Introductory Basics

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Basics in three areas

Some of the notations and concepts from these areas will be employed from time to time in the presentations for this course:

- Software engineering
- Operating systems
- Networks.

Software Engineering Basics

Procedural versus Object-oriented Programming

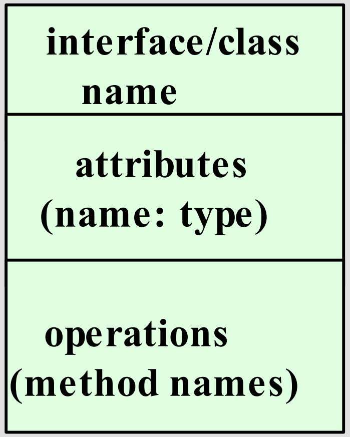
In building network applications, there are two main classes of programming languages: procedural language and object-oriented language.

- Procedural languages, with the C language being the primary example, use procedures (functions) to break down the complexity of the tasks that an application entails.
- Object-oriented languages, exemplified by Java, use objects to encapsulate the details. Each object simulates an object in real life, carrying state data as well as behaviors. State data are represented as instance data. Behaviors are represented as methods.

UML Class Diagram Notations

Basic UML Class Diagram Notations

A class/interface is represented as follows:



interface/class name

attributes (name: type)

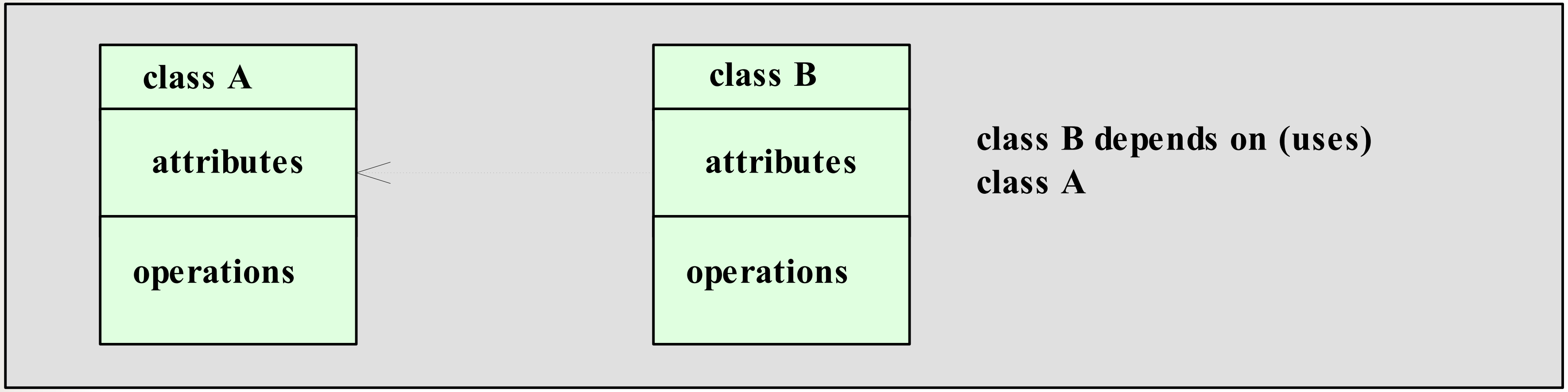
operations (method names)

attributes are static/ instance variables/constants

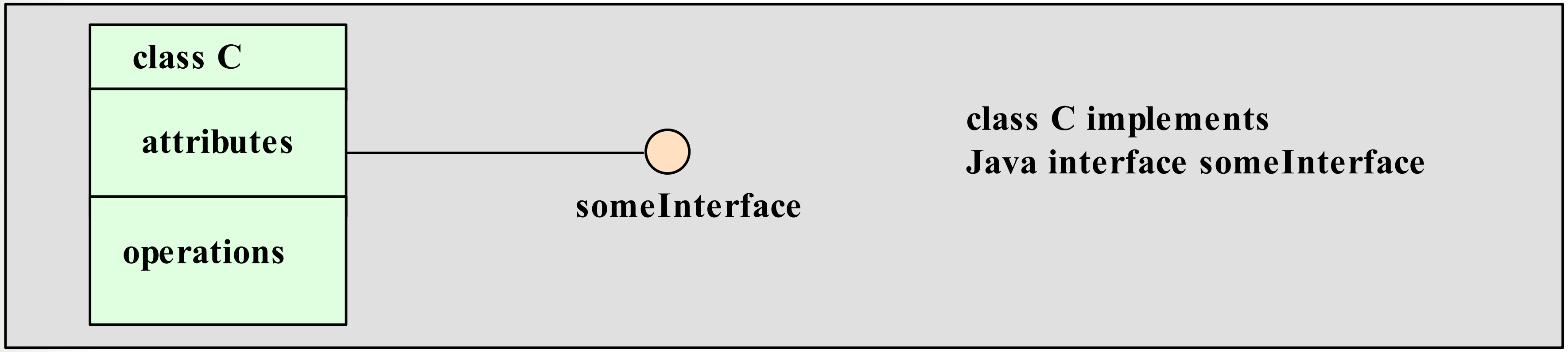
operations are static or instance methods.

NOTE: The shape, the style of the line (dashed or solid), the direction of the arrow, and the shape of the arrowheads (pointed, hollow, or solid) are significant.

