Presentation Services

- need for a presentation services
- ASN.1
  - declaring data type
  - encoding data types
- implementation issues
- reading: Tannenbaum 7.3.2

Presentation Services: Motivation

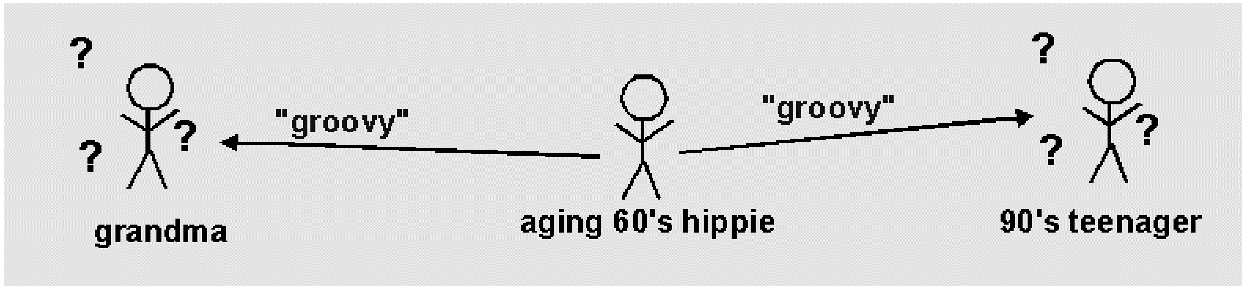
Question: suppose we could copy reliably from one computer's memory to another. Would this "solve" communication problem?

Answer: ?

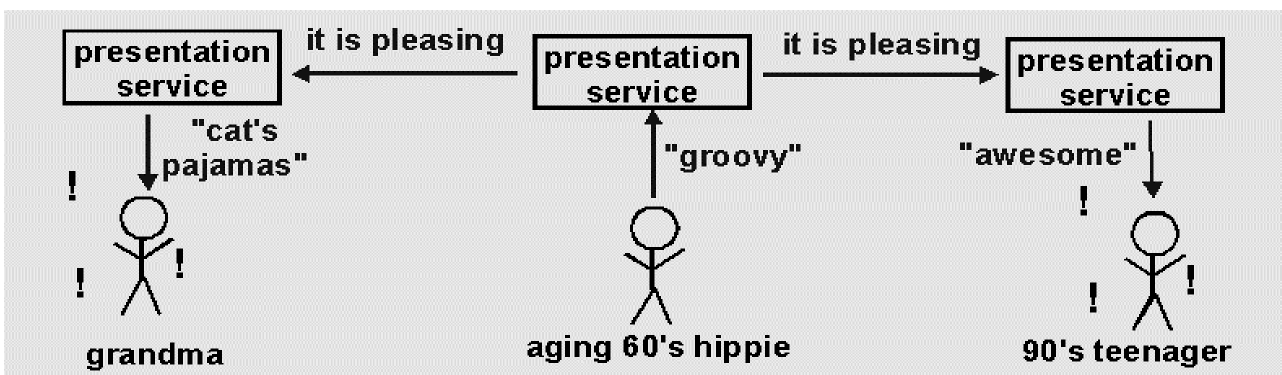
Crux of problem:

- deal with *meaning* of information, not *representation*
- different computers, OS, compilers have different conventions for representing data
  - architecture: big endian versus little endian
  - floating point format
  - data type size: 16, 32, 64 bit int
  - different size, layout of data structures

Solving the representation problem



- have sender encode to receiver's format
- have receiver decode from sender's format
- have machine-, OS-, language-independent method for describing data structures
  - host translates to/from universal description language from/to own format
- pros and cons?



ASN.1: Abstract Syntax Notation 1

ISO standard (one still meaningful)

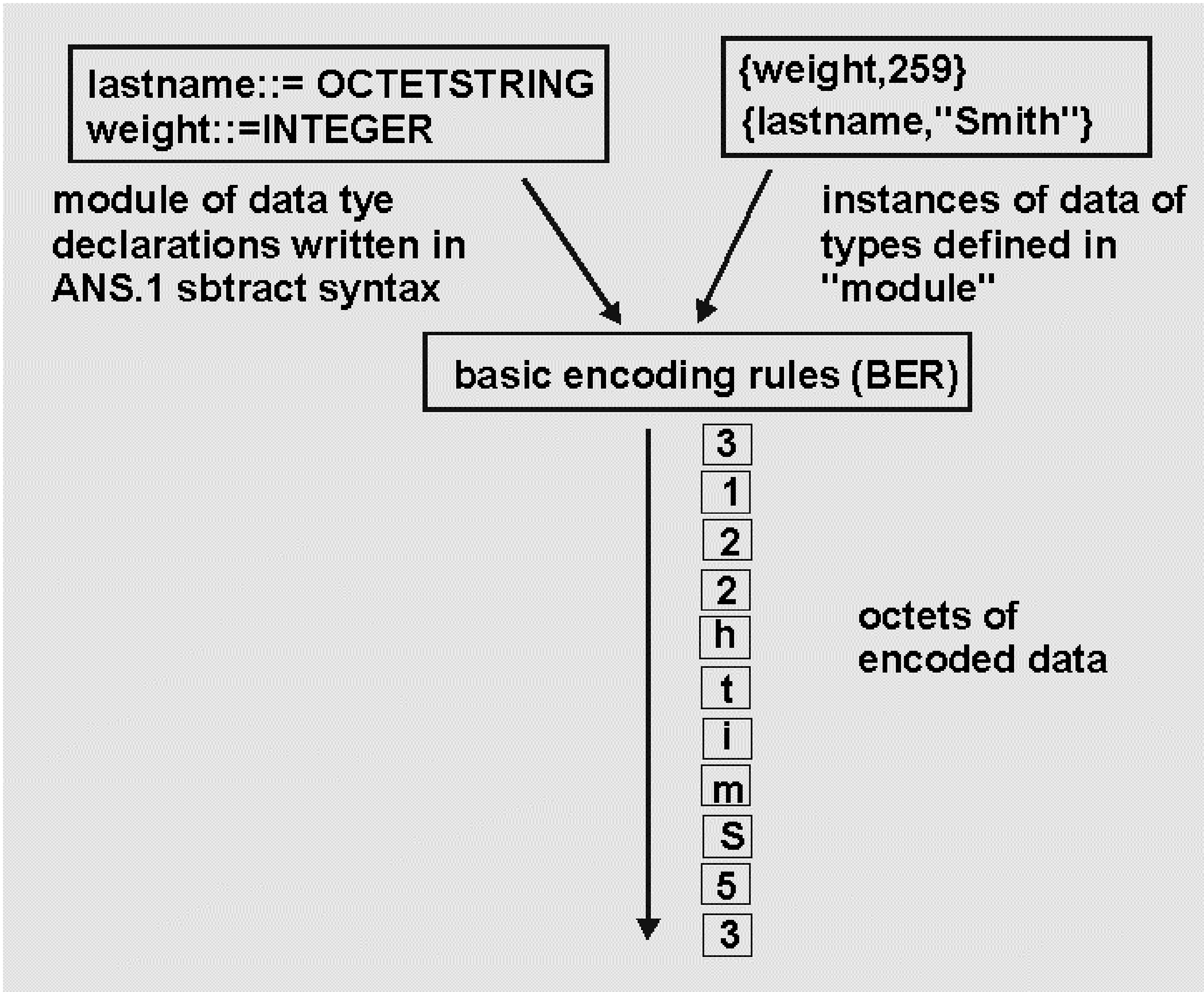
abstract syntax: “language” for describing data structures

