CSE 333 Section 8

Client-side Networking

Logistics

Due Next Monday (11/22):

- Ex-14 @ 10am

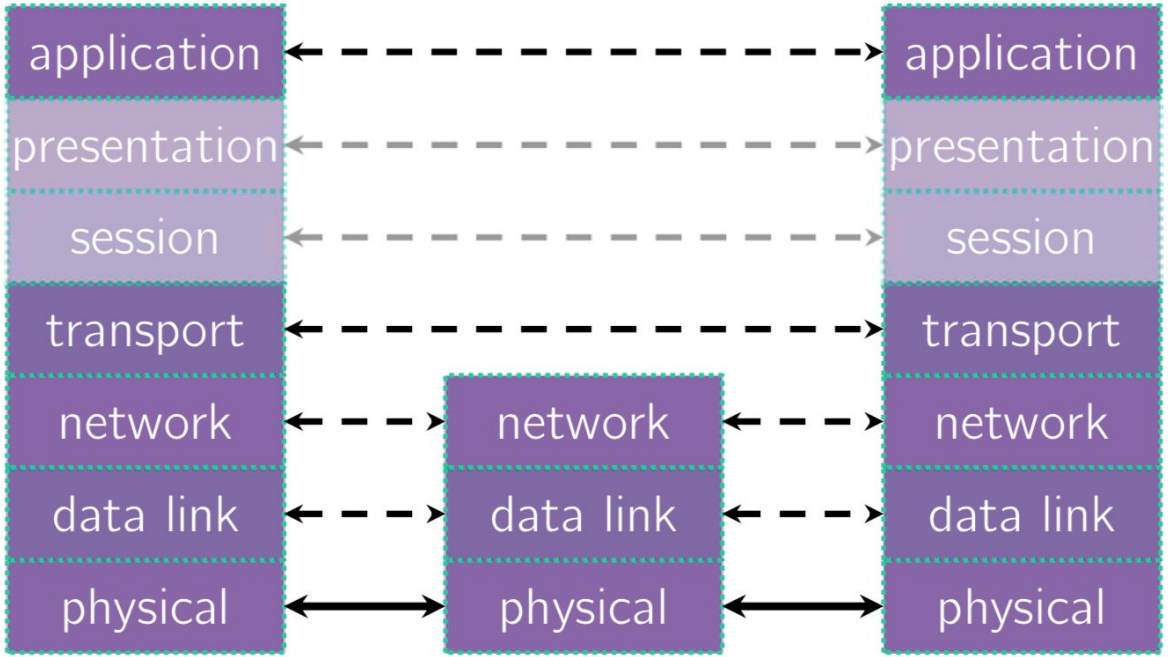
Due Next Wednesday (11/24):

HW3 @ 11pm

Feel free to use provided code from lecture for HW3!