UML Class Diagram Notations

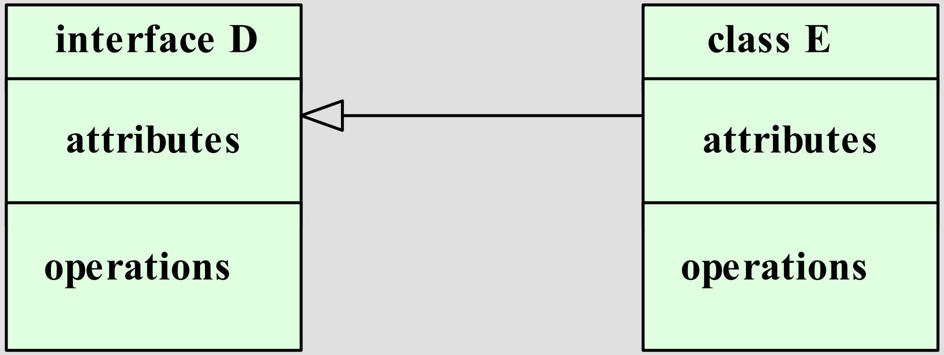


class B depends on (uses)
class A

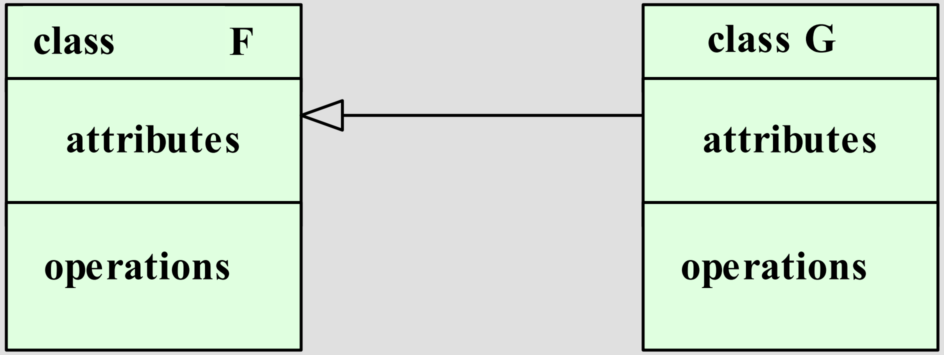


class C implements
Java interface someInterface

UML Class Diagram Notations

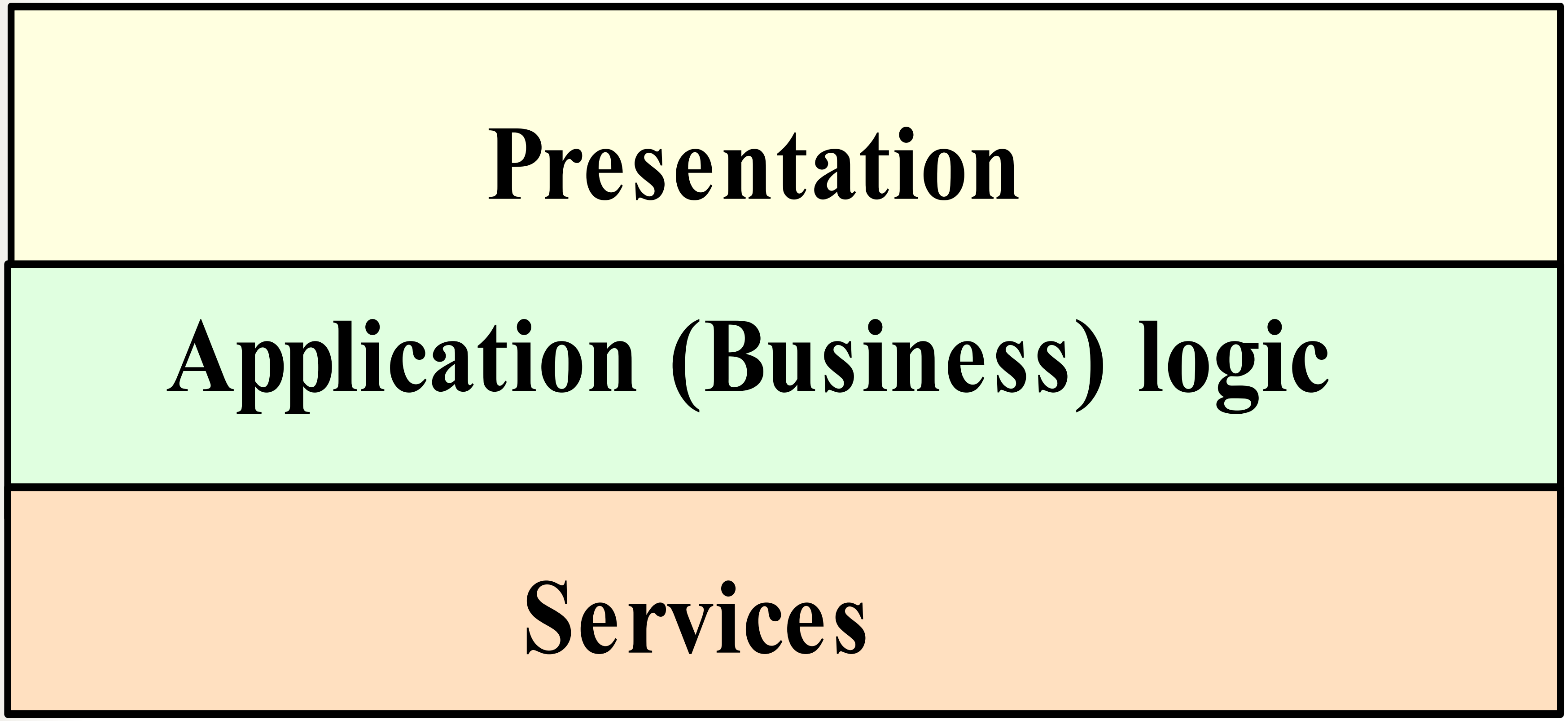


class E implements programmer-provided interface D



class G inherits from class F

The Architecture of Distributed Applications



Presentation

Application (Business) logic

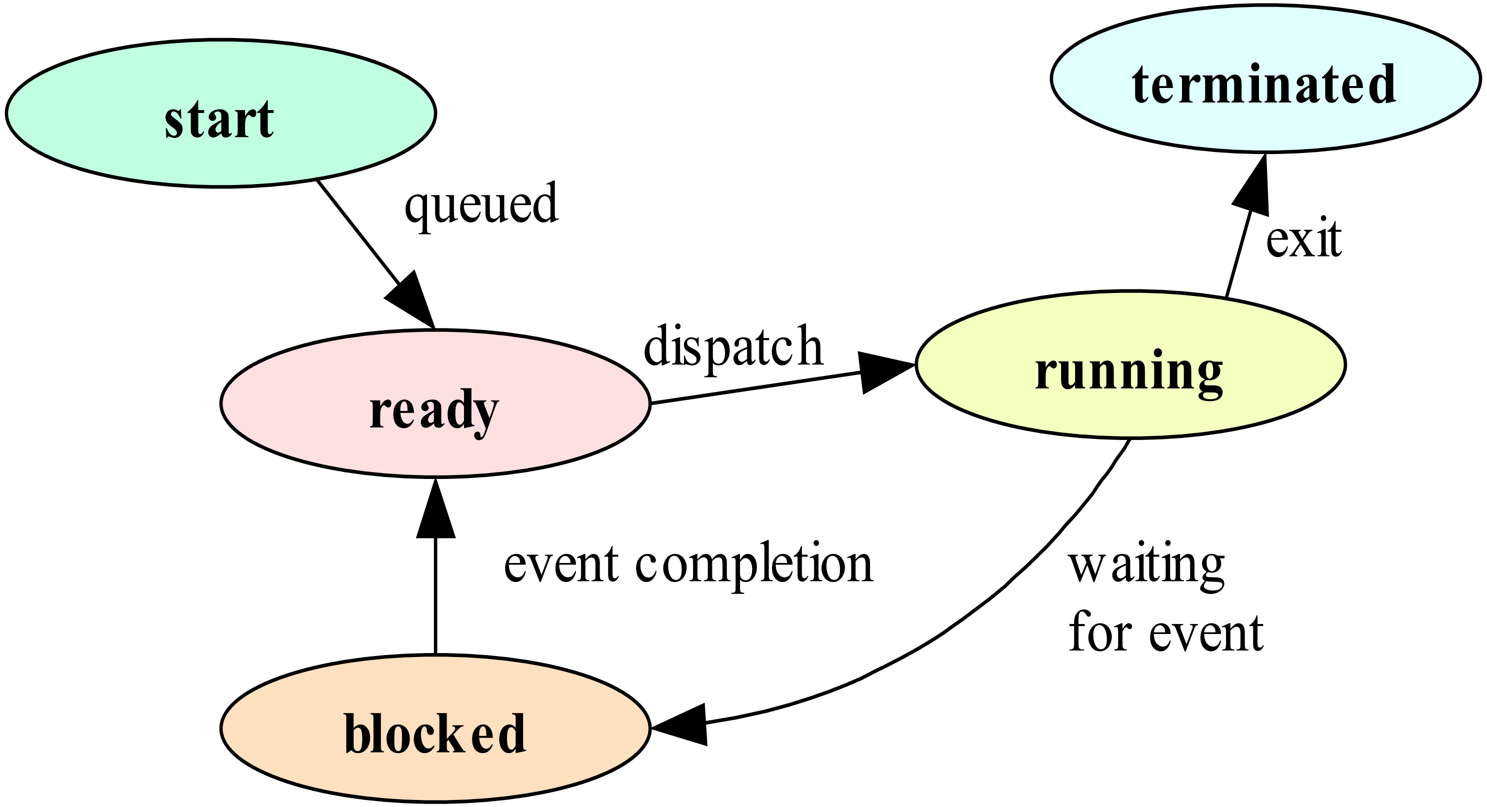
Services

Operating Systems Basics

Operating systems basics

- A process consists of an executing program, its current values, state information, and the resources used by the operating system to manage its execution.
- A program is an artifact constructed by a software developer; a process is a dynamic entity which exists only when a program is run.

Process State Transition Diagram



Simplifed finite state diagram for a process's lifetime

Java processes

- There are three types of Java program: applications, applets, and servlets, all are written as a class.
  - A Java application program has a main method, and is run as an independent(standalone) process.
  - An applet does not have a main method, and is run using a browser or the appletviewer.
  - A servlet does not have a main method, and is run in the context of a web server.
- A Java program is compiled into bytecode, a universal object code. When run, the bytecode is interpreted by the Java Virtual Machine (JVM).

Three Types of Java programs

- **Applications**

  a program whose byte code can be run on any system which has a Java Virtual Machine. An application may be standalone (monolithic) or distributed (if it interacts with another process).

- **Applets**

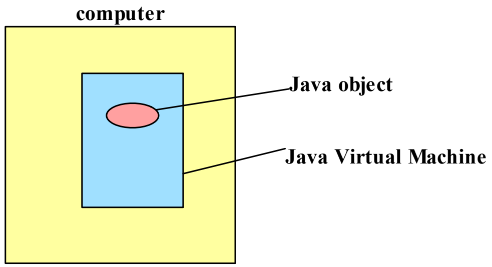
  A program whose byte code is downloaded from a remote machine and is run in the browser's Java Virtual Machine.

- **Servlets**

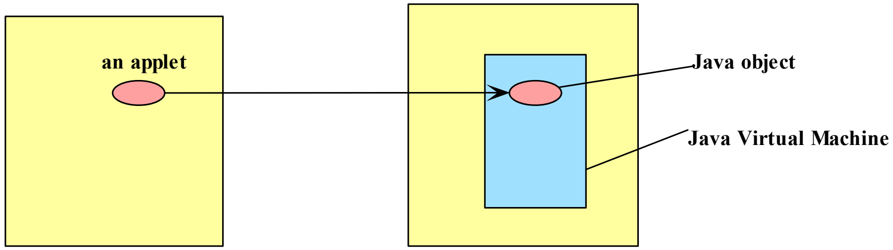
  A program whose byte code resides on a remote machine and is run at the request of an HTTP client (a browser).

Three Types of Java programs

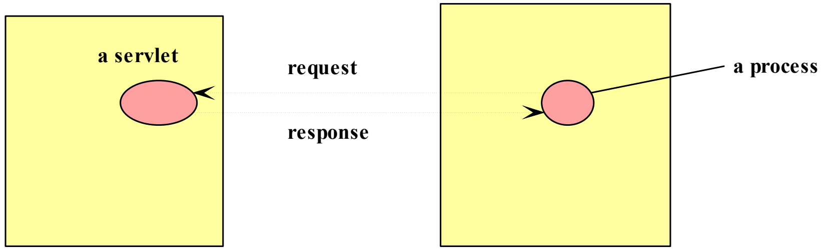
A standalone Java application is run on a local machine



An applet is an object downloaded (transferred) from a remote machine, then run on a local machine.



A servlet is an object that runs on a remote machine and interacts with a local program using a request-response protocol



A sample Java application

```
/**********************************************************
 *  A sample of a simple Java application.
 *   M. Liu              1/8/02
 *********************************************************/

import java.io.*;

class MyProgram{

   public static void main(String[ ] args)
      throws IOException{

      BufferedReader keyboard = new
         BufferedReader(new InputStreamReader(System.in));
      String theName;
      System.out.println("What is your name?");
      theName = keyboard.readLine( );
      System.out.print("Hello " + theName );
      System.out.println(" - welcome to CSC369.\n");

   } // end main

} //end class
```

A Sample Java Applet

```
/***************************************************
 *  A sample of a simple applet.
 *   M. Liu              1/8/02
 ***************************************************/

import java.applet.Applet;
import java.awt.*;

public class MyApplet extends Applet{

   public void paint(Graphics g){
      setBackground(Color.blue);

      Font Claude = new Font("Arial", Font.BOLD, 40);
      g.setFont(Claude);
      g.setColor(Color.yellow);
      g.drawString("Hello World!", 100, 100);
   } // end paint

} //end class
```