- data description language, not programming language
- defines universal data types
- allows user-defined data types

basic encoding rules:

- convert abstract syntax specification of data structure into series of bytes (for transmission)

ASN.1: a pictorial view



ASN.1: Universal Types

predefined types with given tag value

Tag	Type	Commend
1	BOOLEAN	value is true or false
2	INTEGER	can be arbitrarily big
3	BITSTRING	list of one or more bits
4	OCTET STRING	list of one or more bytes
5	NULL	no value
6	OBJECT IDENTIFIER	refers to an “object”, e.g. protocol number
9	REAL	floating point

Example declarations: think of ::= as defining new data type in terms of universal data type

```
Married ::= BOOLEAN
SSN ::= INTEGER
Lname ::= OCTETSTRING
Salary ::= REAL
IPAddress ::= OCTETSTRING (SIZE 4)
```

ASN.1 Syntax: constructors

ASN.1 defines constructor types for building more complex data types of “simpler” data types:

Tag	Type	Comments
16	SEQUENCE	ordered list, each element an ASN.1 type
17	SET	same as sequence but unordered
11	CHOISE	a type taken from specified list

example of constructed data type:

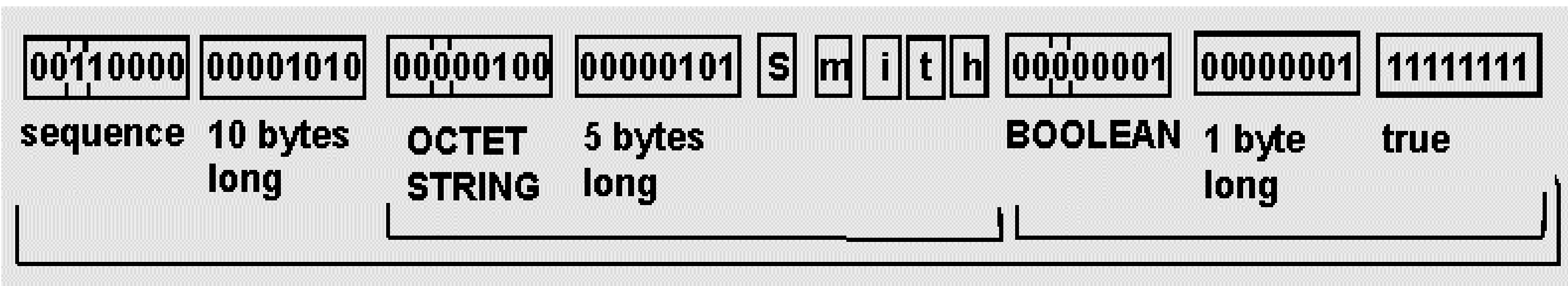
```
studentRecord ::=  SEQUENCE {
    Lname OCTETSTRING,
    Fname  OCTETSTRING,
    Mname OCTETSTRING,
    Married BOOLEAN DEFAULT FALSE,
    SSN INTEGER
    }
```

ASN.1 Encoding Example

The ASN.1 definition:

```
Attendee ::= SEQUENCE {
    name  OCTET STRING,
    paid    BOOLEAN }
```

The data {“Smith”,T} would be encoded:



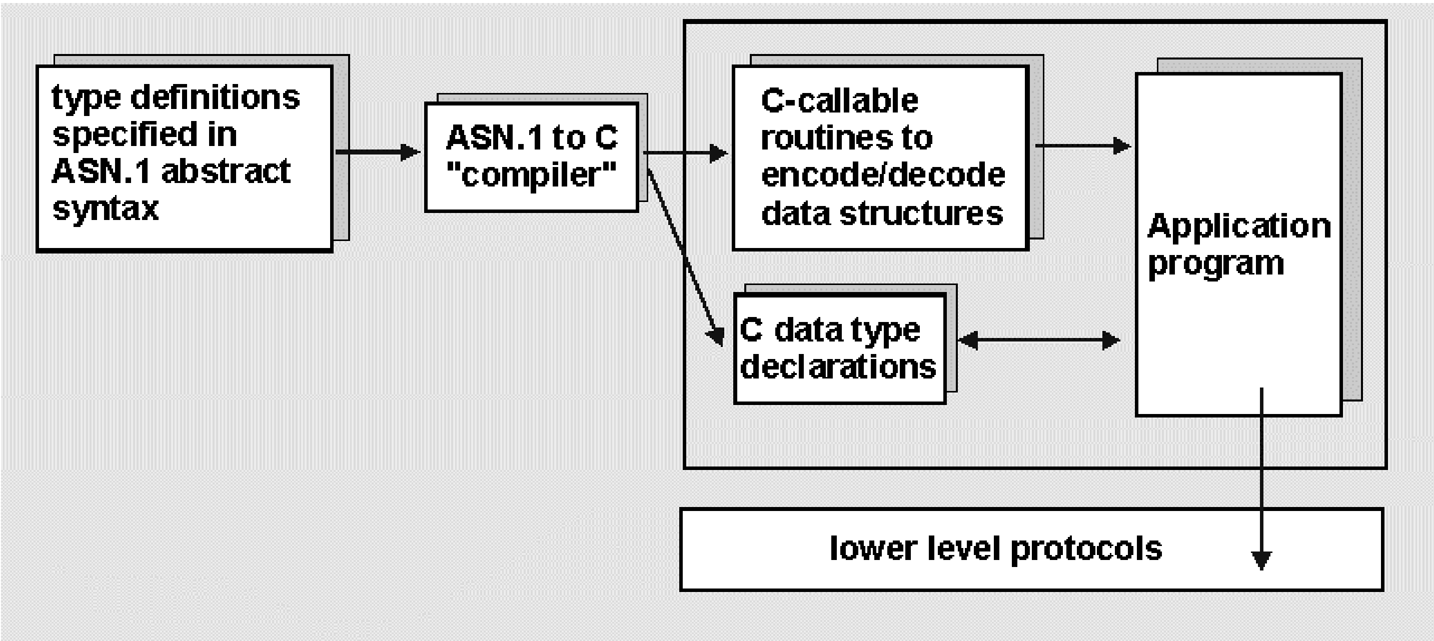
Note nesting of TLV structure in above example

ASN.1: But how do I use it?

Normal people don't want to write encoding/decoding routines!

ASN.1 "compilers" take ASN.1 abstract syntax module and produce

- C data type definitions (e.g., typedef's) that user can #include to create data structures having these types
- library of C-callable rouitnes (e.g., one for each data type) to encode/decode each typedef to/from TLV encoding



External Data Representation: XDR

- developed by SUN (RFC 1014)
- similar to ASN.1 in power
- the de facto standard for most client-server applications
  - underlies SUN RPC and NFS
- both stream oriented (TCP) and record oriented (UDP)
- XDR can be combined with remote procedure calls
  - rpcgen compiler allows you to write rpc and encodes data in XDR format

Presentation Services: closing thoughts

- presentation processing expensive:
  - up to 90% processing time on ethernet/IP/TCP/presentation stack
  - cost to encode array of int’s 5-20 times more expensive than copy
  - too heavyweight?
- interesting reading:
  - John Larmouth's book "Understanding OSI" : chapter 8: ASN.1
  - role of ASN.1 in next generation http
  - Neufeld and Y. Yang, “An ASN.1 to C compiler,” *IEEE Trans. Software Engineering*, Oct. 1990
  - C. Huitema and A. Doghri, “Defining Faster Transfer Syntaxes for the OSI Presentation Protocol,” *ACM Computer Communication Rev*. Oct. 1989
  - D.E. Comer, D.L. Stevens, *Internetworking with TCP/IP, vol. III,* Prentice Hall, 1994.

Network Application Programming

Introduction: issues

Sockets: programming and implementation

Other API's:

- winsock
- java
- transport layer interface (TLI)
- Novell netware API

Reading: Tannenbaum, page 486-487, KR Chapter 2

ftp://gaia.cs.umass.edu/cs653/sock.ps

The Application Programming Interface: API

- ***API:*** the programming model, application callable services, interfaces, and abstractions provided by the network (i.e., lower layers) to the application.
- does an API provide for:
  - ***naming and service location:*** must application know precise location (e.g., host address and port) of service? Can services be requested by name? Can servers registers services?
  - ***connection management.*** must applications do low-level handshaking required to setup/teardown connection?

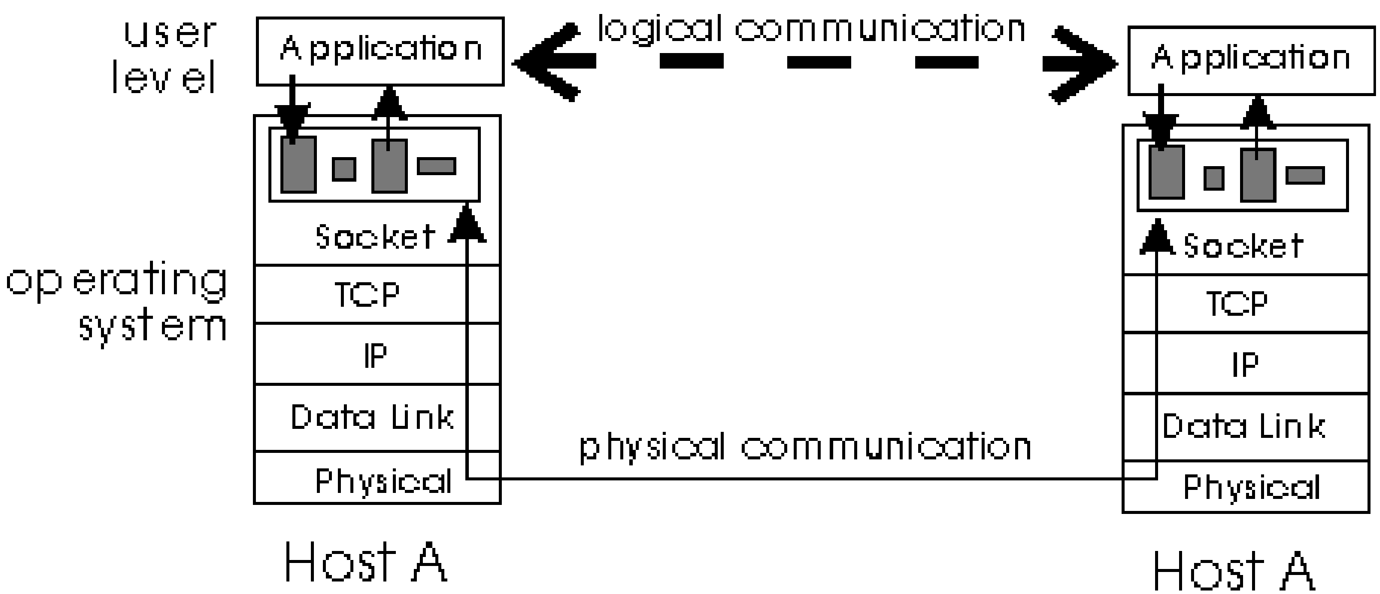
The API (continued)