Networking - At a High Level

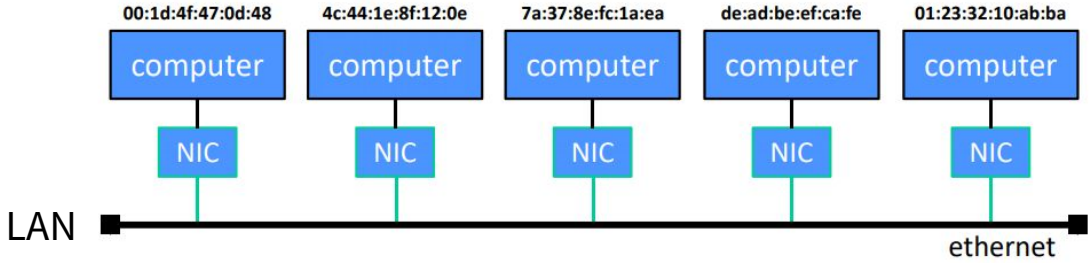
Computer Networks: A 7-ish Layer Cake



Computer Networks: A 7-ish Layer Cake

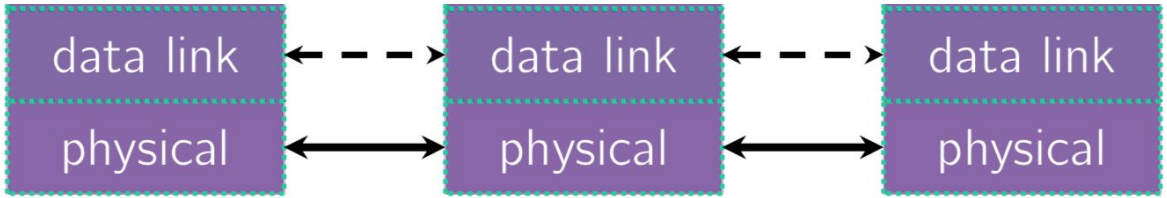
bit encoding at signal level

Computer Networks: A 7-ish Layer Cake

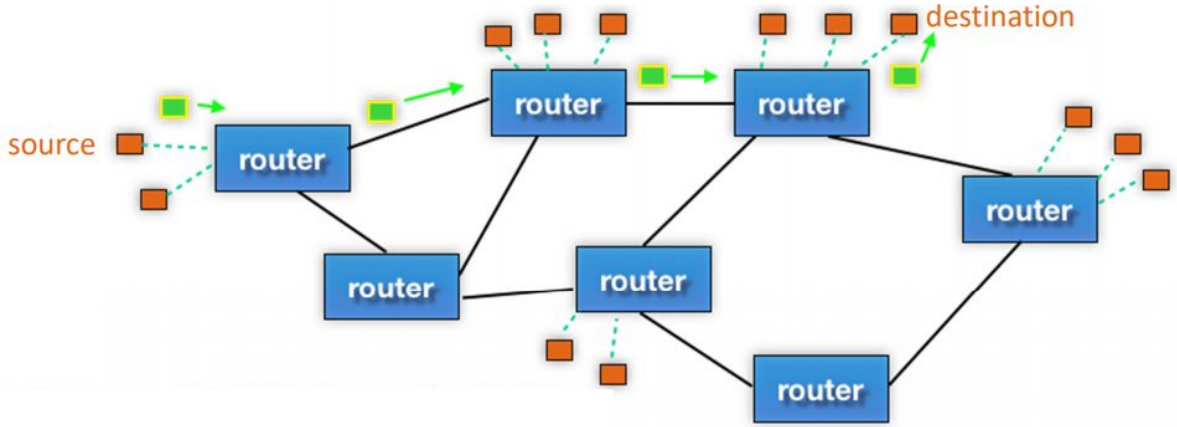


multiple computers on a local network

bit encoding at signal level



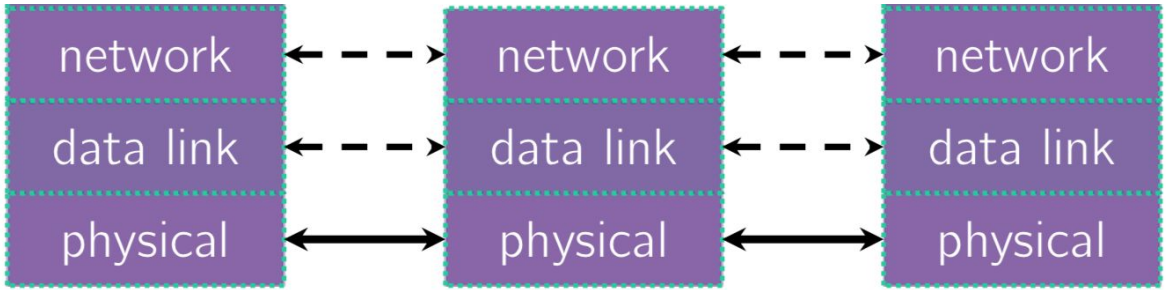
Computer Networks: A 7-ish Layer Cake



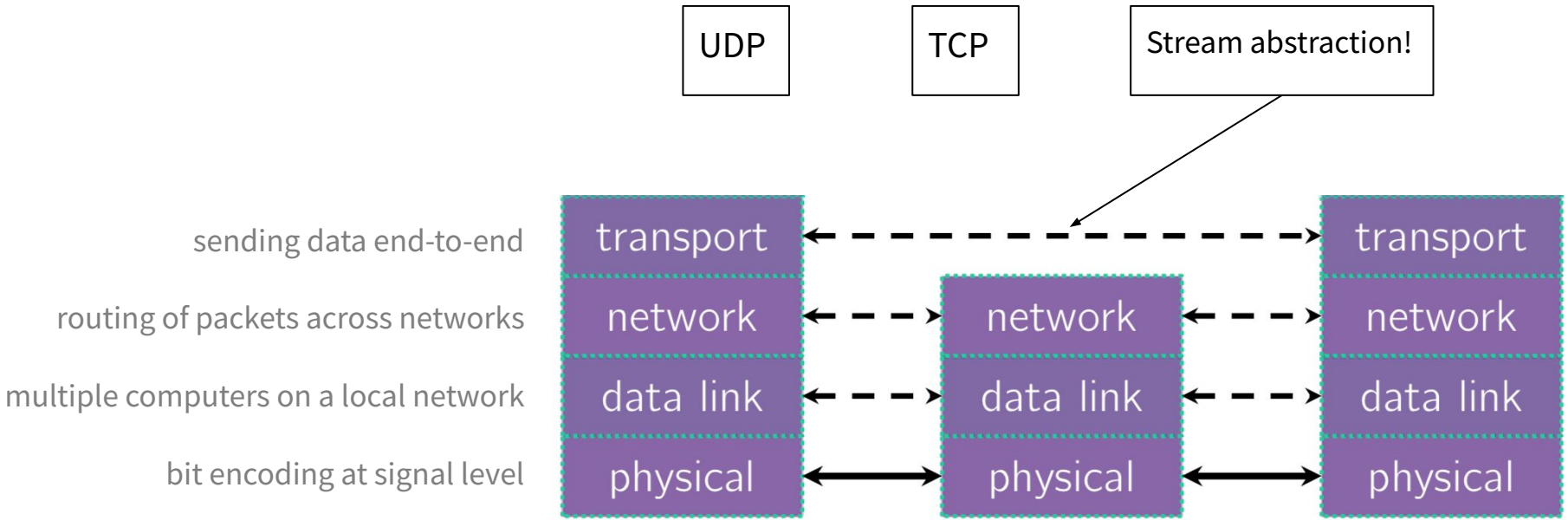
routing of packets across networks

multiple computers on a local network

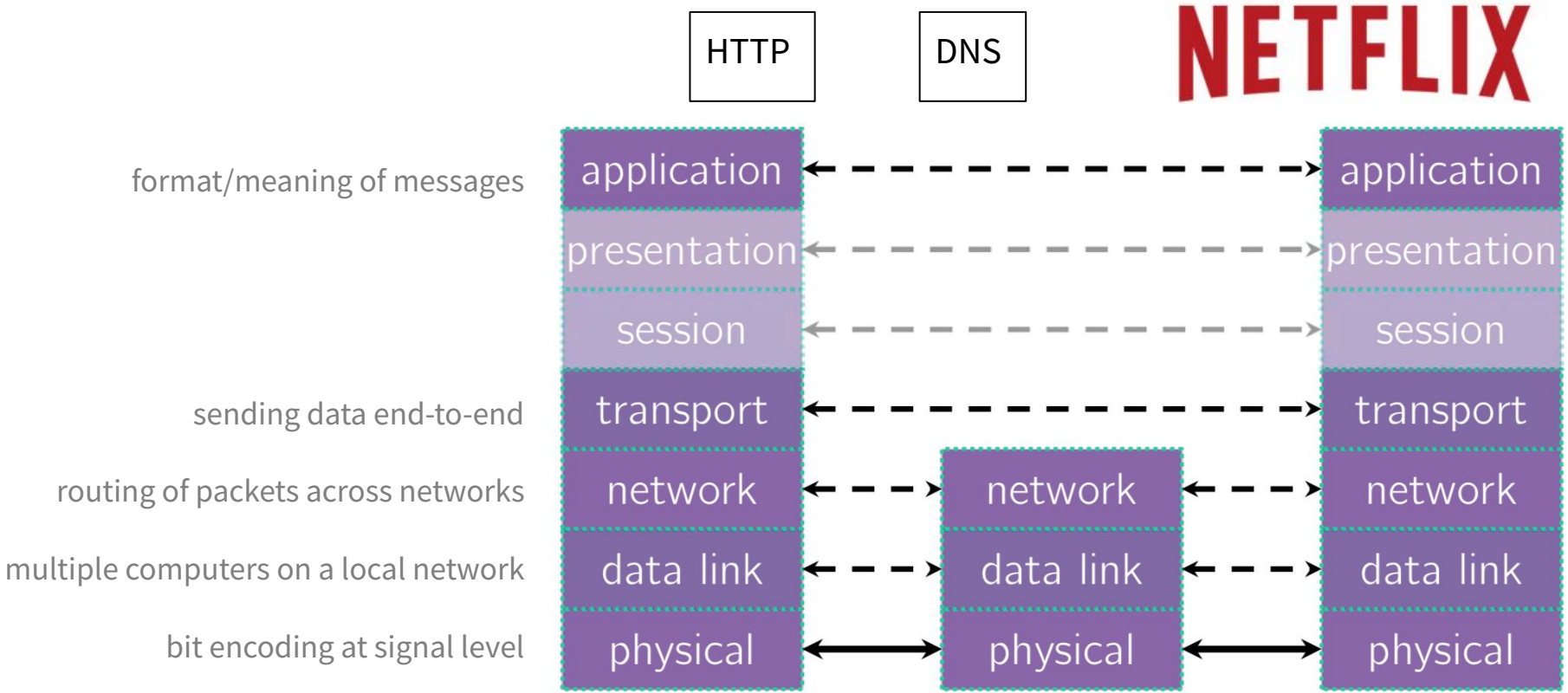
bit encoding at signal level



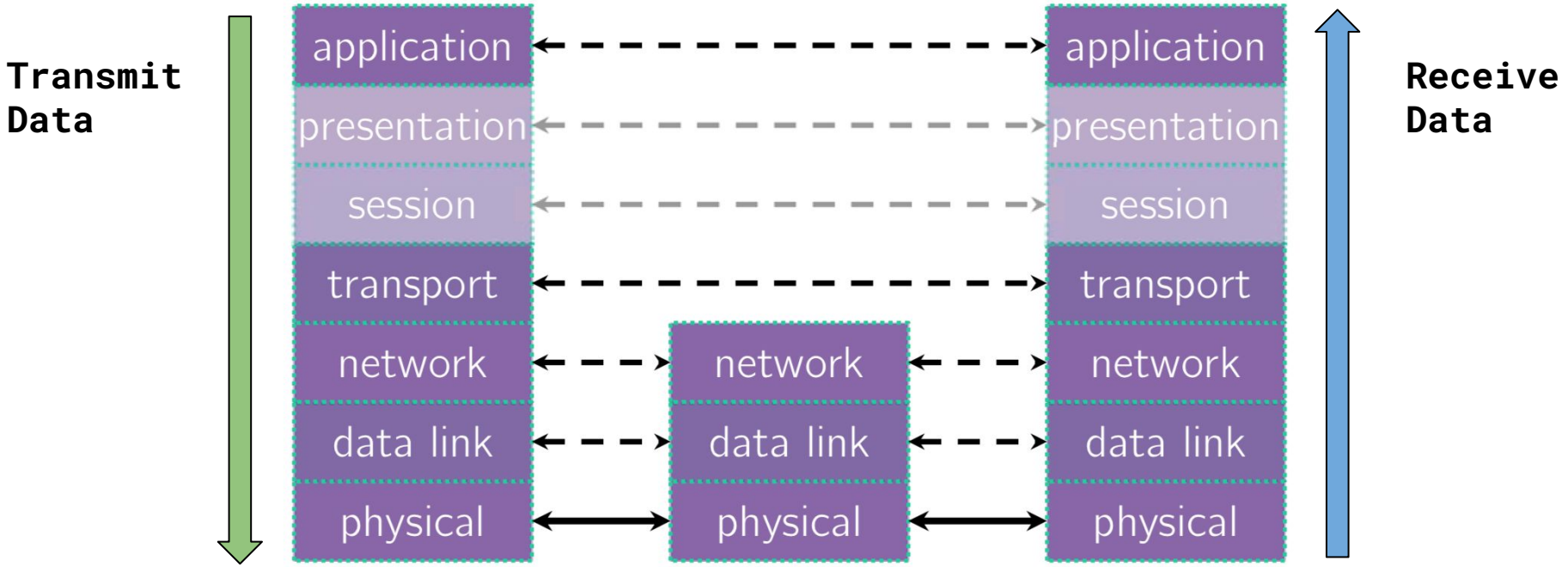
Computer Networks: A 7-ish Layer Cake



Computer Networks: A 7-ish Layer Cake



Data flow

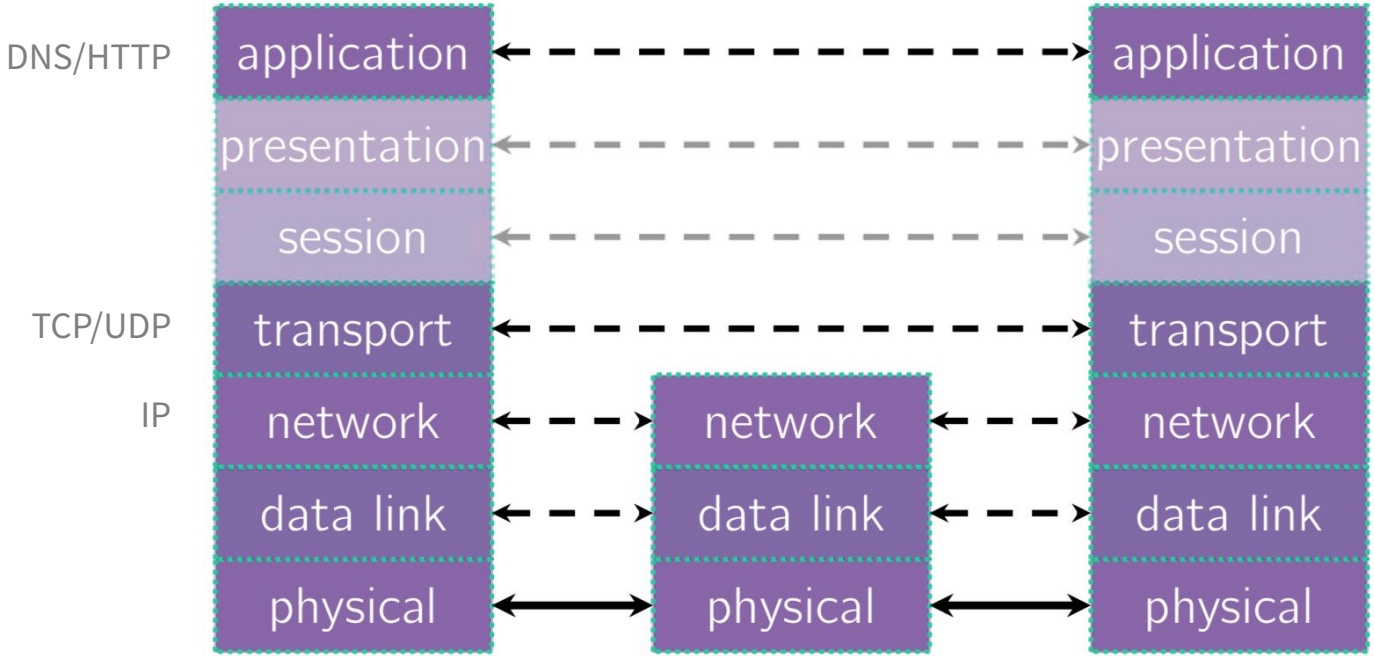

Transmit Data
application
presentation
session
transport
network
data link
physical
network
data link
physical
application
presentation
session
transport
network
data link
physical
Receive Data

Exercise 1

Exercise 1

- DNS: Translating between IP addresses and host names. (Application Layer)