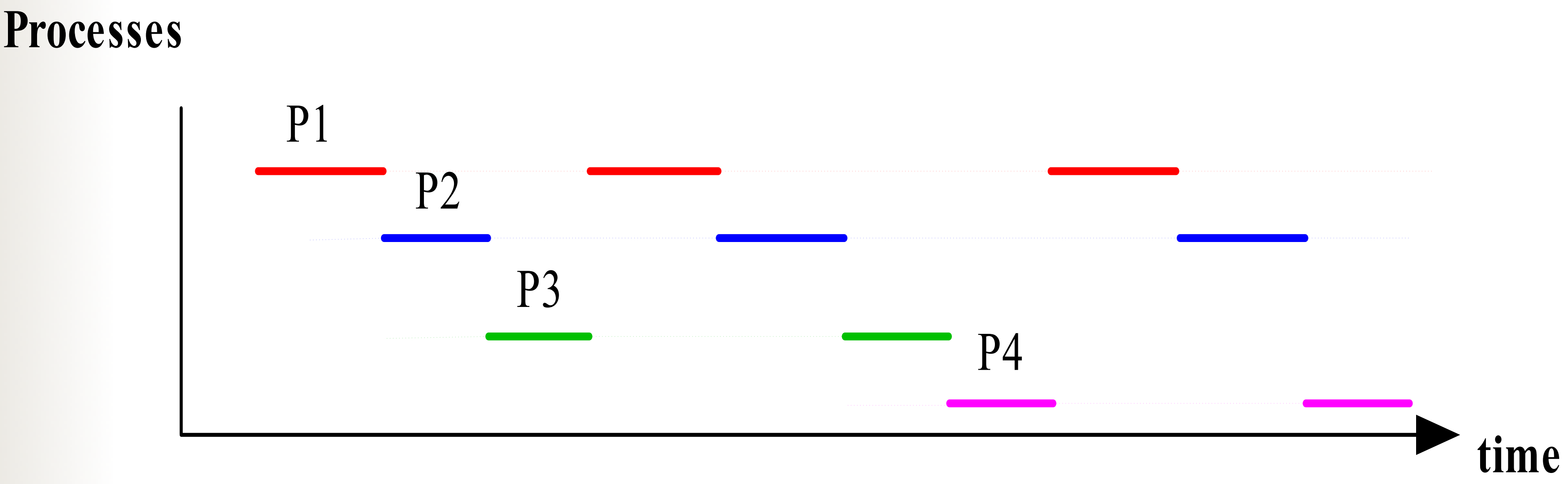
```
<!-- A web page which, when browsed, will run >
<!-- the MyApplet applet>
<!-- M. Liu 1/8/02>

<title>SampleApplet</title>
<hr>

<applet code="MyApplet.class" width=500 height=500>
</applet>

<hr>
<a href="Hello.java">The source.</a>
```

A Sample Java Servlet

```
/**************************************************************
 *  A sample of a simple Java servlet.
 *   M. Liu              1/8/02
 ************************************************************/
import java.io.*;
import java.text.*;
import java.util.*;
import javax.servlet.*;
import javax.servlet.http.*;

public class MyServlet extends HttpServlet {

   public void doGet (HttpServletRequest request,
                      HttpServletResponse response)
      throws ServletException, IOException {

      PrintWriter out;
      String title = "MyServlet Output";
      // set content type and other response header
      //   fields first
      response.setContentType("text/html");
      // then write the data of the response
      out = response.getWriter();
      out.println("<HTML><HEAD><TITLE>");
      out.println(title);
      out.println("</TITLE></HEAD><BODY>");
      out.println("<H1>" + title +   "</H1>");
      out.println("<P>Hello World!");
      out.println("</BODY></HTML>");
      out.close();
   } //end doGet

} //end class
```

Concurrent Processing

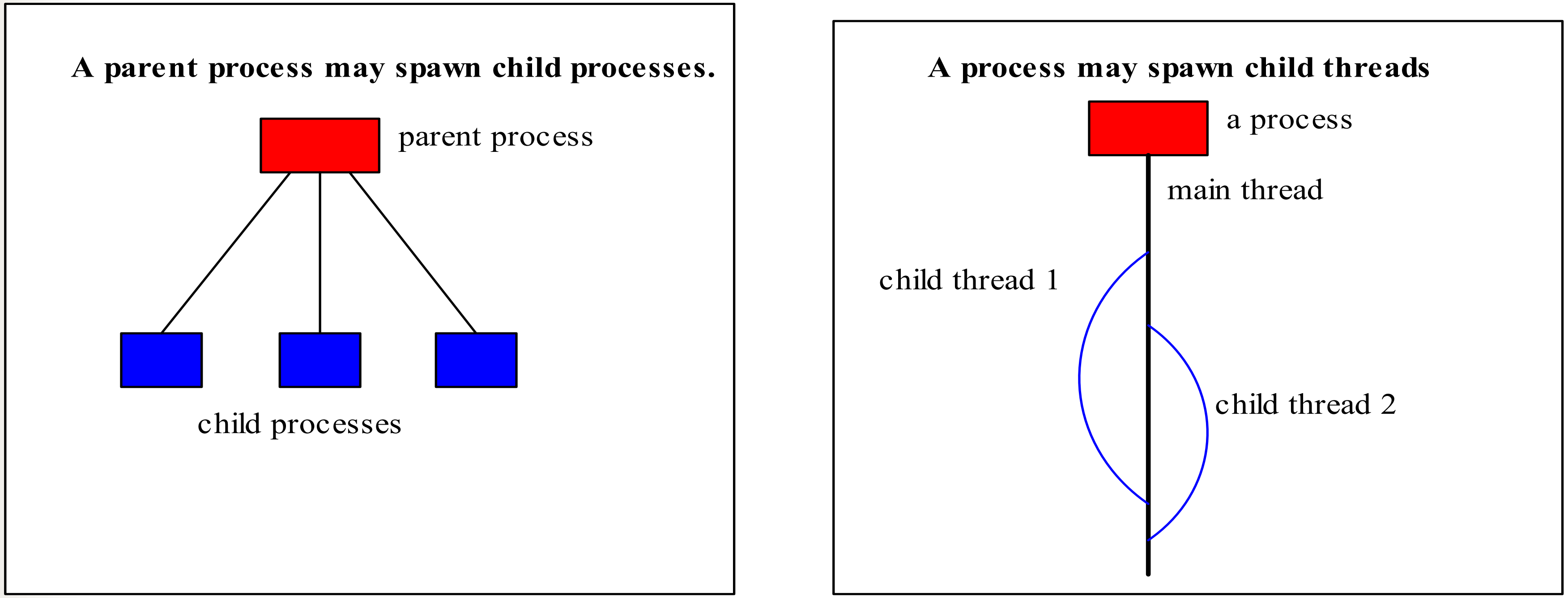
On modern day operating systems, multiple processes *appear* to be executing concurrently on a machine by timesharing resources.



Timesharing of a resource

Concurrent processing within a process

It is often useful for a process to have parallel threads of execution, each of which timeshare the system resources in much the same way as concurrent processes.



Concurrent processing within a process

Java threads

- The Java Virtual Machine allows an application to have multiple threads of execution running concurrently.
- Java provides a Thread class:

  public class **Thread**
  extends Object
  implements Runnable

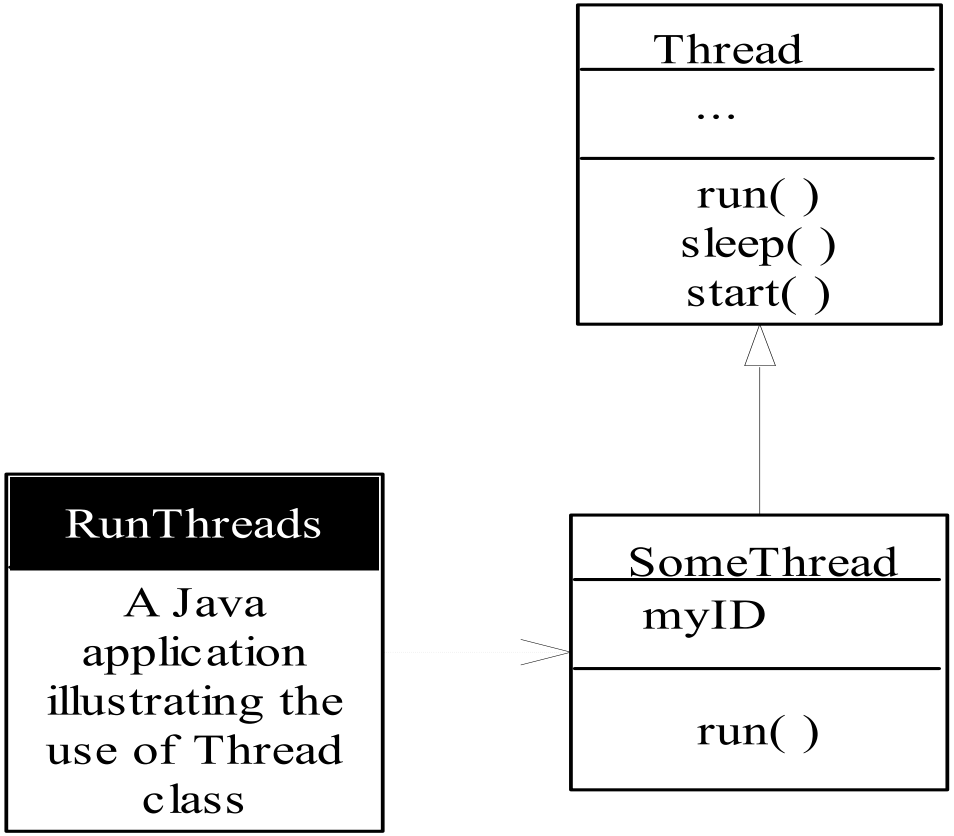
- When a Java Virtual Machine starts up, there is usually a single thread (which typically calls the method named main of some designated class). The Java Virtual Machine continues to execute threads until either of the following occurs:
  - The exit method of class Runtime has been called and the security manager has permitted the exit operation to take place.
  - All threads have terminated, either by returning from the call to the run method or by throwing an exception that propagates beyond the run method.