Does an API provide for:

- **message transfer**
  - application-selectable data transfer services: best-effort versus reliable?
  - message priorities?
  - multi-site atomic actions?
  - structured versus byte-stream communication?
- **communication flexibility**
- can application select and/or modify protocol stacks (statically or dynamically)?
- **Quality of Service specification**
  - can application specify QoS requirements to network?

The SOCKET API

- introduced in 1981 BSD 4.1 UNIX
- a ***host-local, application created/owned, OS-controlled interface*** into which application process can both ***send and receive messages*** to/from another (remote or local) application process



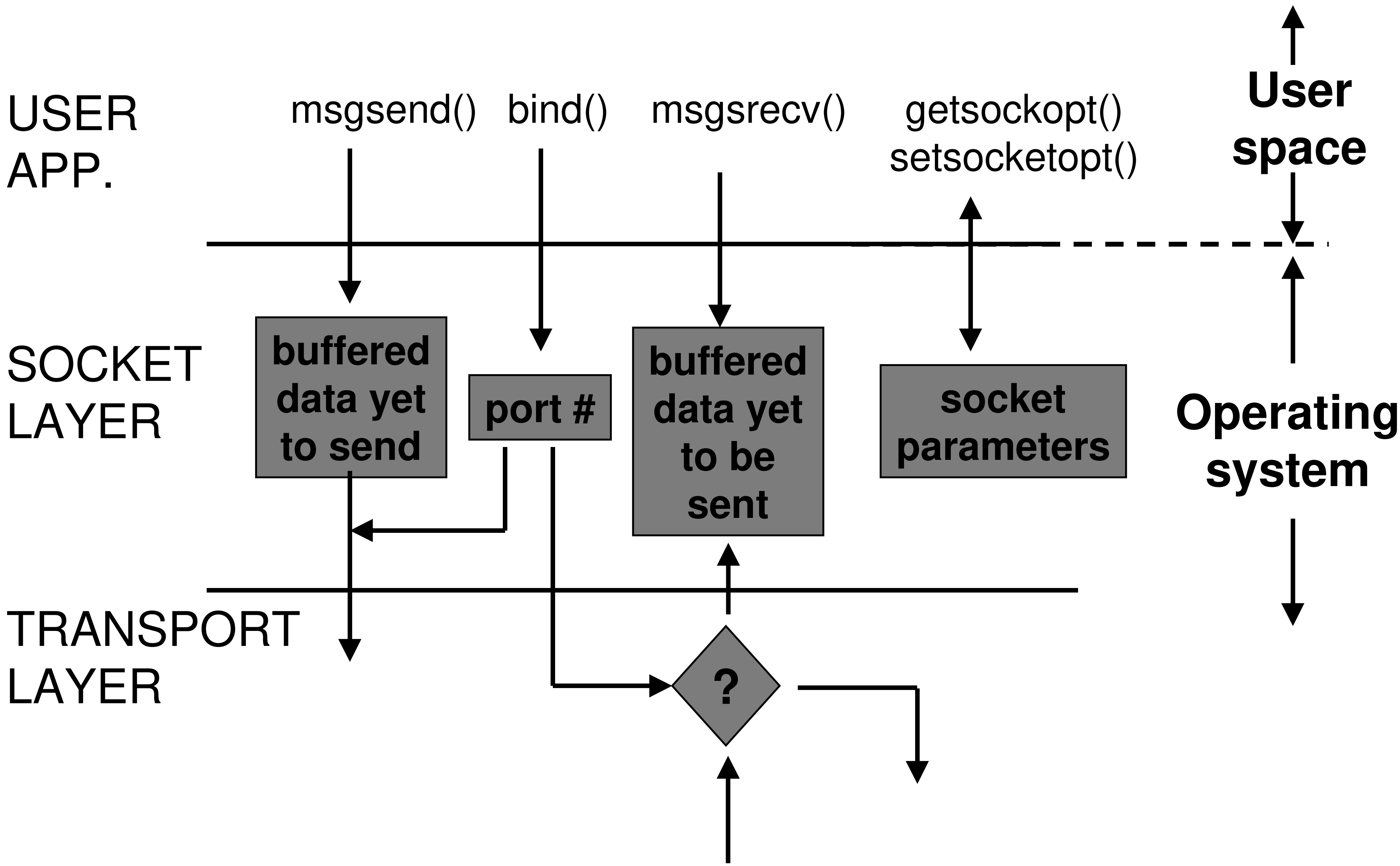
The SOCKET API (cont)

- two sockets on separate hosts ``connected'' by OS socket management routines. Application only sees local socket.
- sockets explicitly created, used, released by applications
- based on client/server paradigm
- two types of transport service via socket API:
  - unreliable datagram
  - reliable, stream-oriented
- presentation, session layers missing in UNIX networking (an application concern!).