- IP: Routing packets across the Internet. (Network Layer)
- TCP: Reliable, stream-based networking on top of IP. (Transport Layer)
- UDP: Unreliable, packet-based networking on top of IP. (Transport Layer)
- HTTP: Sending websites and data over the Internet. (Application Layer)

Exercise 1


DNS/HTTP
application
presentation
session
TCP/UDP
transport
IP
network
data link
physical
network
data link
physical
application
presentation
session
transport
network
data link
physical

TCP versus UDP

Transmission Control Protocol(TCP)

- Connection oriented Service
- Reliable and Ordered
- Flow control

User Datagram Protocol(UDP)

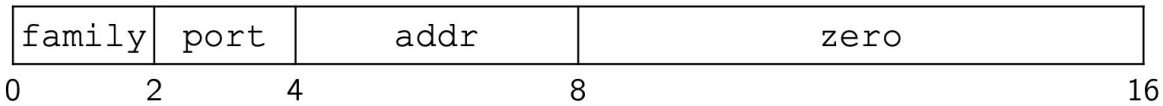
- Connectionless service
- Unreliable packet delivery
- Faster
- No feedback

Client-side Networking

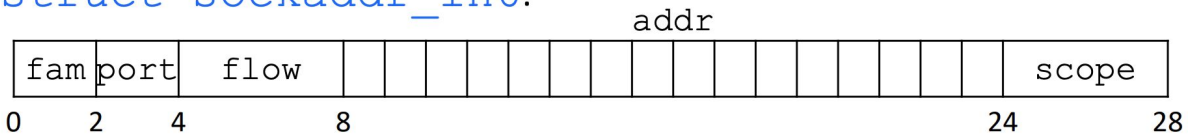
Sockets

- Just a file descriptor for network communication
- Types of Sockets
  - Stream sockets (TCP)
  - Datagram sockets (UDP)
- Each socket is associated with **a port number** and **an IP address**
  - Both port and address are stored in network byte order (big endian)

