNo,
                    LastName);
            if (SalaryNI >= 0)
                    printf("%lf\n", Salary);
            else
                    printf("Unknown\n");
    }
}
```

```
// Close The Open Cursor
EXEC SQL CLOSE C1;
// Commit The Transaction
EXEC SQL COMMIT;
// Terminate The Database Connection
EXEC SQL DISCONNECT CURRENT;
// Return Control To The Operating System
return(0);

}
```

- A cursor is an iterator for looping through a relation instance.
- Why is a cursor construct necessary ?

# Updates

- SQL syntax except where clause require current of <cursor>

```
EXEC SQL BEGIN DECLARE
     SECTION;
  int certNo , worth ;
  char execName[31],
     execName[31],
     execAddr [256],
     SQLSTATE [6];
EXEC SQL END DECLARE
     SECTION;
```

```
EXEC SQL DECLARE execCursor CURSOR FOR
     MovieExec;
EXEC SQL OPEN execCursor
while (1) {
  EXEC SQL FETCH FROM execCursor
     INTO :execName, :execAddr, :certNo, :worth;
  if (NO_MORE_ TUPLES) break;
  if ( worth < 1000)
     EXEC SQL DELETE FROM MovieExec
                WHERE CURRENT OF execCursor;
  else
     EXEC SQL UPDATE MovieExec
                SET netWorth=2*netWorth
                WHERE CURRENT OF execCursor;
}
EXEC SQL CLOSE execCursor
```

# Static vs Dynamic SQL

- Static SQL refers to SQL queries that are completely specified at compile time. Eg.

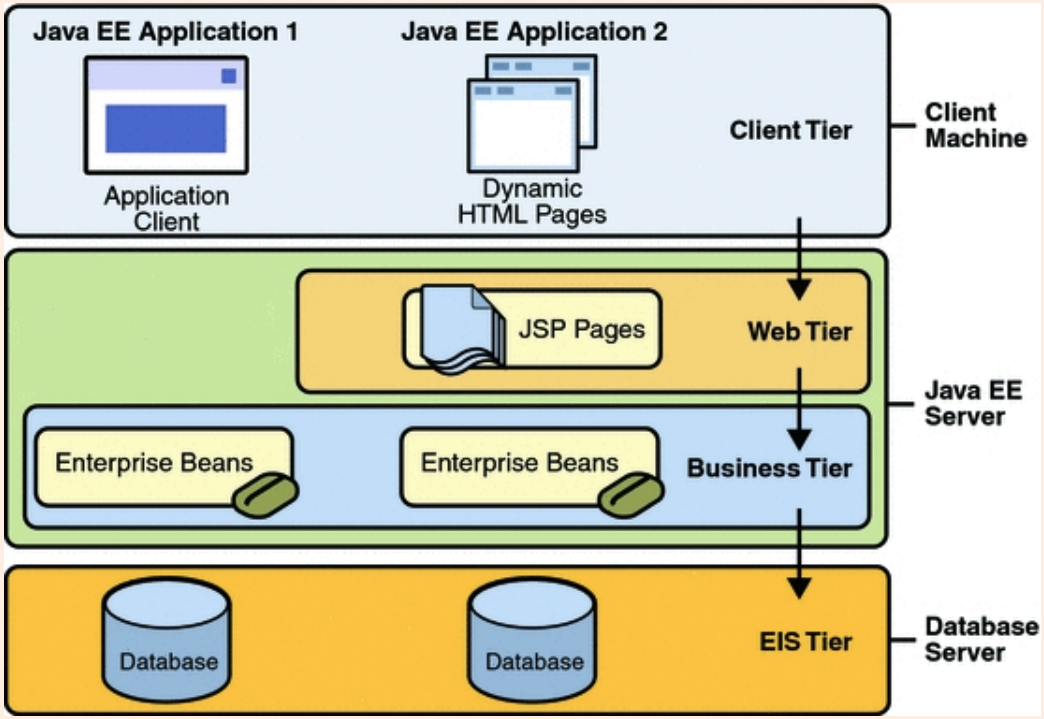
```
// Declare A Static Cursor
EXEC SQL DECLARE C1 CURSOR FOR
SELECT EMPNO, LASTNAME,
    DOUBLE(SALARY)
FROM EMPLOYEE
WHERE JOB = 'DESIGNER';
```

- Dynamic SQL refers to SQL queries that are note completely specified at compile time. Eg.

```
strcpy(SQLStmt, "SELECT * FROM
    EMPLOYEE WHERE JOB=");
strcat(SQLStmt,  argv[1]);
EXEC SQL PREPARE SQL_STMT
    FROM :SQLStmt;
EXEC SQL EXECUTE SQL_STMT;
```

# J2EE: Java to Platform, Enterprise Edition

- Think in terms of "Servicing a request"
  - Eg., a click on a "create" button on a "customer" page in a browser is a request.
- Building a Web application requires an approach of handling and processing http requests and sending appropriate responses back to the requesters




see http://www.javacodegeeks.com/2013/02/introduction-to-javaee-concepts.html