Sockets: conceptual view

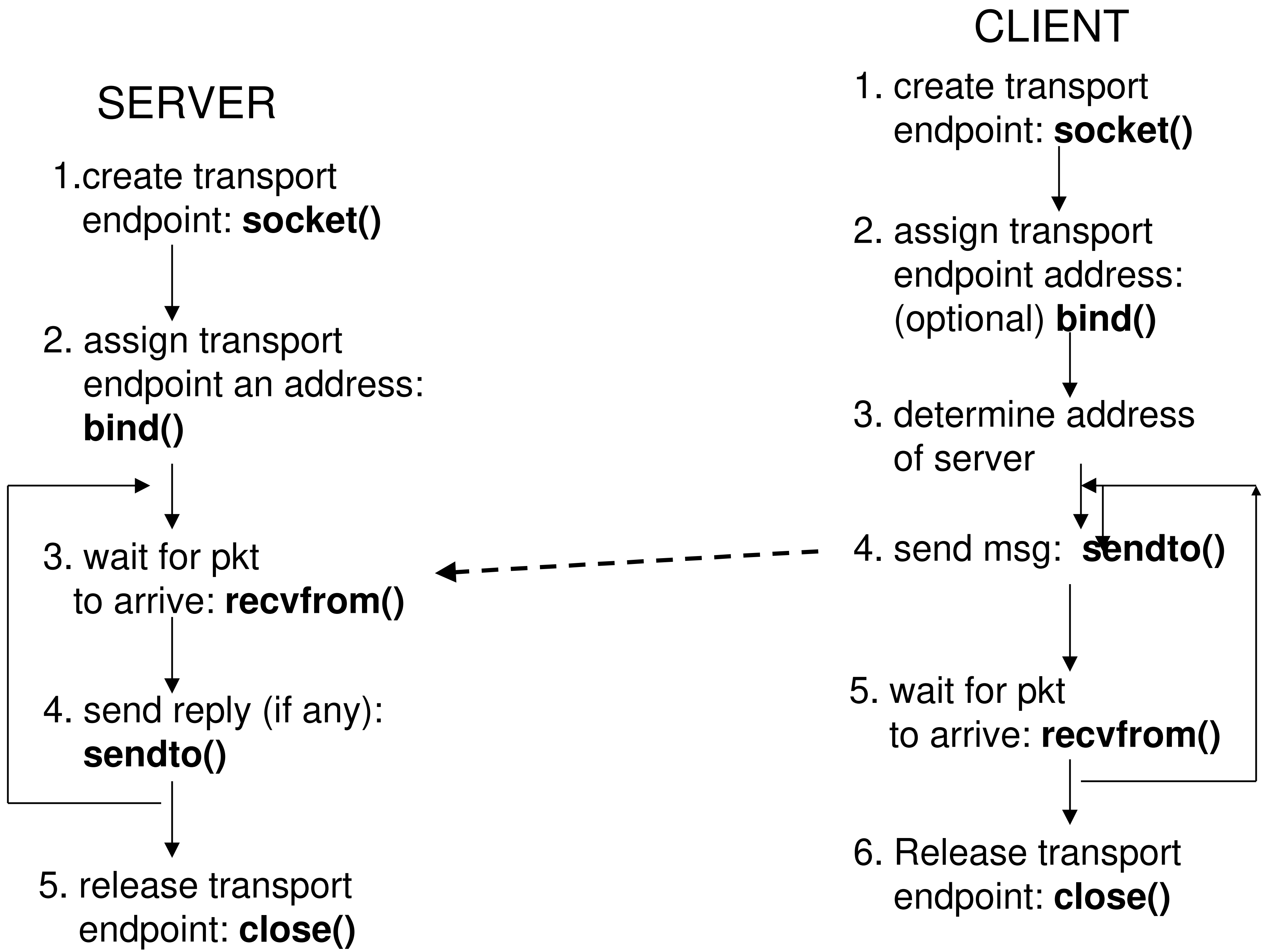
- each socket has separate send/receive buffers, port id, parameters (application queryable and setable).
- socket operations implemented as system calls into OS
- user/kernel boundary crossed: overhead