`struct sockaddr_in`:

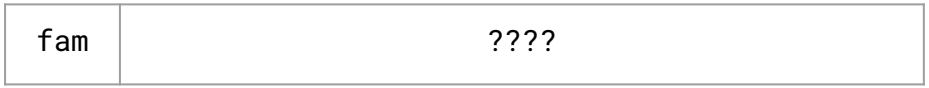


`struct sockaddr_in6`:



Sockets

struct sockaddr (pointer to this struct is used as parameter type in system calls)



....

struct sockaddr_in (IPv4)

16

struct sockaddr_in6 (IPv6)

28

struct sockaddr_storage

Big enough to hold either

Byte Ordering and Endianness

- **N**etwork Byte Order (Big Endian)
  - The most significant byte is stored in the highest address
- **H**ost byte order
  - Might be big or little endian, depending on the hardware
- To convert between orderings, we can use
  - `uint16_t htons (uint16_t hostlong);`
  - `uint16_t ntohs (uint16_t hostlong);`
  - `uint32_t htonl (uint32_t hostlong);`
  - `uint32_t ntohl (uint32_t hostlong);`

Networking methods

```
// Figure out what IP address and port to talk to
// returns 0 on success, negative number on failure
int getaddrinfo(const char *hostname,    // hostname to lookup
        const char *servname,            // service name
        const struct addrinfo *hints,    // desired output (optional)
        struct addrinfo **res);          // results structure


// Frees memory allocated by getaddrinfo()
void freeaddrinfo(struct addrinfo *ai);
```

Networking methods

```
struct addrinfo {
    int ai_flags;              // additional flags
    int ai_family;             // AF_INET, AF_INET6, AF_UNSPEC
    int ai_socktype;           // SOCK_STREAM, SOCK_DGRAM, 0
    int ai_protocol;           // IPPROTO_TCP, IPPROTO_UDP, 0
    size_t ai_addrlen;         // length of socket addr in bytes
    struct sockaddr* ai_addr;  // pointer to socket addr
    char* ai_canonname;        // canonical name
    struct addrinfo* ai_next;  // can have linked list of records
}
```

- `ai_addr` points to a `struct sockaddr` describing a socket address, can be IPv4 or IPv6

Networking methods

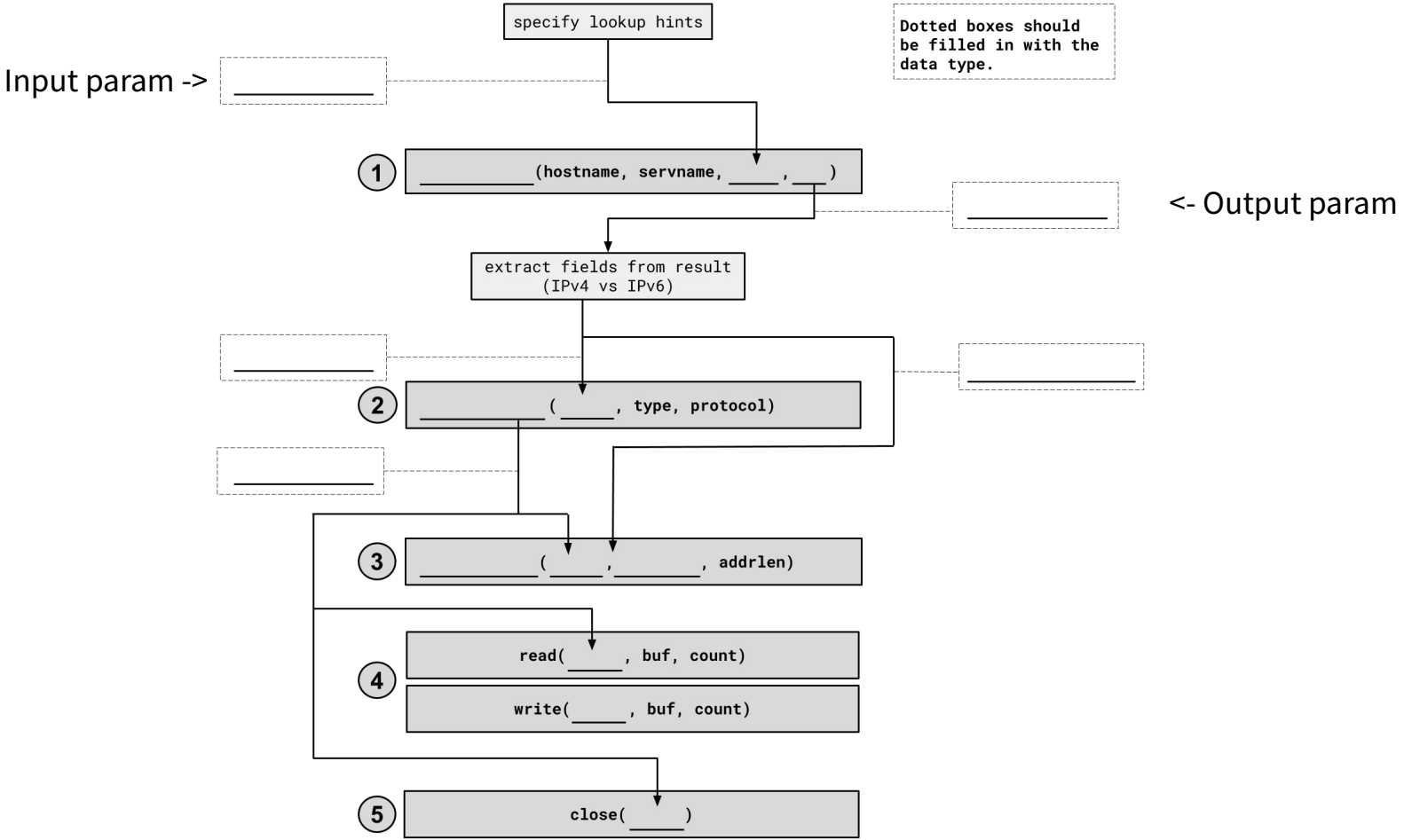
```
// Creates a socket
// returns file descriptor on success, -1 on failure (errno set)
int socket(int domain,      // AF_INET, AF_INET6, etc.
        int type,           // SOCK_STREAM, SOCK_DGRAM, etc.
        int protocol);      // usually 0


 // Connects to the server
 // returns 0 on success, -1 on failure (errno set)
 int connect(int sockfd,                    // socket file descriptor
         struct sockaddr *serv_addr,        // socket addr of server
         socklen_t addrlen);                // size of serv_addr
```

