

Building a Web Server

Multiprocessing

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Recall: Steps to Accept TCP/IP Network Connections

```
socket(AF_INET, SOCK_STREAM, IPPROTO_IP) = 3
bind(3,
     {sa_family=AF_INET,
      sin_port=htons(80),
      sin_addr=inet_addr("0.0.0.0")},
     16)                                = 0
listen(3, 0)                           = 0
accept(3, NULL, NULL)                   = 4
```

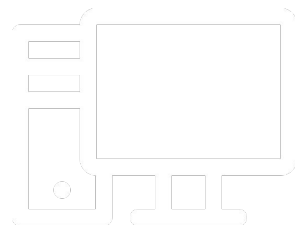
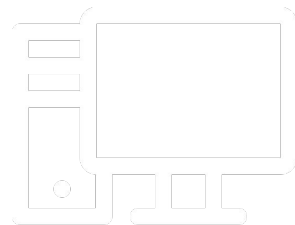
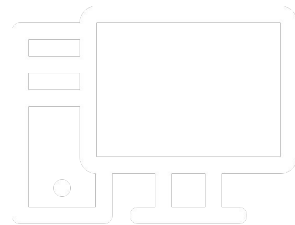
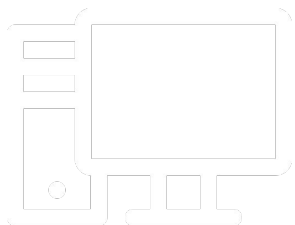
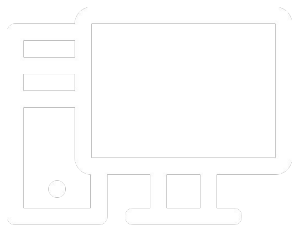
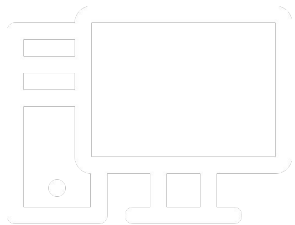
PROCESS	
PID	42
PPID	1
Real User ID	1000
Effective User ID	1000
Saved User ID	1000
FD 0	/dev/pts/1
FD 1	/dev/pts/1
FD 2	/dev/pts/1
FD 3	socket: [31337]
FD 4	socket: [31338]
...	
FD 1024	
555555554000-555555555000 r--p /bin/program	
555555555000-555555556000 r-xp /bin/program	
...	
7fffff7da6000-7fffff7dc8000 r--p /lib/.../libc.so.6	
7fffff7dc8000-7fffff7f40000 r-xp /lib/.../libc.so.6	
...	
7fffffde000-7ffffffffff000 rw-p [stack]	

Lots of HTTP Request

GET / HTTP/1.0

GET / HTTP/1.0

GET / HTTP/1.0



Single Accept

```
socket(AF_INET, SOCK_STREAM, IPPROTO_IP) = 3
bind(3,
     {sa_family=AF_INET,
      sin_port=htons(80),
      sin_addr=inet_addr("0.0.0.0")},
     16)                                = 0
listen(3, 0)                           = 0
accept(3, NULL, NULL)                   = 4
```

PROCESS	
PID PPID	42 1
Real User ID Effective User ID Saved User ID	1000 1000 1000
FD 0 FD 1 FD 2 FD 3 FD 4 ... FD 1024	/dev/pts/1 /dev/pts/1 /dev/pts/1 socket: [31337] socket: [31338]
555555554000-555555555000 r--p /bin/program 555555555000-555555556000 r-xp /bin/program ... 7ffff7da6000-7ffff7dc8000 r--p /lib/.../libc.so.6 7ffff7dc8000-7ffff7f40000 r-xp /lib/.../libc.so.6 ... 7ffff7fde000-7ffff7fff000 rw-p [stack]	