Sockets: conceptual view



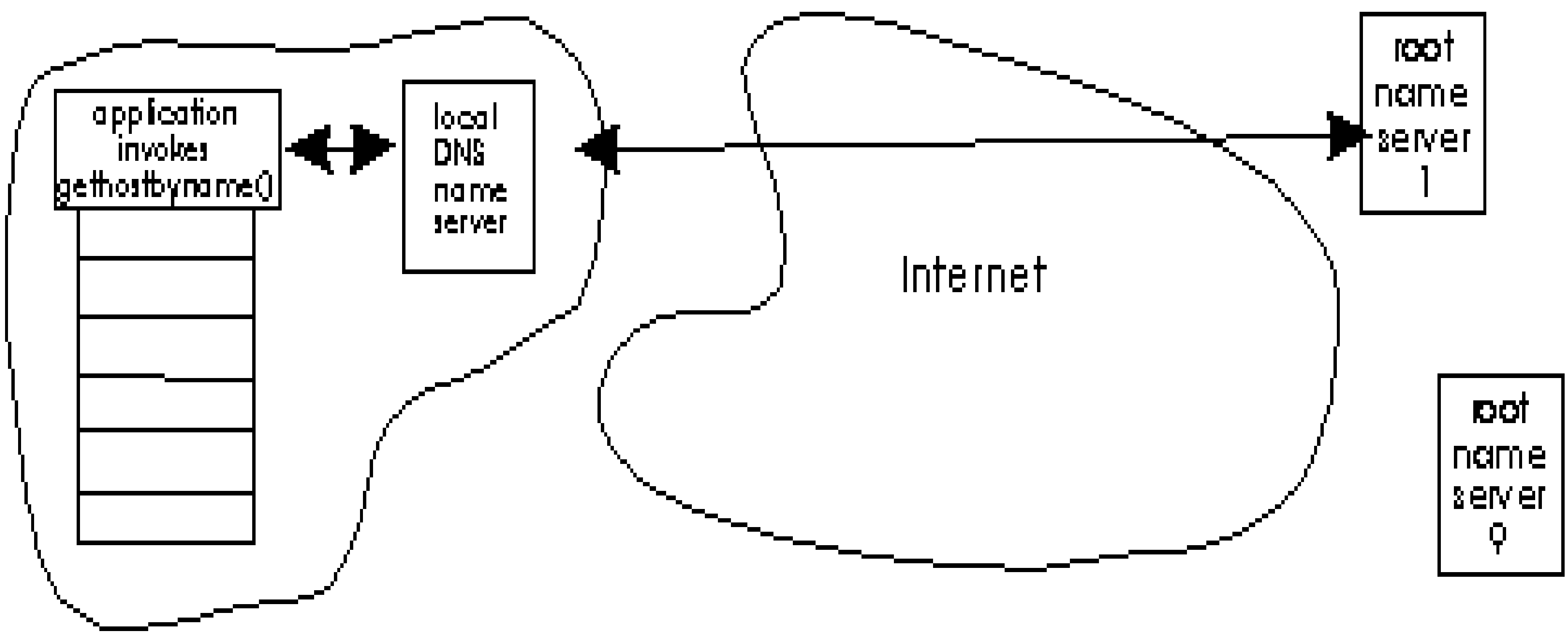
Connectionless Service

- ***datagram service:*** underlying transport protocols ***do not guarantee delivery***
- no explicit identification of who is server, who is client
- **if initiating contact** with other side, need to know
  - IP address
  - port number of process waiting to be contacted.
- **if waiting for contact** from other side, need to declare
  - port number at which waiting for other side


SERVER
1.create transport endpoint: **socket()**
2. assign transport endpoint an address: **bind()**
3. wait for pkt to arrive: **recvfrom()**
4. send reply (if any): **sendto()**
5. release transport endpoint: **close()**
CLIENT
1. create transport endpoint: **socket()**
2. assign transport endpoint address: (optional) **bind()**
3. determine address of server
4. send msg: **sendto()**
5. wait for pkt to arrive: **recvfrom()**
6. Release transport endpoint: **close()**

DNS: Internet Domain Name System

- a **distributed database** used by TCP/IP applications to map to/from hostnames from/to IP addresses
- **name servers :**
  - user-level library routines `gethostbyname()` and `gethostbyaddress()` contact local nameserver via port 53
  - name server returns IP address of requested hostname


application
invokes
gethostbyname()
local
DNS
name
server
Internet
root
name
server
1
root
name
server
9

DNS: non-local names

finding non-local names

- no single name server has complete info
- if local name server can't resolve address, contacts root name server:
  - 9 redundant root nameservers world-wide
  - each has addresses of names servers for all level-two name servers (e.g., umass.edu, ibm.com)
  - contacted root server returns IP address of name server resolver should contact
  - contacted level-two name server may itself return a pointer to another name server
  - name resolution an iterative process of following name server pointers
  - DNS protocol specifies packet formats for exchanges with DNS servers

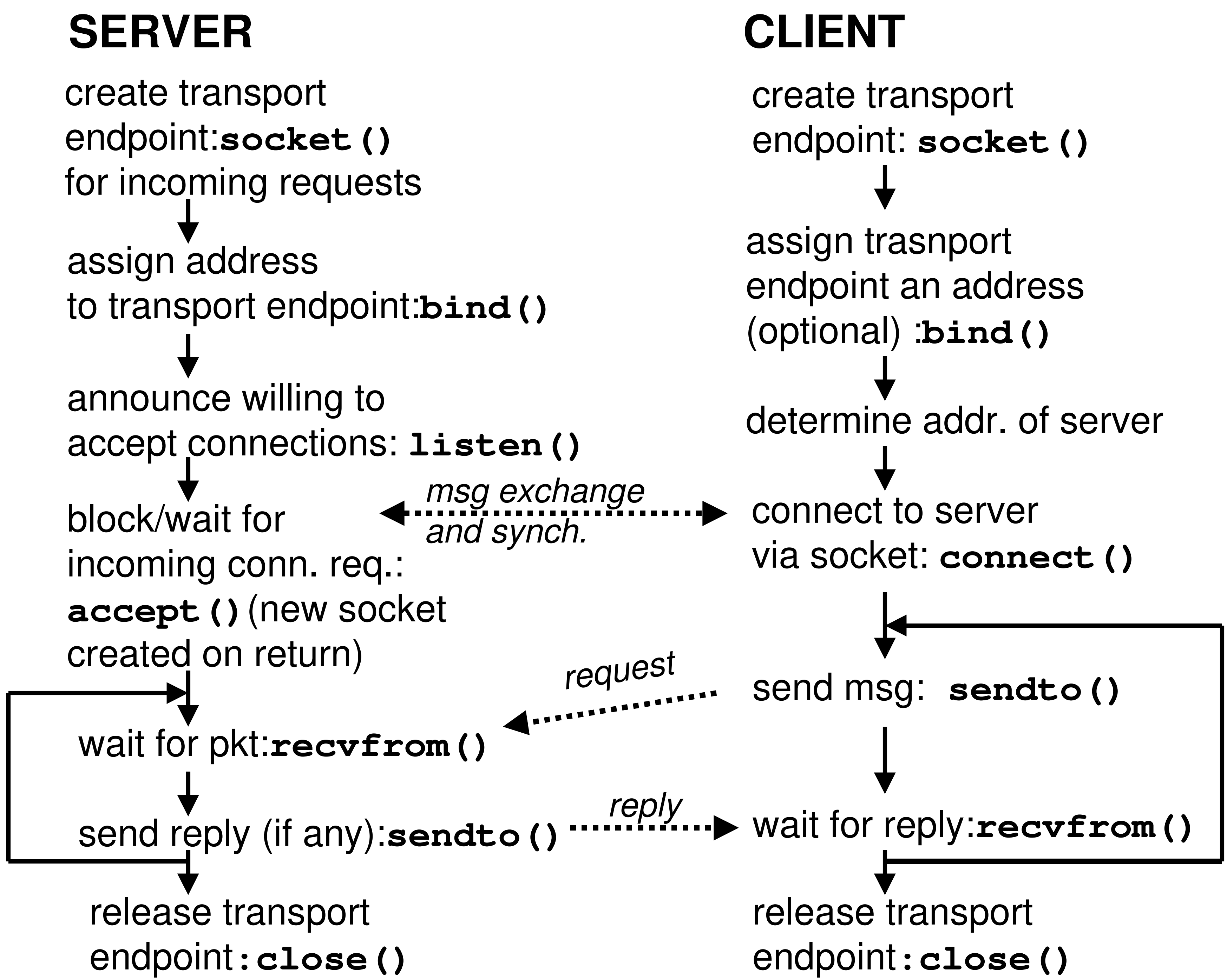
Assigning socket a network address: bind()