Two ways to create a new thread of execution

- Using a subclass of the **Thread** class
- Using a class that implements the **Runnable** interface

Create a class that is a subclass of the Thread class

Declare a class to be a subclass of Thread. This subclass should override the run method of class Thread. An instance of the subclass can then be allocated and started:



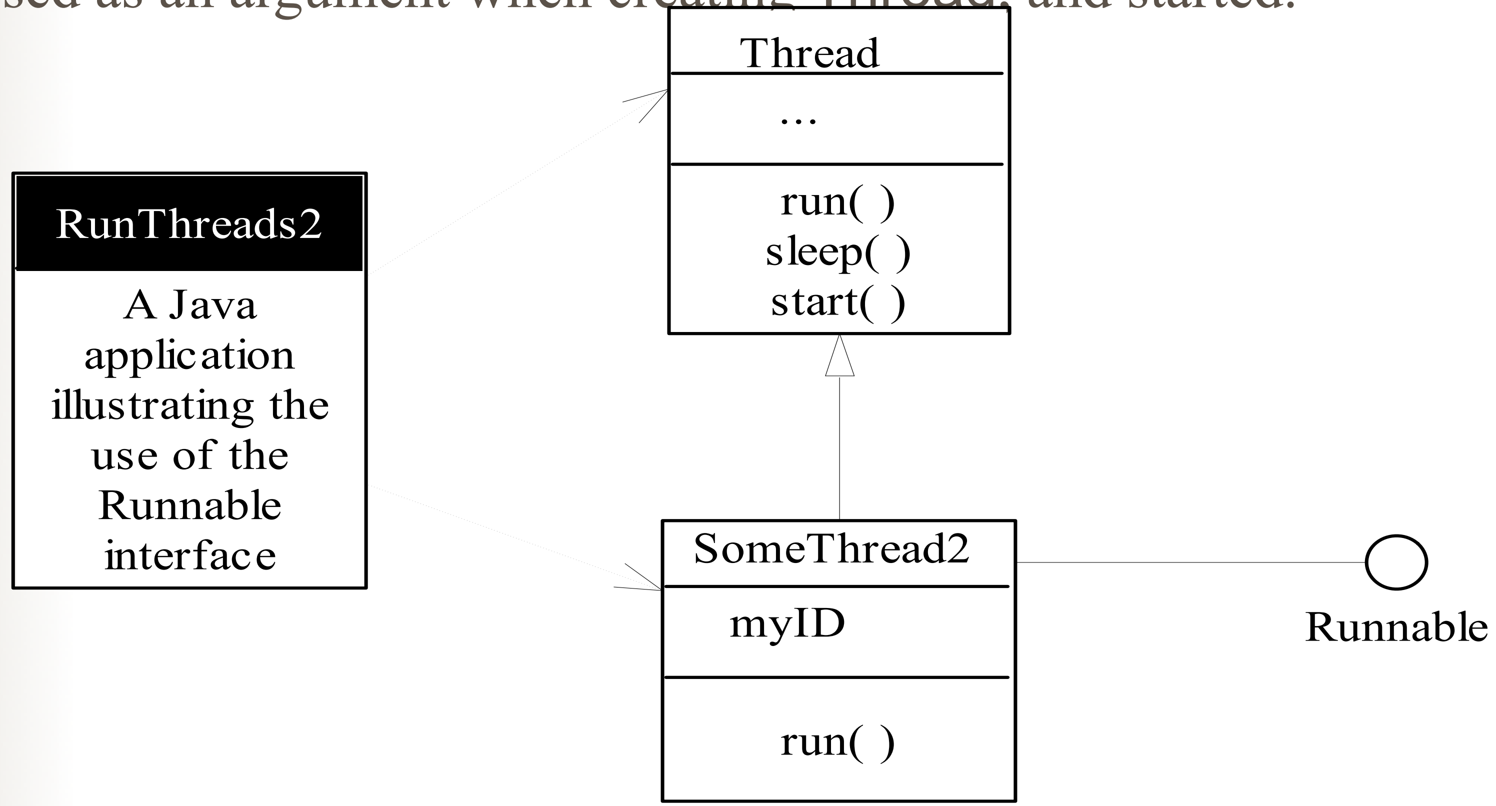
Create a class that is a subclass of the Thread class

```
import SomeThread;
public class RunThreads
{
   public static void main (String[] args)
   {
     SomeThread p1 = new SomeThread(1);
     p1.start();

     SomeThread p2 = new SomeThread(2);
     p2.start();

     SomeThread p3 = new SomeThread(3);
     p3.start();
   }
}// end class RunThreads
```

```
public class SomeThread extends Thread {
   int myID;

   SomeThread(int id) {
      this.myID = id;
   }

   public void run( ) {
      int i;
      for (i = 1; i < 11; i++)
         System.out.println ("Thread"+myID + ": " + i);
   }
} //end class SomeThread
```

Java Threads-2

The other way to create a thread is to declare a class that implements the Runnable interface. That class then implements the run method. An instance of the class can then be allocated, passed as an argument when creating Thread, and started.



Create a class that implements the Runnable interface

```
public class RunThreads2
{
   public static void main (String[] args)
   {
     Thread p1 = new Thread(new SomeThread2(1));
     p1.start();

     Thread p2 = new Thread(new SomeThread2(2));
     p2.start();

     Thread p3 = new Thread(new SomeThread2(3));
     p3.start();
   }
}
```

```
class SomeThread2 implements Runnable {
   int myID;

   SomeThread2(int id) {
      this.myID = id;
   }

   public void run() {
      int i;
      for (i = 1; i < 11; i++)
        System.out.println ("Thread"+myID + ": " + i);
   }
} //end class SomeThread
```

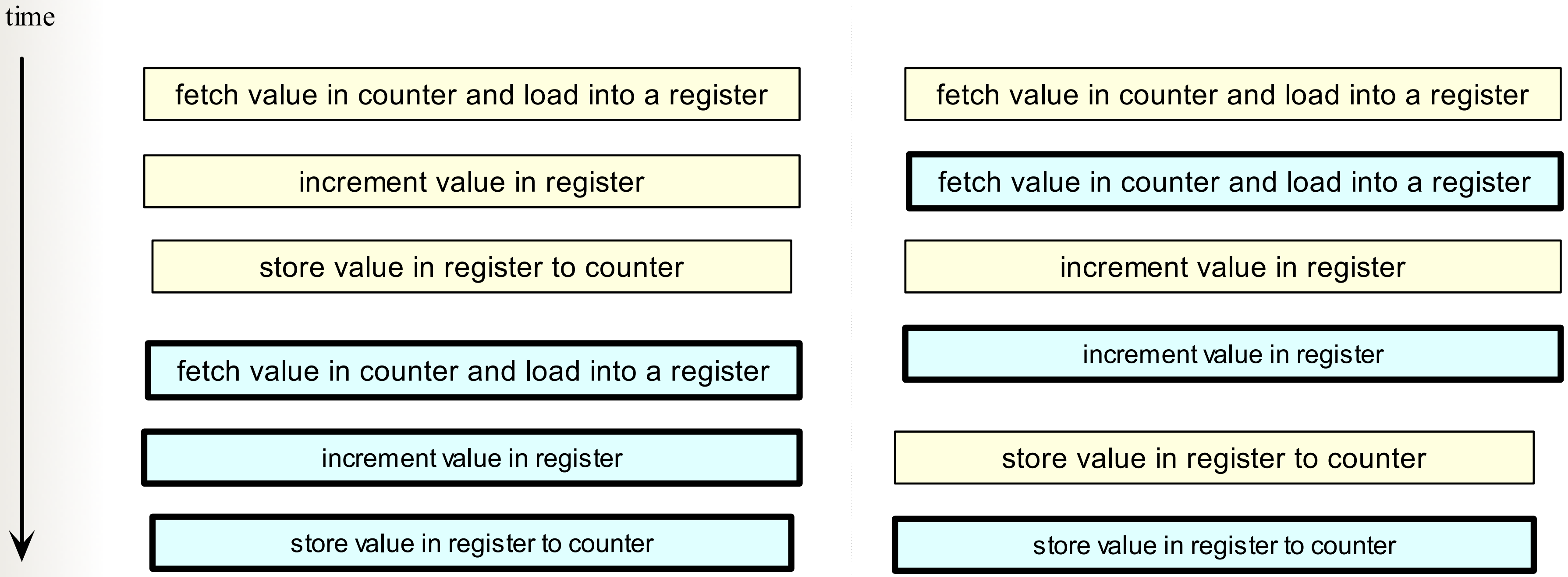
Program samples

- RunThreads.java
- SomeThread.java
- RunThreads2.java
- SomeThread2.java

Thread-safe Programming

- When two threads independently access and update the same data object, such as a counter, as part of their code, the updating needs to be synchronized. (See next slide.)
- Because the threads are executed concurrently, it is possible for one of the updates to be overwritten by the other due to the sequencing of the two sets of machine instructions executed in behalf of the two threads.
- To protect against the possibility, a synchronized method can be used to provide mutual exclusion.

Race Condition



time

fetch value in counter and load into a register

increment value in register

store value in register to counter

fetch value in counter and load into a register

increment value in register

store value in register to counter

This execution results in the value 2 in the counter

fetch value in counter and load into a register

fetch value in counter and load into a register

increment value in register

increment value in register

store value in register to counter

store value in register to counter

This execution results in the value 1 in the counter

🟨 instruction executed in concurrent process or thread 1

🟦 instruction executed in concurrent process or thread 2

Synchronised method in a thread

```
class SomeThread3 implements Runnable {
   static int count=0;

   SomeThread3() {
      super();
   }

   public void run() {
      update( );
   }

   static public synchronized void update( ){
      int myCount = count;
      myCount++;
      count = myCount;
      System.out.println("count="+count+
        "; thread count=" + Thread.activeCount( ));
   }
}
```

Network Basics

Network standards and protocols

- On public networks such as the Internet, it is necessary for a common set of rules to be specified for the exchange of data.
- Such rules, called protocols, specify such matters as the formatting and semantics of data, flow control, error correction.
- Software can share data over the network using network software which supports a common set of protocols.

