

Network Application Programming Interface (API)

- The services provided by the operating system that provide the interface between application and protocol software.

Application		
Network API		
Protocol A	Protocol B	Protocol C

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Network API

- Generic Programming Interface.
- Support for message oriented and connection oriented communication.
- Work with existing I/O services (when this makes sense).
- Operating System independence.

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Generic Programming Interface

- Support multiple communication protocol suites (families).
- Address (endpoint) representation independence.
- Provide special services for Client and Server?

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TCP/IP

- TCP/IP does not include an API definition.
- There are a variety of APIs for use with TCP/IP:
 - Sockets
 - TLI, XTI
 - Winsock
 - MacTCP

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Functions needed:

- Specify local and remote communication endpoints
- Initiate a connection
- Wait for incoming connection
- Send and receive data
- Terminate a connection gracefully
- Error handling

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Berkeley Sockets

- Generic:
 - support for multiple protocol families.
 - address representation independence
- Uses existing I/O programming interface as much as possible.

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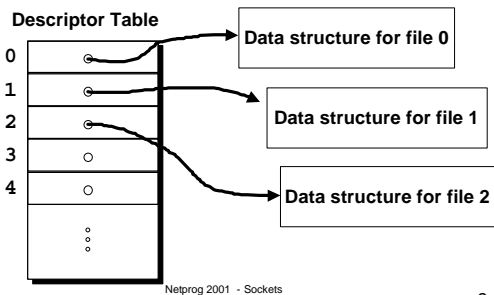
Socket

- A socket is an abstract representation of a communication endpoint.
- Sockets work with Unix I/O services just like files, pipes & FIFOs.
- Sockets (obviously) have special needs:
 - establishing a connection
 - specifying communication endpoint addresses

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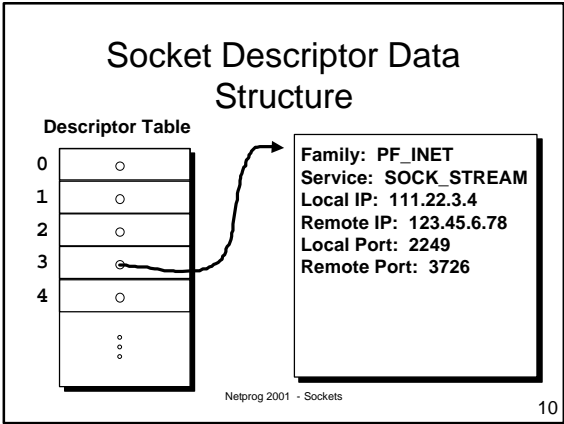
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Unix Descriptor Table



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Creating a Socket

```
int socket(int family,int type,int proto);
```

- `family` specifies the protocol family (PF_INET for TCP/IP).
- `type` specifies the type of service (SOCK_STREAM, SOCK_DGRAM).
- `protocol` specifies the specific protocol (usually 0, which means *the default*).

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socket ()

- The `socket ()` system call returns a socket descriptor (small integer) or a -1 on error.
- `socket ()` allocates resources needed for a communication endpoint - but it does not deal with endpoint addressing.

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Specifying an Endpoint Address

- Remember that the sockets API is generic.
- There must be a generic way to specify endpoint addresses.
- TCP/IP requires an IP address and a port number for each endpoint address.
- Other protocol suites (families) may use other schemes.

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POSIX data types

<code>int8_t</code>	signed 8bit int
<code>uint8_t</code>	unsigned 8 bit int
<code>int16_t</code>	signed 16 bit int
<code>uint16_t</code>	unsigned 16 bit int
<code>int32_t</code>	signed 32 bit int
<code>uint32_t</code>	unsigned 32 bit int

`u_char, u_short, u_int, u_long`

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More POSIX data types

<code>sa_family_t</code>	address family
<code>socklen_t</code>	length of struct
<code>in_addr_t</code>	IPv4 address
<code>in_port_t</code>	IP port number

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Generic socket addresses

```
struct sockaddr {  
    uint8_t    sa_len;  
    sa_family_t sa_family;  
    char       sa_data[14];  
};
```

← Used by kernel

- `sa_family` specifies the address type.
- `sa_data` specifies the address value.