Networking methods

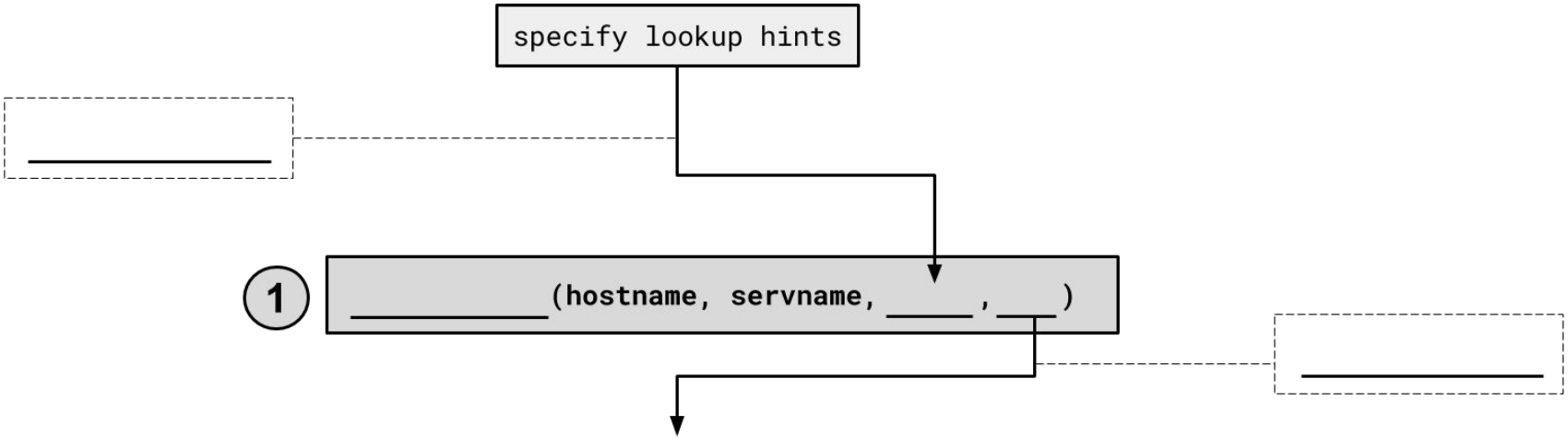
```
// returns amount read, 0 for EOF, -1 on failure (errno set)
ssize_t read(int fd, void *buf, size_t count);

// returns amount written, -1 on failure (errno set)
ssize_t write(int fd, void *buf, size_t count);

// returns 0 for success, -1 on failure (errno set)
int close(int fd);
```

- Same POSIX methods we used for file I/O!
  (so they require the same error checking...)

Exercise 2


Input param ->
specify lookup hints
Dotted boxes should be filled in with the data type.
1
_____(hostname, servname, _____, ___)
<- Output param
extract fields from result (IPv4 vs IPv6)
2
_____(_____, type, protocol)
3
_____(_____, _____, addrlen)
4
read(_____, buf, count)
write(_____, buf, count)
5
close(_____)

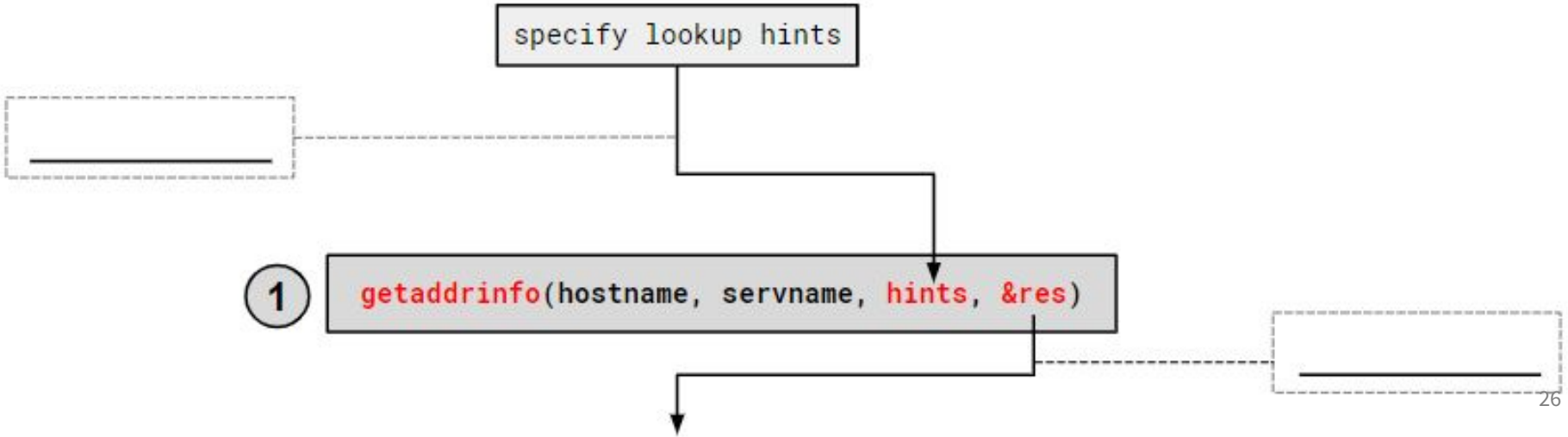
1.



1. getaddrinfo()

```
int getaddrinfo(const char *hostname,
                const char *service,
                const struct addrinfo *hints,
                struct addrinfo **res);
```

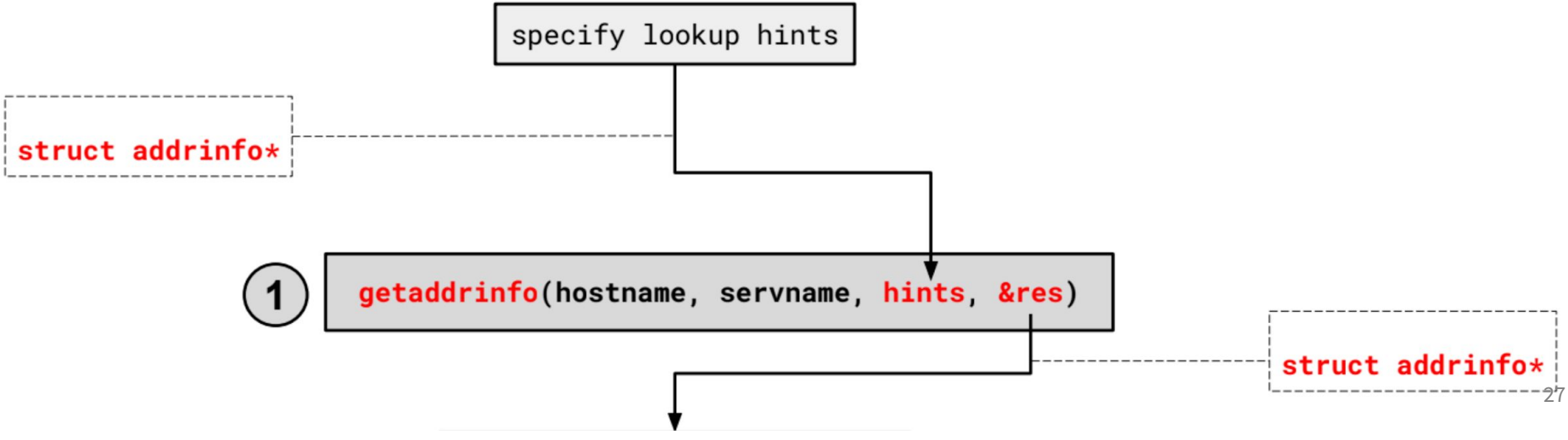
- Performs a **DNS Lookup** for a hostname