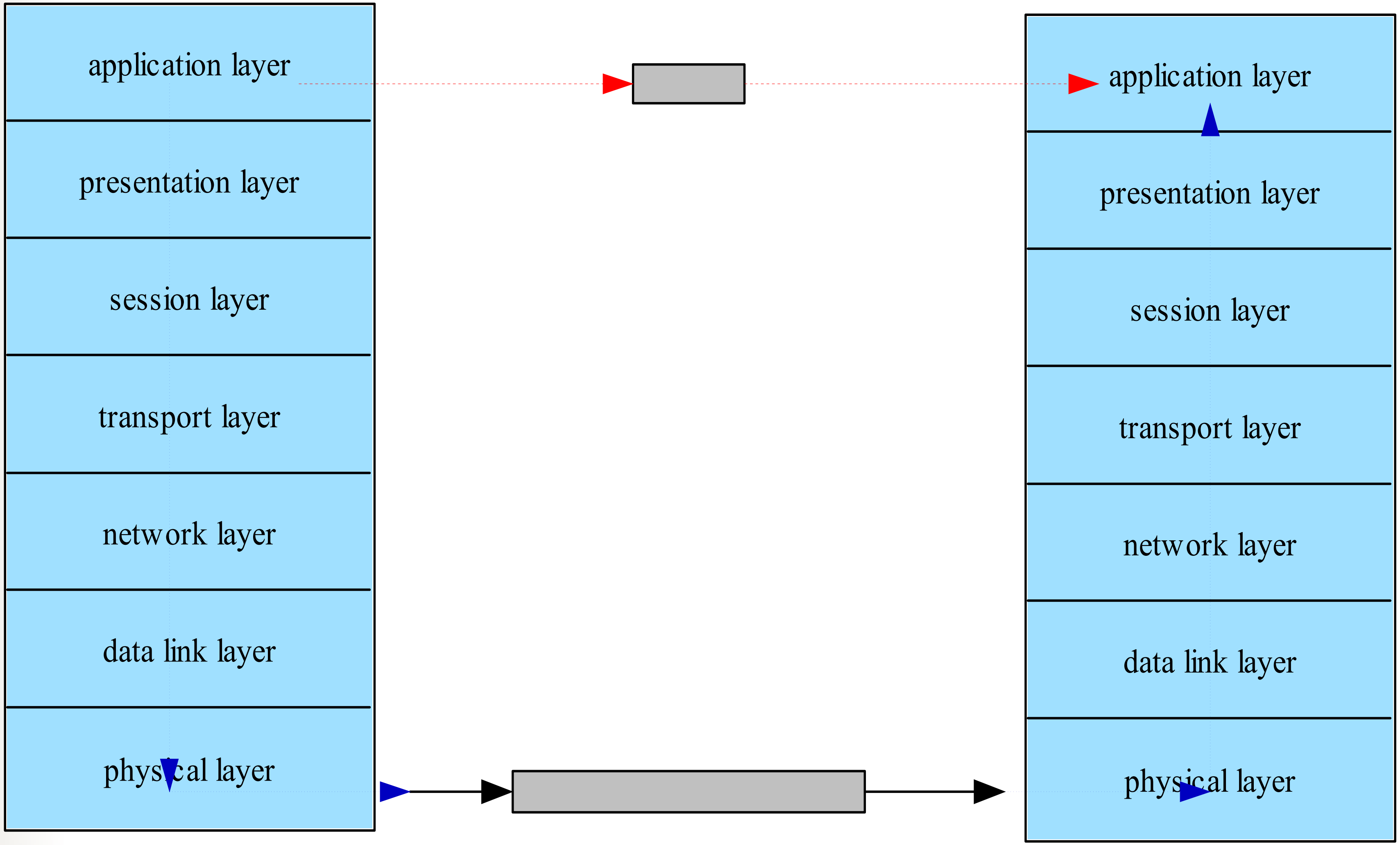
Protocols

- **In the context of communications, a protocol is a set of rules that must be observed by the participants.**
- In communications involving computers, protocols must be formally defined and precisely implemented. For each protocol, there must be rules that specify the followings:
  - **How is the data exchanged encoded?**
  - **How are events (sending , receiving) synchronised so that the participants can send and receive in a coordinated order?**
- **The specification of a protocol does not dictate how the rules are to be implemented.**

The network architecture

- **Network hardware transfers electronic signals,which represent a bit stream, between two devices.**
- **Modern day network applications require an application programming interface (API) which masks the underlying complexities of data transmission.**
- **A layered network architecture allows the functionalities needed to mask the complexities to be provided incrementally, layer by layer.**
- **Actual implementation of the functionalities may not be clearly divided by layer.**

The OSI seven-layer network architecture



Network Architecture

The division of the layers is conceptual: the implementation of the functionalities need not be clearly divided as such in the hardware and software that implements the architecture.

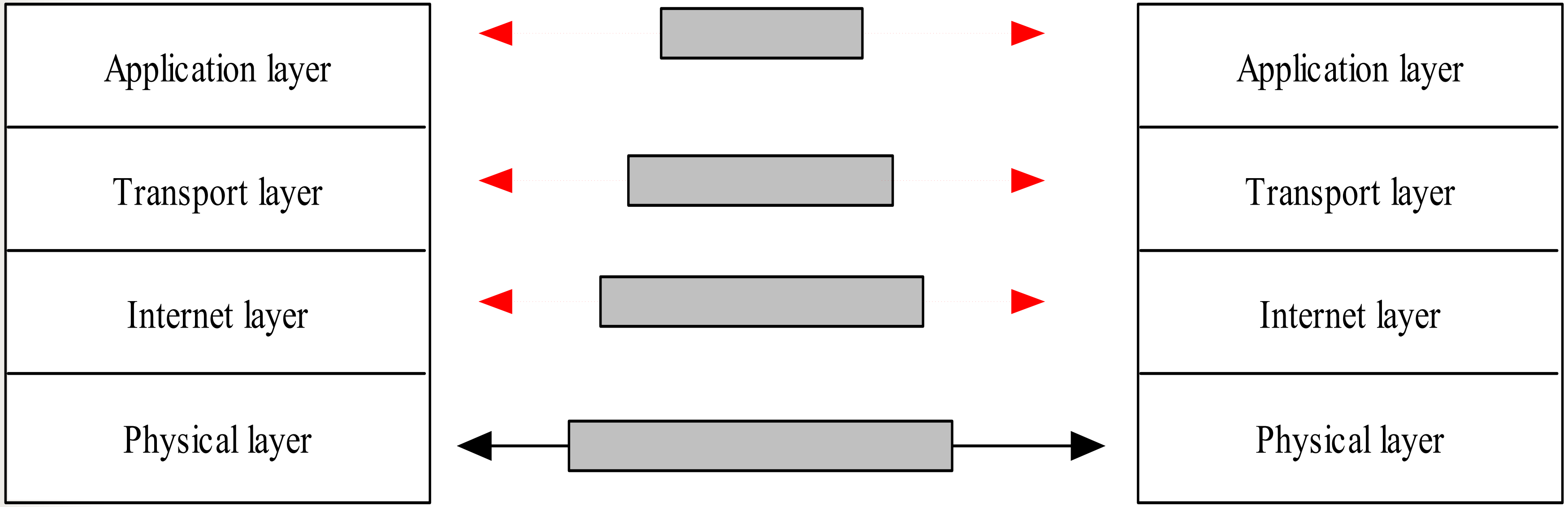
The conceptual division serves at least two useful purposes :

1. Systematic specification of protocols

   it allows protocols to be specified systematically
2. **Conceptual Data Flow**: it allows programs to be written in terms of logical data flow.

The TCP/IP Protocol Suite

- The Transmission Control Protocol/Internet Protocol suite is a set of network protocols which supports a four-layer network architecture.
- It is currently the protocol suite employed on the Internet.



The Internet network architecture

The TCP/IP Protocol Suite -2

- The Internet layer implements the Internet Protocol, which provides the functionalities for allowing data to be transmitted between any two hosts on the Internet.
- The Transport layer delivers the transmitted data to a specific process running on an Internet host.
- The Application layer supports the programming interface used for building a program.

Network Resources

- Network resources are resources available to the participants of a distributed computing community.
- Network resources include hardware such as computers and equipment, and software such as processes, email mailboxes, files, web documents.
- An important class of network resources is network services such as the World Wide Web and file transfer (FTP), which are provided by specific processes running on computers.

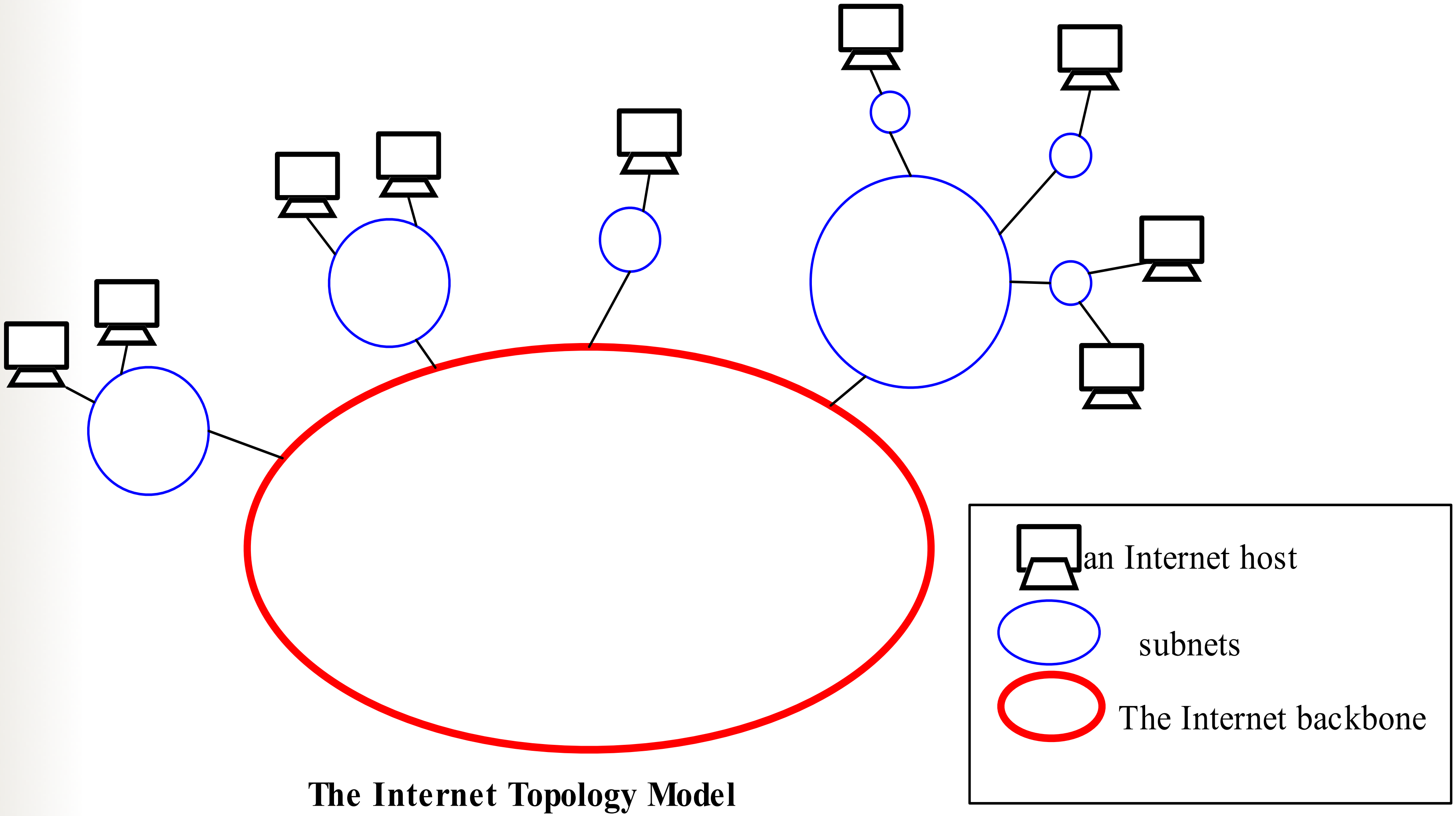
Identification of Network Resources

One of the key challenges in distributed computing is the unique identification of resources available on the network, such as e-mail mailboxes, and web documents.