- each socket must be associated with a local, host-unique 16-bit port number.
- need to associate socket with globally unique network address (host address and port)
  - OS knows that incoming messages addressed to this host address and port to be delivered (demultiplexed to) to this socket
  - a return address for outgoing messages

Port Numbers

Port number(s)	comment
1 - 255	reserved for standard services
21	ftp service
23	telnet service
25	SMTP email
80	http daemon
1 - 1023	available only to privileged users
1024 - 4999	usable by system and user processes
5000 -	usable only by user processes

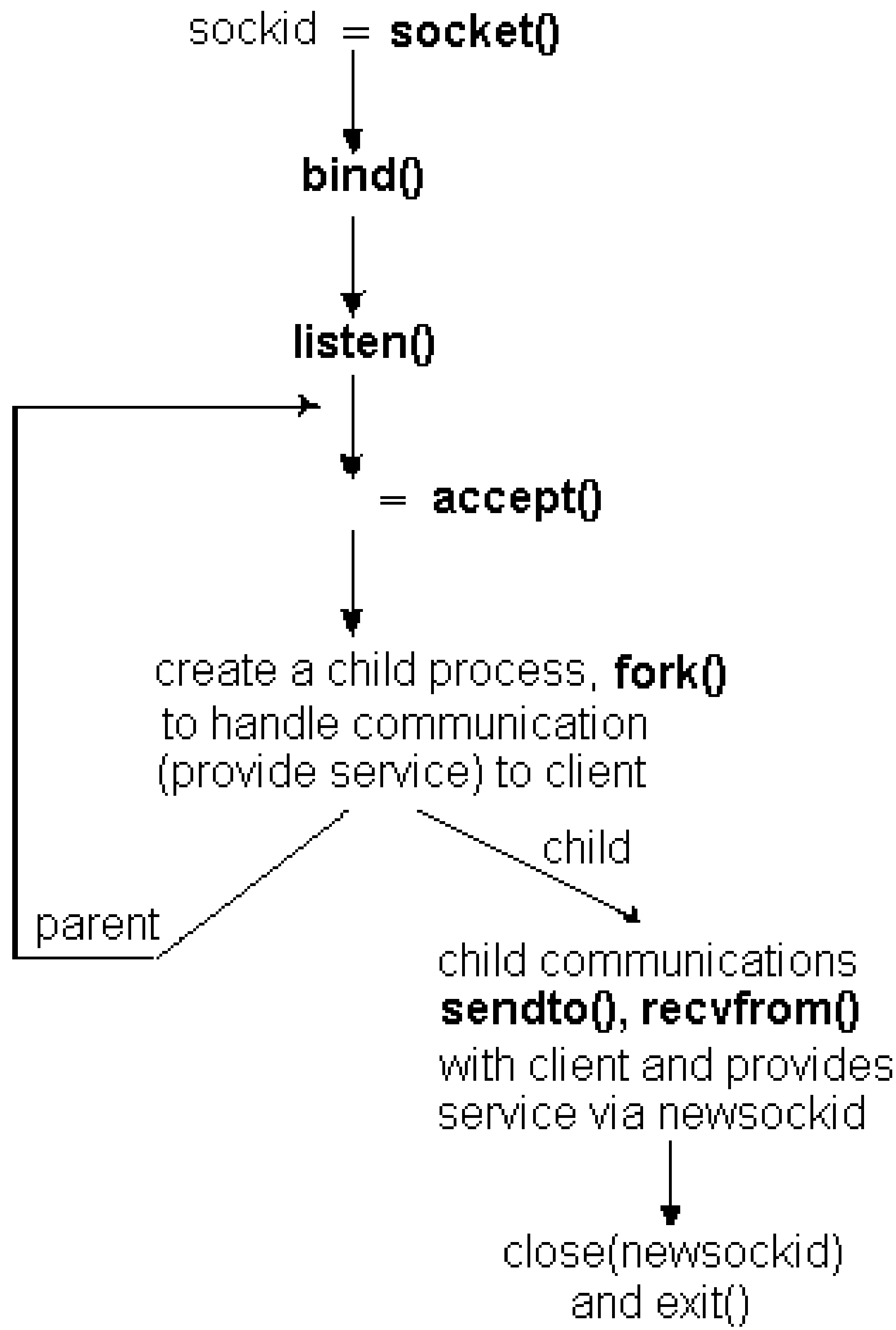
Connection-oriented service


SERVER
create transport
endpoint:socket()
for incoming requests
assign address
to transport endpoint:bind()
announce willing to
accept connections: listen()
block/wait for
incoming conn. req.:
accept() (new socket
created on return)
wait for pkt:recvfrom()
send reply (if any):sendto()
release transport
endpoint:close()
CLIENT
create transport
endpoint: socket()
assign trasnport
endpoint an address
(optional) :bind()
determine addr. of server
connect to server
via socket: connect()
send msg: sendto()
wait for reply:recvfrom()
release transport
endpoint:close()
msg exchange
and synch.
request
reply