1. getaddrinfo()

```
int getaddrinfo(const char *hostname,
                const char *service,
                const struct addrinfo *hints,
                struct addrinfo **res);
```

- Performs a **DNS Lookup** for a hostname
- Use “hints” to specify constraints (`struct addrinfo *`)
- Get back a linked list of `struct addrinfo` results



1. getaddrinfo() - Interpreting Results

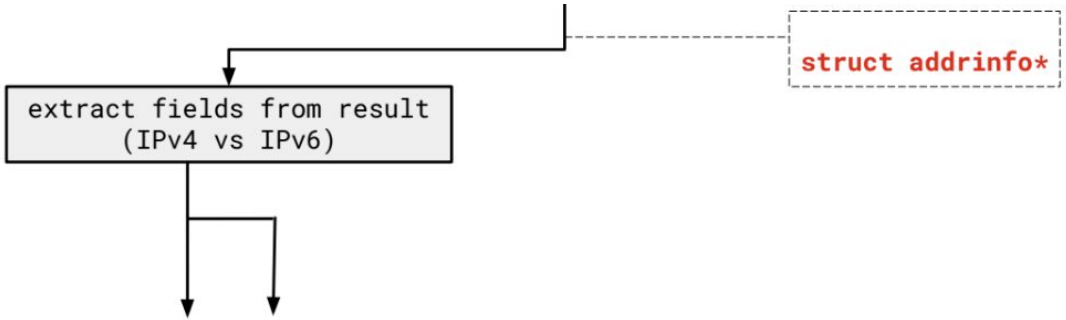
```
struct addrinfo {
    int ai_flags; // additional flags
    int ai_family; // AF_INET, AF_INET6, AF_UNSPEC
    int ai_socktype; // SOCK_STREAM, SOCK_DGRAM, 0
    int ai_protocol; // IPPROTO_TCP, IPPROTO_UDP, 0
    size_t ai_addrlen; // length of socket addr in bytes
    struct sockaddr* ai_addr; // pointer to socket addr
    char* ai_canonname; // canonical name
    struct addrinfo* ai_next; // can form a linked list
};
```

- `ai_addr` points to a `struct sockaddr` describing the socket address

1. getaddrinfo() - Interpreting Results

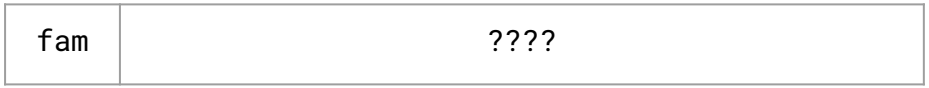
With a `struct sockaddr*`:

- The field `sa_family` describes if it is IPv4 or IPv6
- Cast to `struct sockaddr_in* (v4)` or `struct sockaddr_in6* (v6)` to access/modify specific fields
- Store results in a `struct sockaddr_storage` to have a space big enough for either



1. getaddrinfo() - Interpreting Results

struct sockaddr (pointer to this struct is used as parameter type in system calls)



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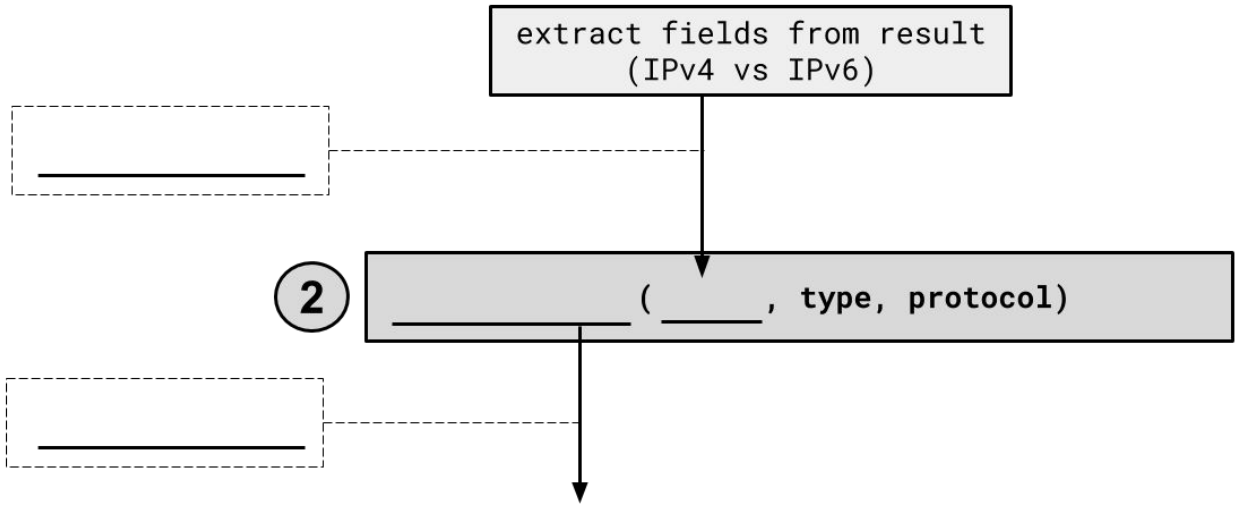
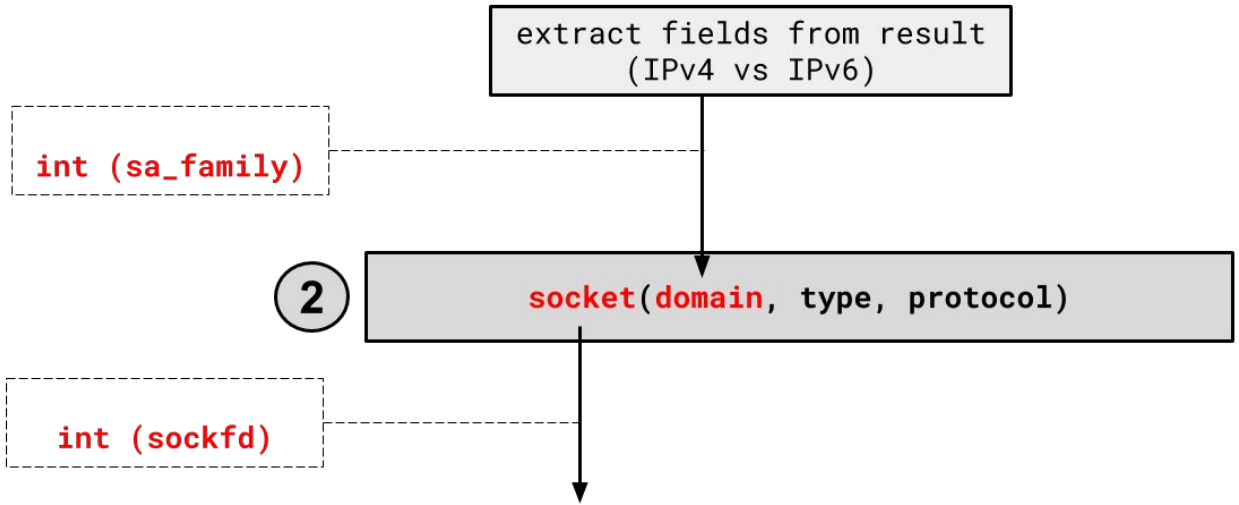
2.