- Addressing an Internet Host
- Addressing a process running on a host
- Email Addresses
- Addressing web contents: URL

Addressing an Internet Host

The Internet Topology



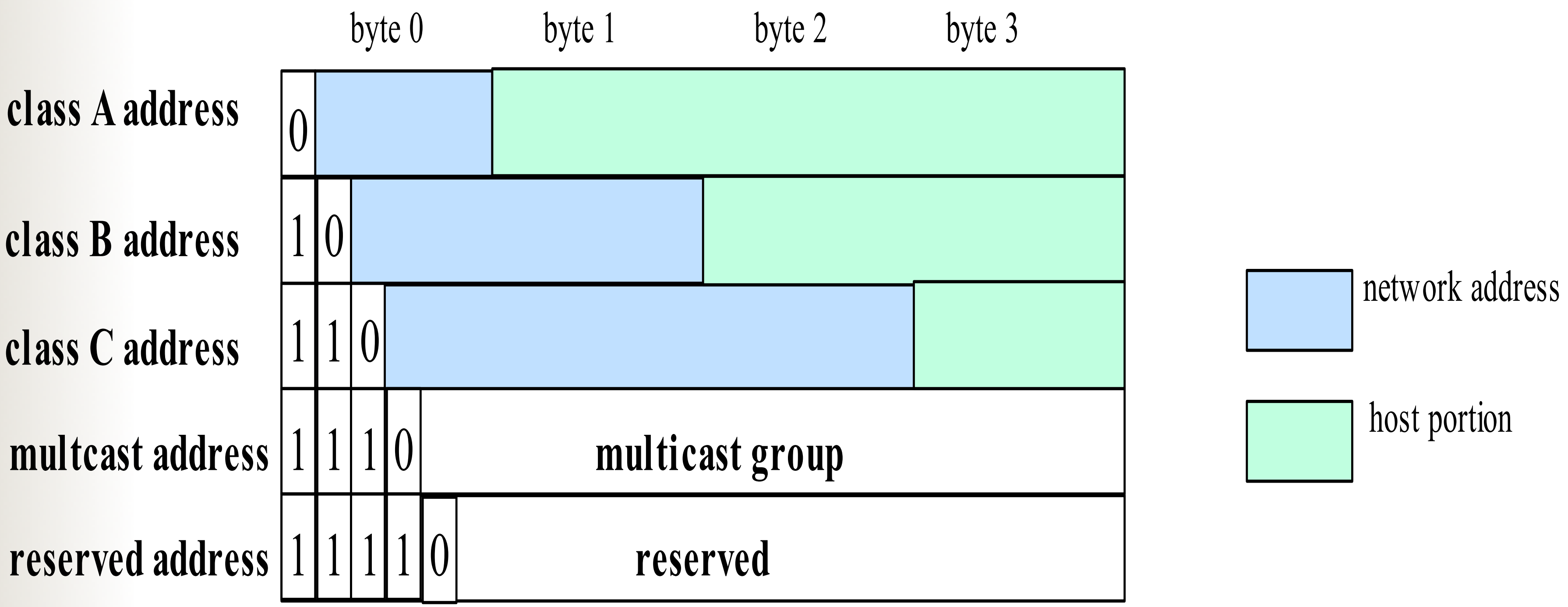
The Internet Topology Model

The Internet Topology

- The internet consists of an hierarchy of networks, interconnected via a network backbone.
- Each network has a unique network address.
- Computers, or hosts, are connected to a network. Each host has a unique ID within its network.
- Each process running on a host is associated with zero or more **ports.** A port is a logical entity for data transmission.

The Internet addressing scheme

- In IP version 4, each address is 32 bit long.
- The address space accommodates 2^{32} (4.3 billion) addresses in total.
- Addresses are divided into 5 classes (A through E)



byte 0 byte 1 byte 2 byte 3

class A address 0

class B address 1 0

class C address 1 1 0

multcast address 1 1 1 0 multicast group

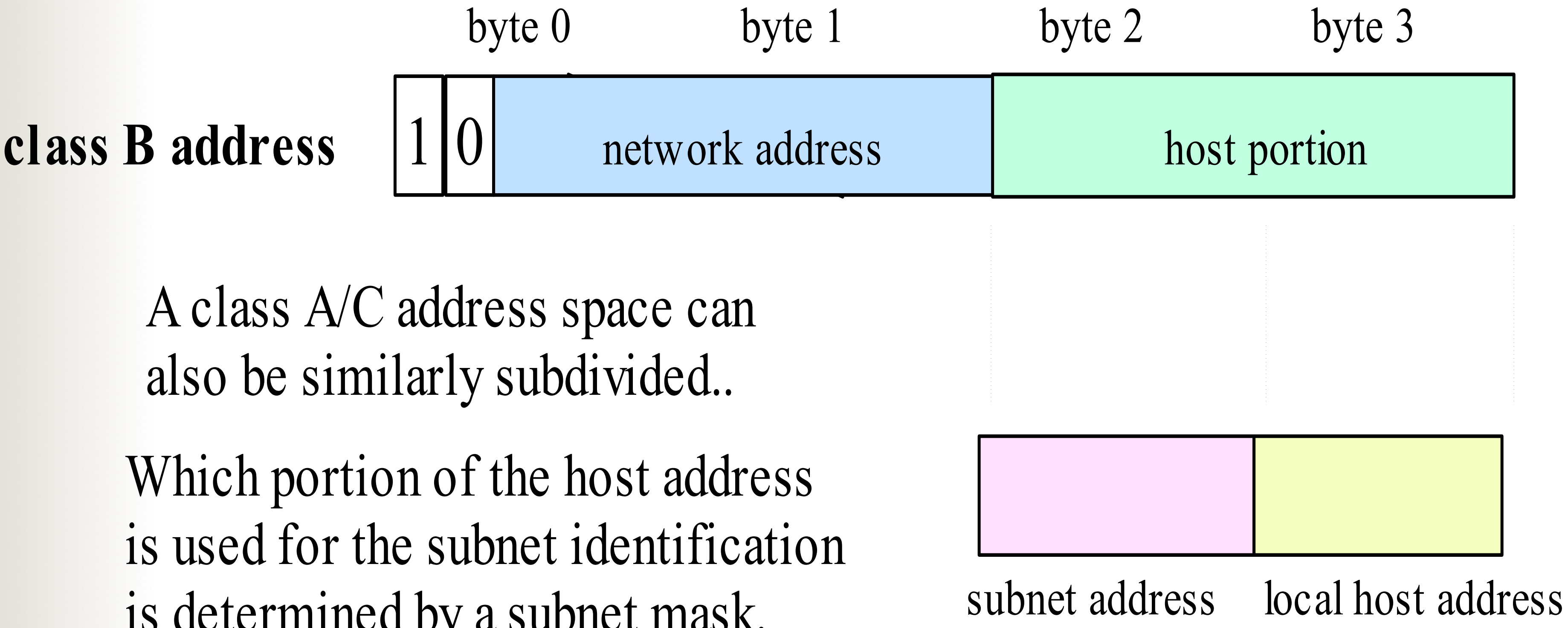
reserved address 1 1 1 1 0 reserved

network address

host portion

The Internet addressing scheme - 2

Subdividing the host portion of an Internet address:

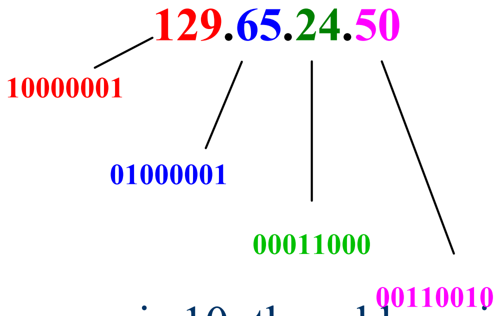


A class A/C address space can also be similarly subdivided..

Which portion of the host address is used for the subnet identification is determined by a subnet mask.

Example:

Suppose the dotted-decimal notation for a particular Internet address is129.65.24.50. The 32-bit binary expansion of the notation is as follows:



129.65.24.50

10000001

01000001

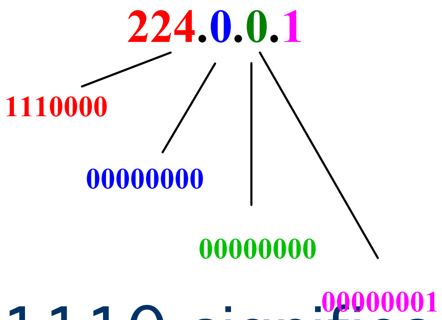
00011000

00110010

Since the leading bit sequence is 10, the address is a **Class B** address. Within the class, the network portion is identified by the remaining bits in the first two bytes, that is, **00000101000001**, and the host portion is the values in the last two bytes, or **0001100000110010**. For convenience, the binary prefix for class identification is often included as part of the network portion of the address, so that we would say that this particular address is at network **129.65** and then at host address **24.50** on that network.

Another example:

Given the address 224.0.0.1, one can expand it as follows:



The binary prefix of 1110 signifies that this is class D, or multicast, address. Data packets sent to this address should therefore be delivered to the multicast group 0000000000000000000000000001.