Connection-oriented service

- client/server handshaking:
  - client must explicitly connect to server before sending or receiving data
  - client will not pass `connect()` until server accepts client
  - server must explicitly accept client before sending or receiving data
  - server will not pass `accept()` until client connect()'s
- connection-oriented service: underlying transport service is **reliable, stream-oriented.**

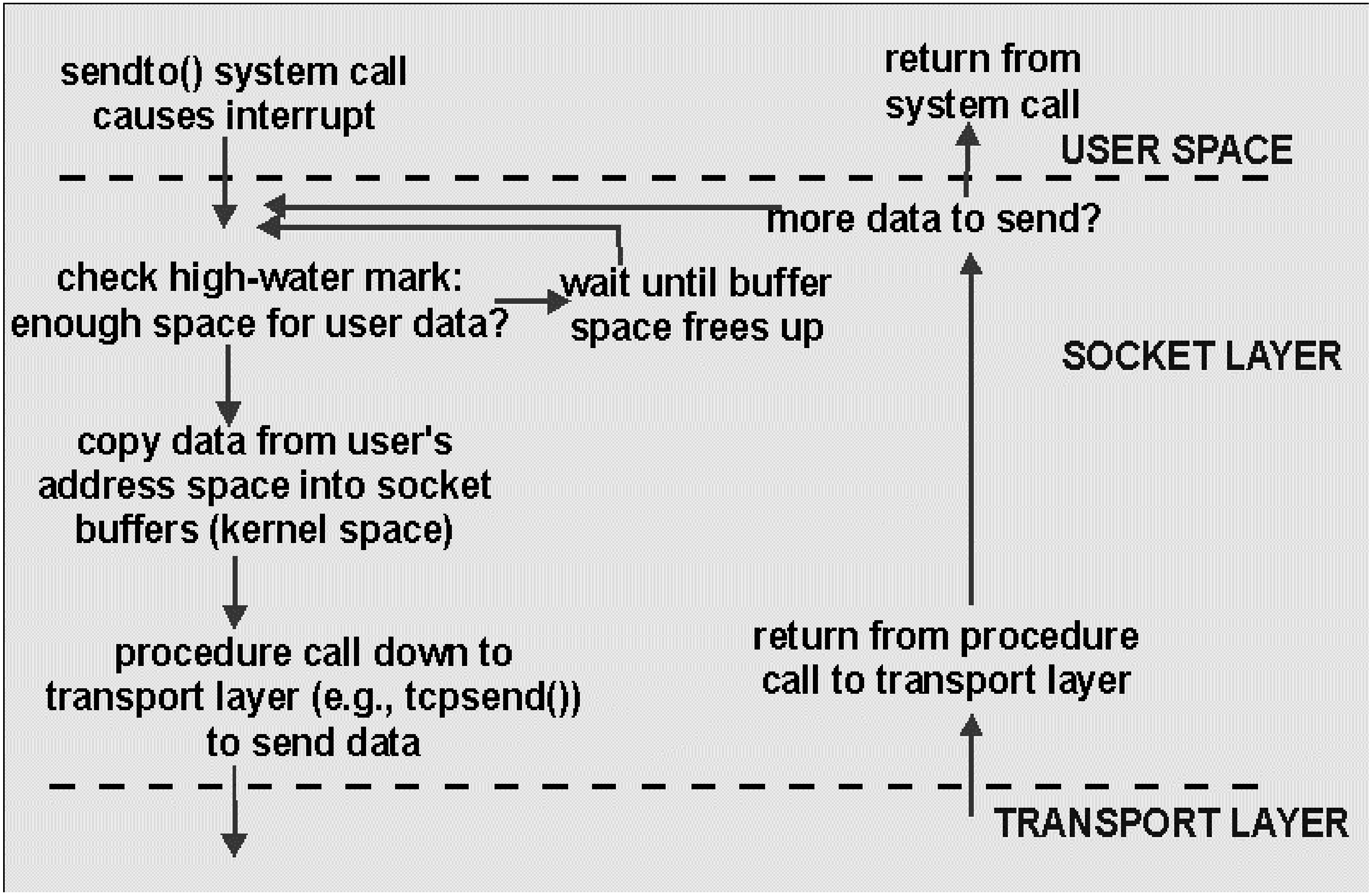
Typical server structure



Aside: other useful system calls and routines

- **`close(sockfd)`** will release a socket
- **`getsockopt()`** and **`setsockopt()`** system calls used to query/set socket options.
- **`ioctl()`** system call used to query/set socket attributes, also network device interface attributes.

Implementation: OS actions on sendto()



Windows Sockets

Based on BSD sockets:

- BSD: ``the de facto standard for TCP/IP Networking'' (quote from Winsock1.1 documentation)
- supports stream(TCP)/datagram(UDP) model
- API the same as what we have seen

A few differences/incompatibilities:

- extensions for asynchronous programming
- different error return codes: -1 not the error return code!
- socket identifier different from file identifier
- read(), write(), close() should not be used
- use socket-specific equivalents instead

API: Summary

- some API's provide only low-level interface to transport services: socket, winsock, TLI
- other API's provide higher-level services (e.g., transaction support, service advertising or request)
  - makes building applications easier
- sockets the de facto standard
- FYI reading:
  - winsock: http://www.sockets.com
  - JAVA: http://java.sun.com
  - Tutorial on sockets: http://manic.cs.umass.edu