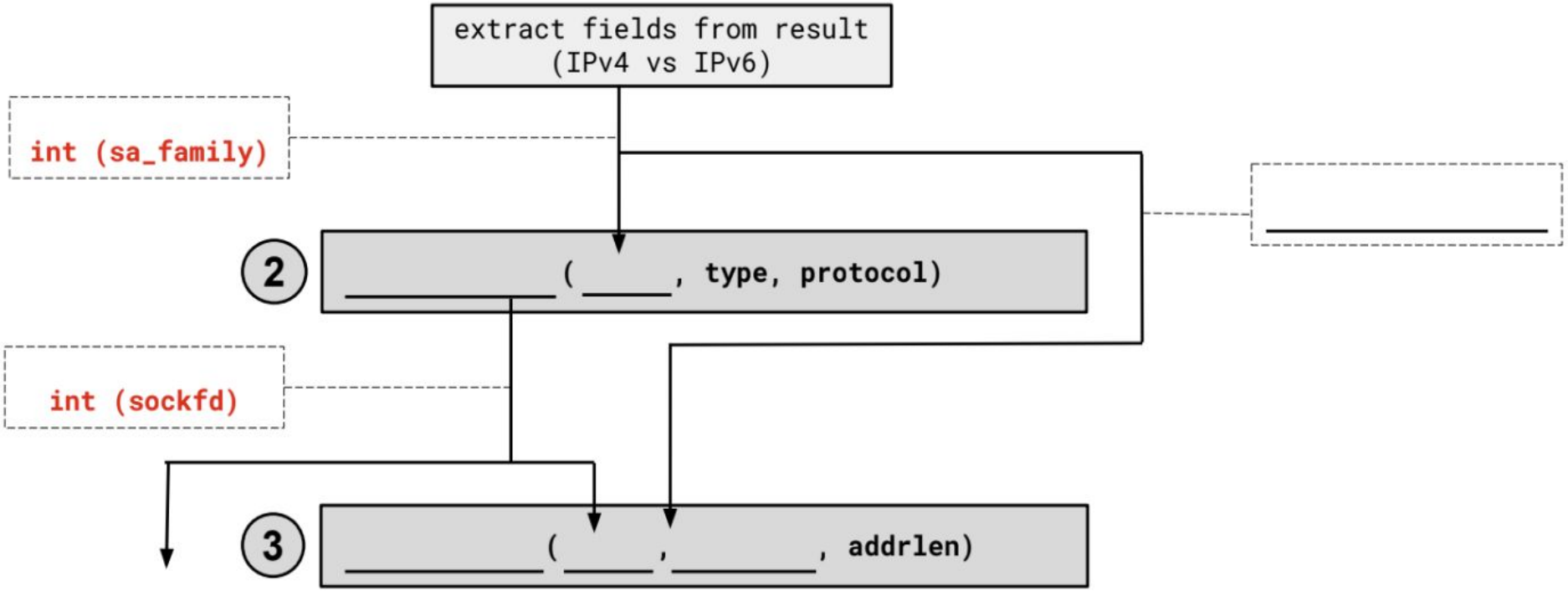
2. socket()

```
int socket(int domain,     // AF_INET, AF_INET6
           int type,       // SOCK_STREAM (TCP)
           int protocol); // 0
```

- Creates a “raw” socket, ready to be bound
- Returns file descriptor (`sockfd`) on success, `-1` on failure



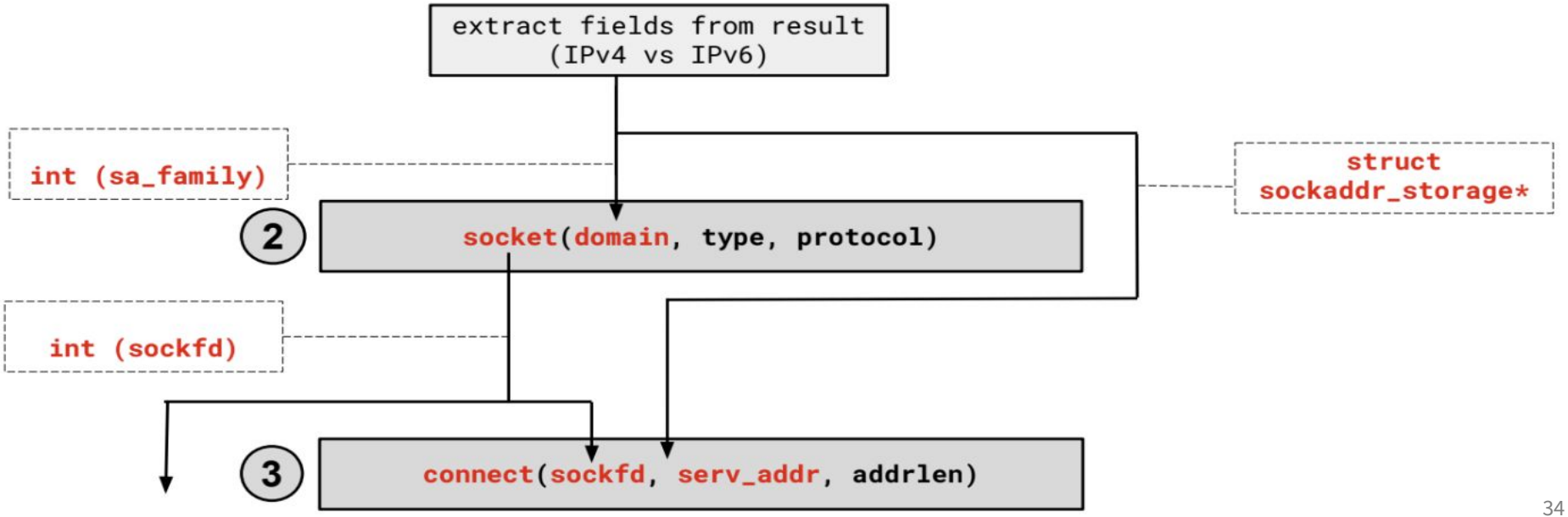
3.


extract fields from result
(IPv4 vs IPv6)
int (sa_family)
2
_____(_____, type, protocol)
int (sockfd)
3
_____(_____, _____, addrlen)

3. connect()

```
int connect (int sockfd,                          // from 2
             const struct sockaddr *serv_addr, // from 1
             socklen_t addrlen);      // size of serv_addr
```