The Internet Address Scheme - 3

- For human readability, Internet addresses are written in a dotted decimal notation:

  nnn.nnn.nnn.nnn, where each nnn group is a decimal value in the range of 0 through 255

```
# Internet host table (found in /etc/hosts file)
127.0.0.1       localhost
129.65.242.5    falcon.csc.calpoly.edu  falcon  loghost
129.65.241.9    falcon-srv.csc.calpoly.edu      falcon-srv
129.65.242.4    hornet.csc.calpoly.edu  hornet
129.65.241.8    hornet-srv.csc.calpoly.edu      hornet-srv
129.65.54.9     onion.csc.calpoly.edu   onion
129.65.241.3    hercules.csc.calpoly.edu        hercules
```

IP version 6 Addressing Scheme

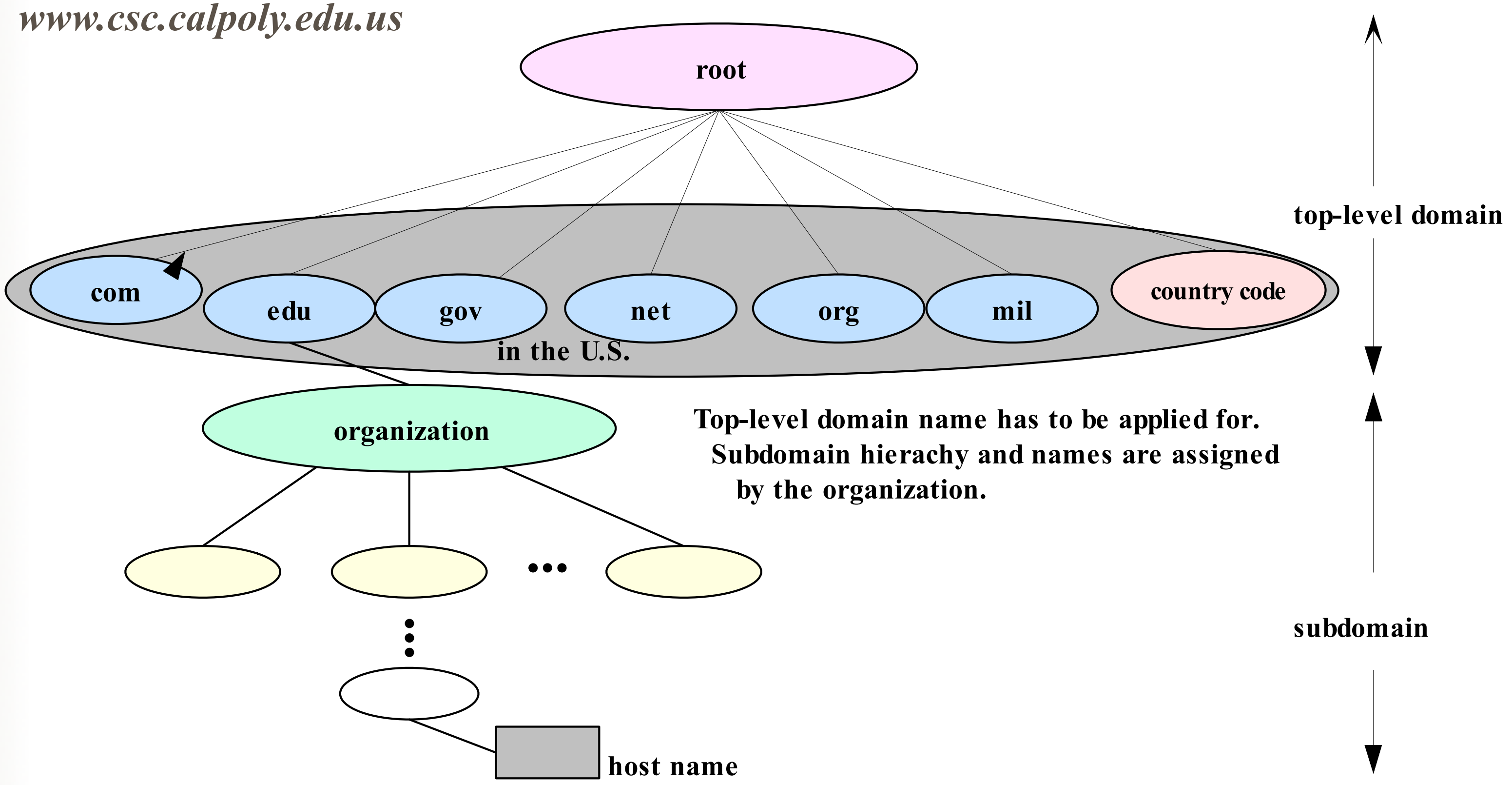
- Each address is 128-bit long.
- There are three types of addresses:
  - Unicast: An identifier for a single interface.
  - Anycast: An identifier for a set of interfaces (typically belonging to different nodes).
  - Multicast: An identifier for a set of interfaces (typically belonging to different nodes). A packet sent to a multicast address is delivered to all interfaces identified by that address.
- See Request for Comments: 2373 http://www.faqs.org/rfcs/ (link is in book's reference)

The Domain Name System (DNS)

For user friendliness, each Internet address is mapped to a symbolic name, using the DNS, in the format of:

<computer-name>.<subdomain hierarchy>.<organization>.<sector name>{.<country code>}

e.g., ***www.csc.calpoly.edu.us***



Top-level domain name has to be applied for.
Subdomain hierachy and names are assigned by the organization.

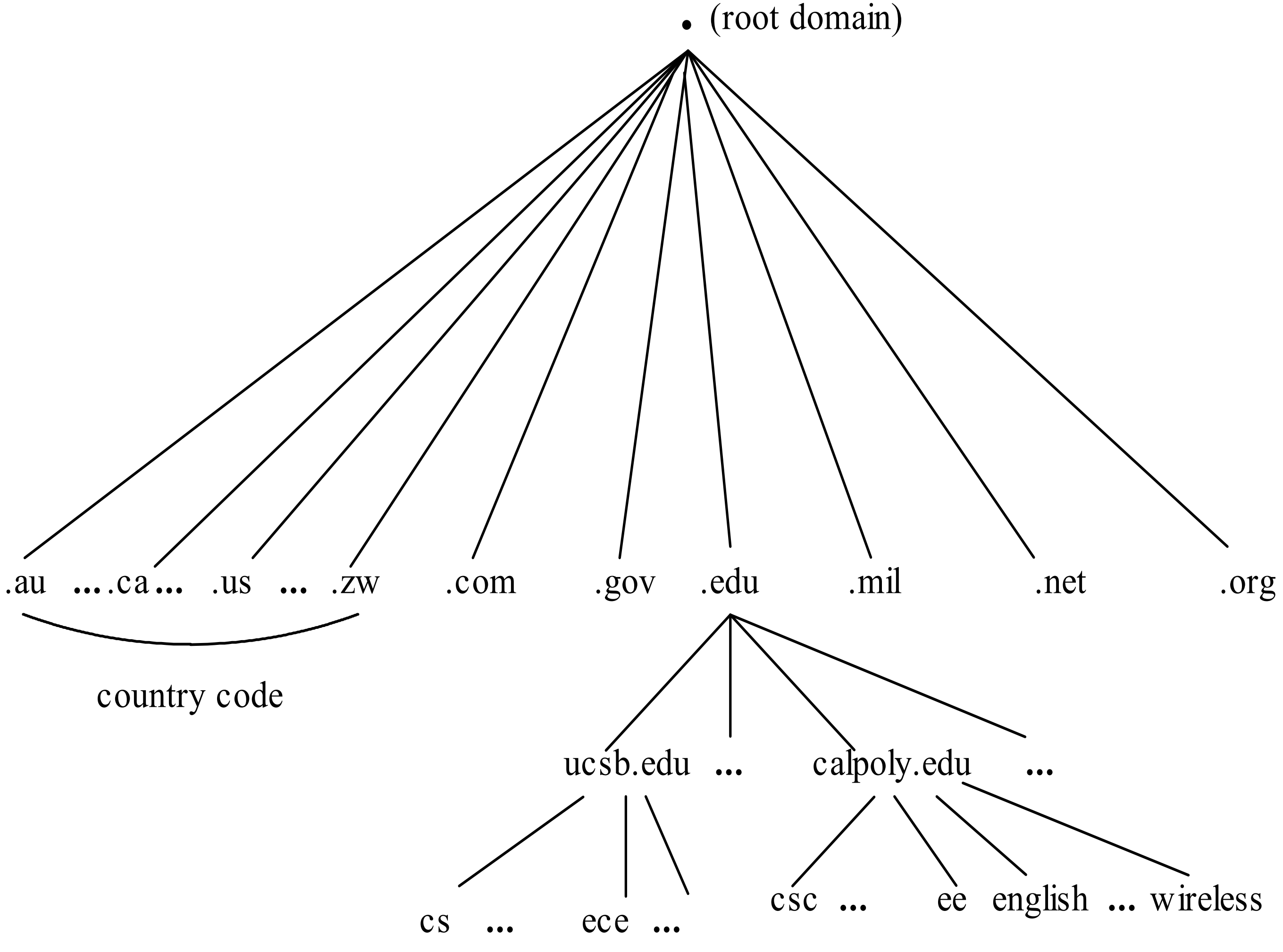
The Domain Name System

- For network applications, a domain name must be mapped to its corresponding Internet address.
- Processes known as domain name system servers provide the mapping service, based on a distributed database of the mapping scheme.
- The mapping service is offered by thousands of DNS servers on the Internet, each responsible for a portion of the name space, called a *zone*. The servers that have access to the DNS information (zone file) for a zone is said to have authority for that zone.

Top-level Domain Names

- .com: For commercial entities, which anyone, anywhere in the world, can register.
- .net : Originally designated for organisations directly involved in Internet operations. It is increasingly being used by businesses when the desired name under "com" is already registered by another organisation. Today anyone can register a name in the Net domain.
- .org: For miscellaneous organisations, including non-profits.
- .edu: For four-year accredited institutions of higher learning.
- .gov: For US Federal Government entities
- .mil: For US military
- Country Codes :For individual countries based on the International Standards Organisation. For example, ca for Canada, and jp for Japan.