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sockaddr

- An address that will allow me to use sockets to communicate with my kids.
- address type `AF_DAVESKIDS`
- address values:

Andrea	1	Mom	5
Jeff	2	Dad	6
Robert	3	Dog	7
Emily	4		

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AF_DAVESKIDS

- Initializing a `sockaddr` structure to point to Robert:

```
struct sockaddr robster;  
  
robster.sa_family = AF_DAVESKIDS;  
robster.sa_data[0] = 3;
```

Really old picture! →

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AF_INET

- For AF_DAVESKIDS we only needed 1 byte to specify the address.
- For AF_INET we need:
 - 16 bit port number
 - 32 bit IP address

IPv4 only!

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struct sockaddr_in (IPv4)

```
struct sockaddr_in {
    uint8_t      sin_len;
    sa_family_t  sin_family;
    in_port_t    sin_port;
    struct in_addr sin_addr;
    char         sin_zero[8];
};
```

A special kind of sockaddr structure

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struct in_addr

```
struct in_addr {
    in_addr_t    s_addr;
};
```

`in_addr` just provides a name for the 'C' type associated with IP addresses.

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Network Byte Order

- All values stored in a `sockaddr_in` must be in network byte order.
 - `sin_port` a TCP/IP port number.
 - `sin_addr` an IP address.



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Network Byte Order Functions

'h' : host byte order 'n' : network byte order
's' : short (16bit) 'l' : long (32bit)

```
uint16_t htons(uint16_t);  
uint16_t ntohs(uint16_t);
```

```
uint32_t htonl(uint32_t);  
uint32_t ntohl(uint32_t);
```

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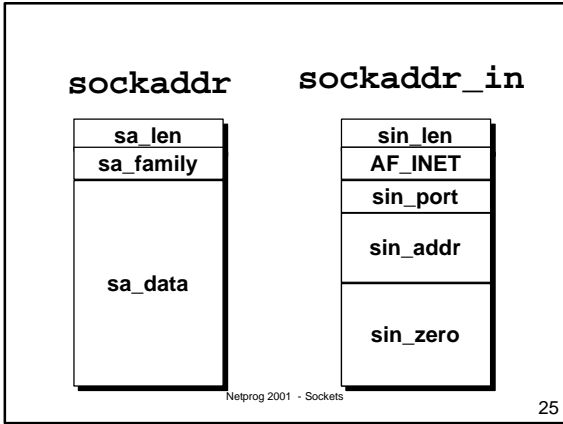
TCP/IP Addresses

- We don't need to deal with `sockaddr` structures since we will only deal with a real protocol family.
- We can use `sockaddr_in` structures.

BUT: The C functions that make up the sockets API expect structures of type `sockaddr`.

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Assigning an address to a socket

- The `bind()` system call is used to assign an address to an existing socket.

```
int bind( int sockfd,
         const struct sockaddr *myaddr,
         int addrlen);
```

const! →

- `bind` returns 0 if successful or -1 on error.

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bind()

- calling `bind()` assigns the address specified by the `sockaddr` structure to the socket descriptor.
- You can give `bind()` a `sockaddr_in` structure:

```
bind( mysock,
      (struct sockaddr*) &myaddr,
      sizeof(myaddr) );
```

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bind() Example

```
int mysock, err;
struct sockaddr_in myaddr;

mysock = socket(PF_INET, SOCK_STREAM, 0);
myaddr.sin_family = AF_INET;
myaddr.sin_port = htons( portnum );
myaddr.sin_addr = htonl( ipaddress);

err = bind(mysock, (sockaddr *) &myaddr,
           sizeof(myaddr));
```

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Uses for bind()

- There are a number of uses for `bind()`:
 - Server would like to bind to a well known address (port number).
 - Client can bind to a specific port.
 - Client can ask the O.S. to assign *any available* port number.

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Port schmort - who cares ?

- Clients typically don't care what port they are assigned.
- When you call `bind` you can tell it to assign you any available port:

```
myaddr.port = htons(0);
```

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What is my IP address ?

- How can you find out what your IP address is so you can tell `bind()` ?
- There is no realistic way for you to know the right IP address to give `bind()` - what if the computer has multiple network interfaces?
- specify the IP address as: `INADDR_ANY`, this tells the OS to take care of things.

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IPv4 Address Conversion

```
int inet_aton( char *, struct in_addr *);
```

Convert ASCII dotted-decimal IP address to network byte order 32 bit value. Returns 1 on success, 0 on failure.

```
char *inet_ntoa(struct in_addr);
```

Convert network byte ordered value to ASCII dotted-decimal (a string).

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Other socket system calls

• General Use

- `read()`
- `write()`
- `close()`

• Connection-oriented (TCP)

- `connect()`
- `listen()`
- `accept()`

• Connectionless (UDP)

- `send()`
- `recv()`

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