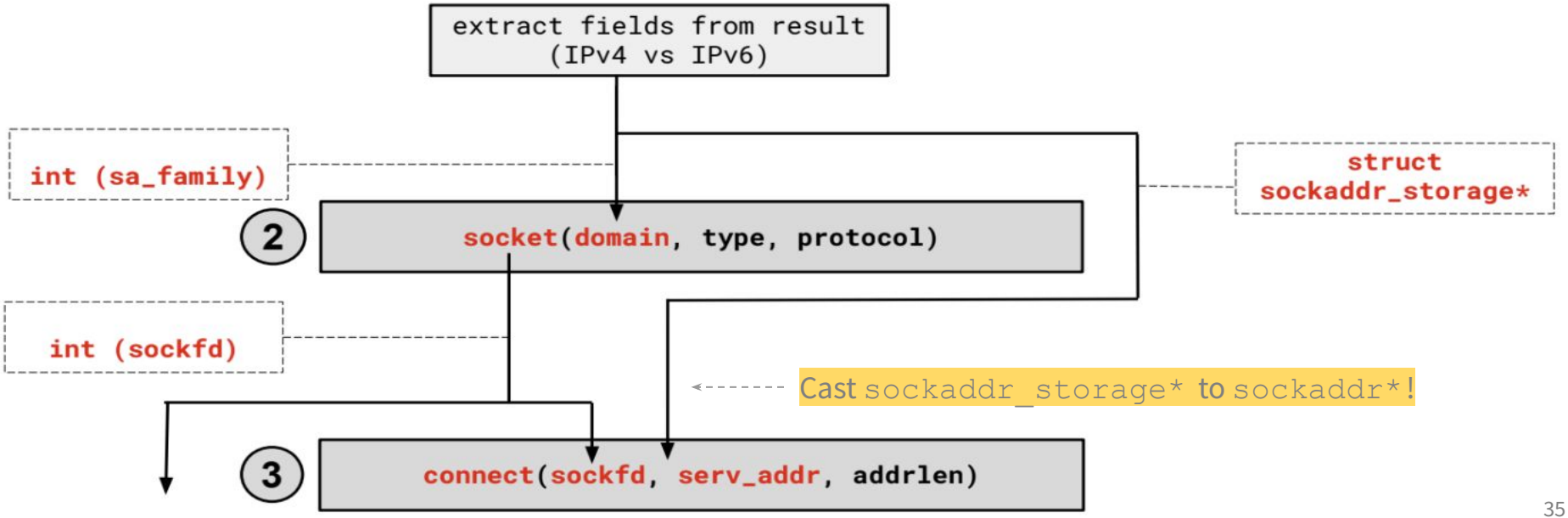
- Connects an available socket to a specified address
- Returns 0 on success, -1 on failure



3. connect()

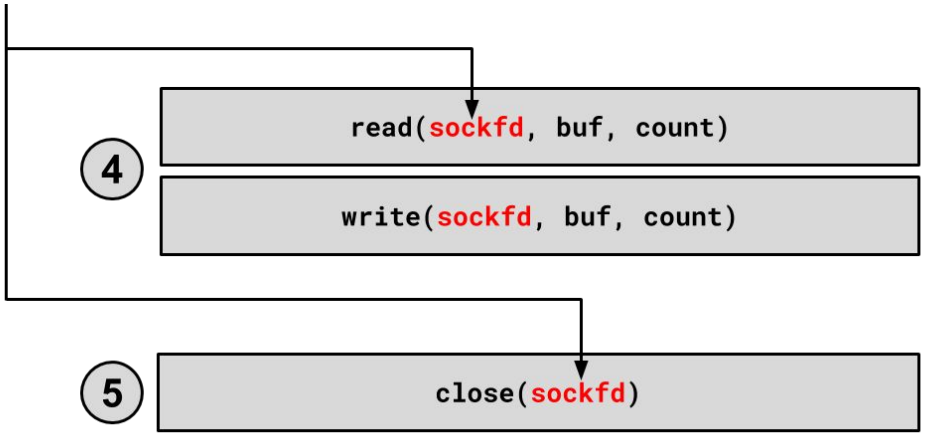
```
int connect (int sockfd,                          // from 2
             const struct sockaddr *serv_addr, // from 1
             socklen_t addrlen) ;      // size of serv_addr
```

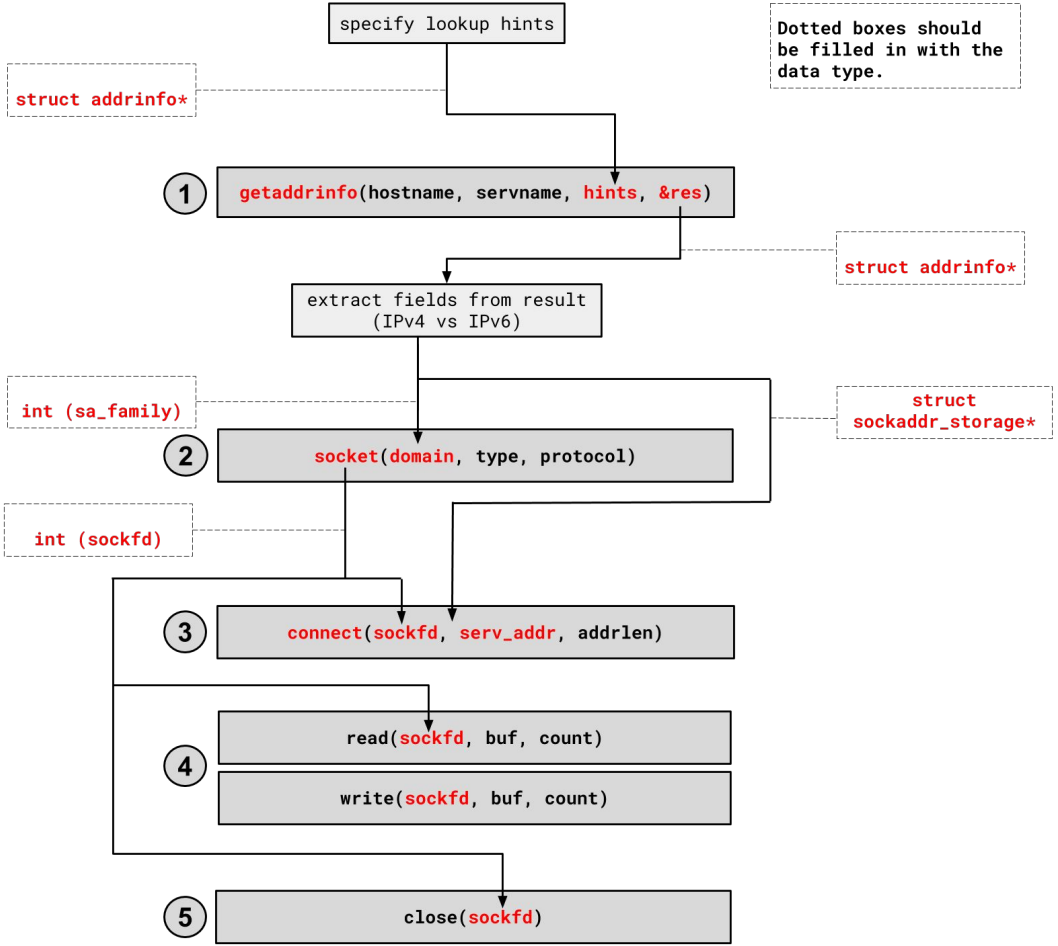
- Connects an available socket to a specified address
- Returns 0 on success, -1 on failure



4. read/write and 5. close

- Thanks to the file descriptor abstraction, use as normal!
- `read` from and `write` to a buffer, the OS will take care of sending/receiving data across the network
- Make sure to `close` the fd afterward




specify lookup hints
Dotted boxes should be filled in with the data type.
struct addrinfo*
1
getaddrinfo(hostname, servname, hints, &res)
struct addrinfo*
extract fields from result (IPv4 vs IPv6)
int (sa_family)
struct sockaddr_storage*
2
socket(domain, type, protocol)
int (sockfd)
3
connect(sockfd, serv_addr, addrlen)
4
read(sockfd, buf, count)
write(sockfd, buf, count)
5
close(sockfd)