Domain Name Hierarchy

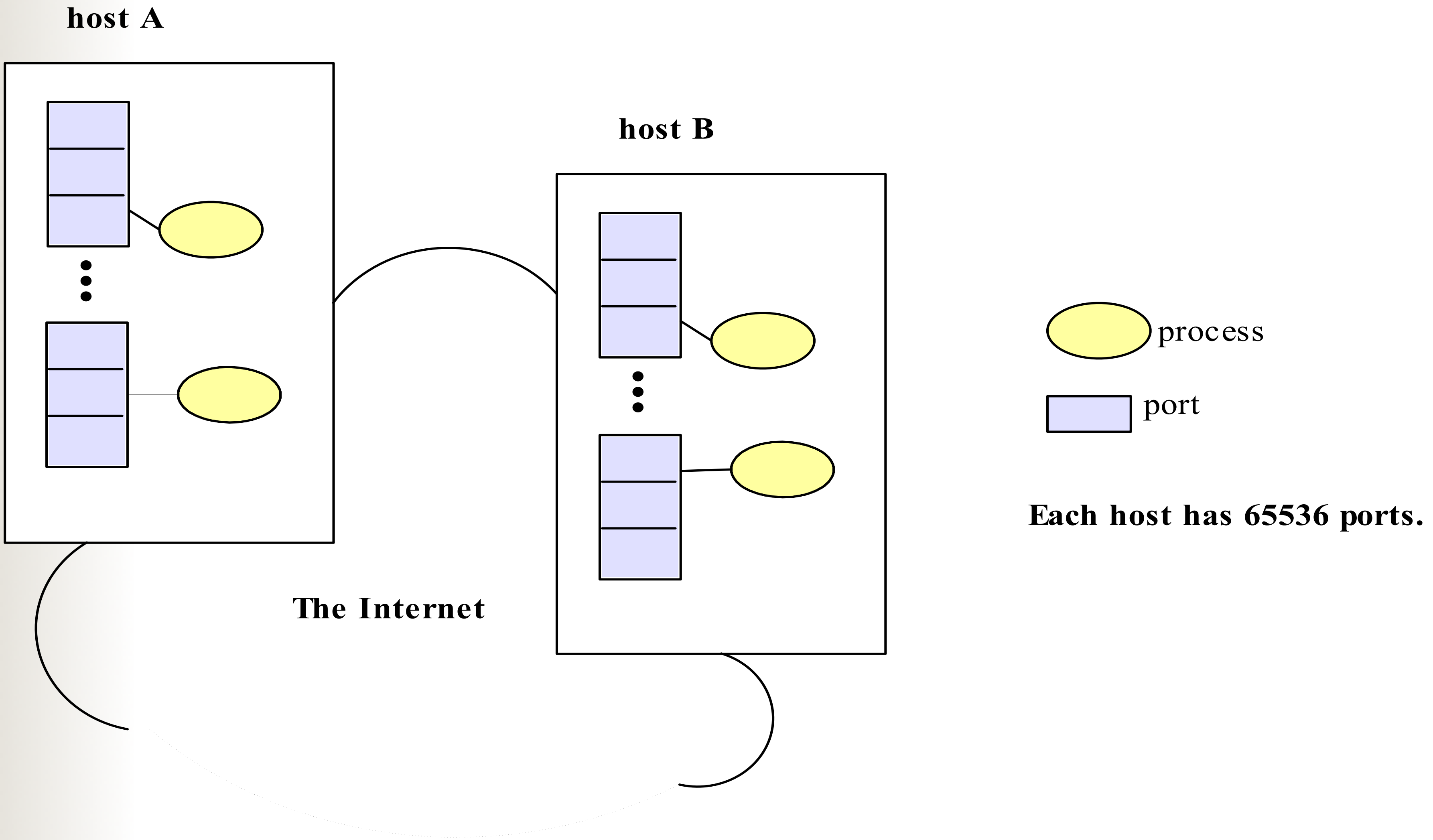


Name lookup and resolution

- If a domain name is used to address a host, its corresponding IP address must be obtained for the lower-layer network software.
- The mapping, or name resolution, must be maintained in some registry.
- For runtime name resolution, a network service is needed; a protocol must be defined for the naming scheme and for the service. Example: The DNS service supports the DNS; the Java RMI registry supports RMI object lookup; JNDI is a network service lookup protocol.

Addressing a process running on a host

Logical Ports



Each host has 65536 ports.

Well Known Ports

- Each Internet host has 2^{16} (65,535) logical ports. Each port is identified by a number between 1 and 65535, and can be allocated to a particular process.
- Port numbers between 1 and 1023 are reserved for processes which provide well-known services such as *finger*, *FTP*, *HTTP*, and *email*.

Well-known ports

Assignment of some well-known ports

Protocol	Port	Service
echo	7	IPC testing
daytime	13	provides the current date and time
ftp	21	file transfer protocol
telnet	23	remote, command-line terminal session
smtp	25	simple mail transfer protocol
time	37	provides a standard time
finger	79	provides information about a user
http	80	web server
RMI Registry	1099	registry for Remote Method Invocation
special web server	8080	web server which supports servlets, JSP, or ASP

Choosing a port to run your program

- For our programming exercises: when a port is needed, choose a random number above the well known ports: 1,024- 65,535.
- If you are providing a network service for the community, then arrange to have a port assigned to and reserved for your service.

Addressing a Web Document

The Uniform Resource Identifier (URI)

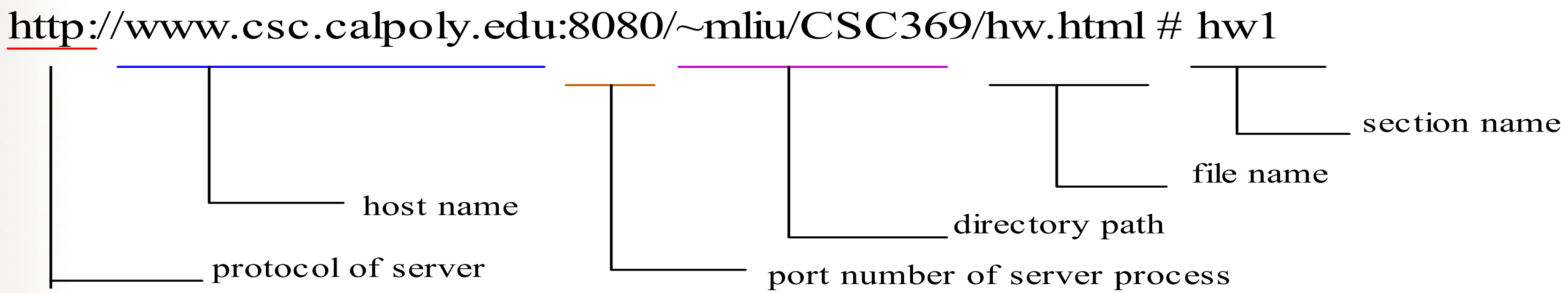
- Resources to be shared on a network need to be uniquely identifiable.
- On the Internet, a URI is a character string which allows a resource to be located.
- There are two types of URIs:
  - URL (Uniform Resource Locator) points to a specific resource at a specific location
  - URN (Uniform Resource Name) points to a specific resource at a nonspecific location.

URL

A URL has the format of:

protocol://host address[:port]/directory path/file name#section

A sample URL:



http://www.csc.calpoly.edu:8080/~mliu/CSC369/hw.html # hw1

section name

file name

host name

directory path

protocol of server

port number of server process

Other protocols that can appear in a URL are:

file
ftp
gopher
news
telnet
WAIS

More on URL

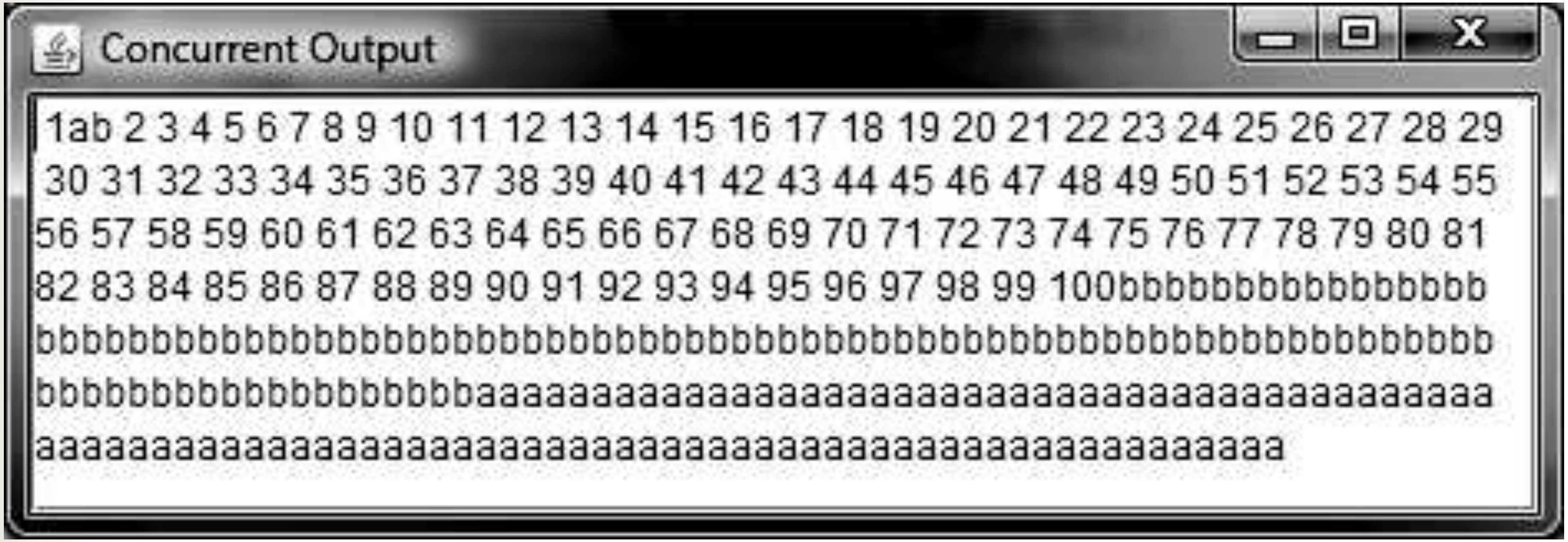
- The path in a URL is relative to the document root of the server. On the CSL systems, a user's document root is ~/www.
- A URL may appear in a document in a relative form:

  < a href="another.html">

  and the actual URL referred to will be *another.html* preceded by the protocol, hostname, directory path of the document .

Exercise

- (*Revise Listing the examples and exercise code "TaskThreadDemo.java" on moodle*) Rewrite the exercise code to display the output in a text area, as shown in the Figure below.



```
1ab 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29
30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55
56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81
82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 100bbbbbbbbbbbbbbbb
bbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbb
bbbbbbbbbbbbbbbbbbbaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaa
aaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaa
```