Single Accept

```
socket(AF_INET, SOCK_STREAM, IPPROTO_IP) = 3
bind(3,
     {sa_family=AF_INET,
      sin_port=htons(80),
      sin_addr=inet_addr("0.0.0.0")},
     16)                                = 0
listen(3, 0)                            = 0
accept(3, NULL, NULL)                    = 4
...
```

PROCESS	
PID PPID	42 1
Real User ID Effective User ID Saved User ID	1000 1000 1000
FD 0 FD 1 FD 2 FD 3 FD 4 ... FD 1024	/dev/pts/1 /dev/pts/1 /dev/pts/1 socket: [31337] socket: [31338]
555555554000-555555555000 r--p /bin/program 555555555000-555555556000 r-xp /bin/program ... 7ffff7da6000-7ffff7dc8000 r--p /lib/.../libc.so.6 7ffff7dc8000-7ffff7f40000 r-xp /lib/.../libc.so.6 ... 7ffff7fde000-7ffff7fff000 rw-p [stack]	

fork

fork() creates a new process by duplicating the calling process. The new process is referred to as the child process. The calling process is referred to as the parent process.

fork

```
socket(AF_INET, SOCK_STREAM, IPPROTO_IP) = 3
bind(3,
     {sa_family=AF_INET,
      sin_port=htons(80),
      sin_addr=inet_addr("0.0.0.0")},
     16)                                = 0
listen(3, 0)                           = 0
accept(3, NULL, NULL)                   = 4
fork()                                  = ?
```

PROCESS	
PID	42
PPID	1
Real User ID	1000
Effective User ID	1000
Saved User ID	1000
FD 0	/dev/pts/1
FD 1	/dev/pts/1
FD 2	/dev/pts/1
FD 3	socket: [31337]
FD 4	socket: [31338]
...	
FD 1024	
555555554000-555555555000 r--p /bin/program	
555555555000-555555556000 r-xp /bin/program	
...	
7ffff7da6000-7ffff7dc8000 r--p /lib/.../libc.so.6	
7ffff7dc8000-7ffff7f40000 r-xp /lib/.../libc.so.6	
...	
7ffff7ffde000-7ffff7ffff000 rw-p [stack]	

fork

On success, the PID of the child process is returned in the parent, and 0 is returned in the child.

fork

```
socket(AF_INET, SOCK_STREAM, IPPROTO_IP) = 3
```

```
bind(3,  
    {sa_family=AF_INET,  
      sin_port=htons(80),  
      sin_addr=inet_addr("0.0.0.0")},  
    16) = 0
```

```
listen(3, 0) = 0
```

```
accept(3, NULL, NULL) = 4
```

```
fork() = 43      fork() = 0
```

fork

PROCESS (parent)		
PID	42	
PPID	1	
Real User ID	1000	
Effective User ID	1000	
Saved User ID	1000	
FD 0	/dev/pts/1	
FD 1	/dev/pts/1	
FD 2	/dev/pts/1	
FD 3	socket:[31337]	
FD 4	socket:[31338]	
...		
FD 1024		
55555554000-55555555000 r--p /bin/program		
55555555000-55555556000 r-xp /bin/program		
...		
7ffff7da6000-7ffff7dc8000 r--p /lib/.../libc.so.6		
7ffff7dc8000-7ffff7f40000 r-xp /lib/.../libc.so.6		
...		
7ffff7fde000-7ffff7fff000 rw-p [stack]		

PROCESS (child)		
PID	43	
PPID	42	
Real User ID	1000	
Effective User ID	1000	
Saved User ID	1000	
FD 0	/dev/pts/1	
FD 1	/dev/pts/1	
FD 2	/dev/pts/1	
FD 3	socket:[31337]	
FD 4	socket:[31338]	
...		
FD 1024		
55555554000-55555555000 r--p /bin/program		
55555555000-55555556000 r-xp /bin/program		
...		
7ffff7da6000-7ffff7dc8000 r--p /lib/.../libc.so.6		
7ffff7dc8000-7ffff7f40000 r-xp /lib/.../libc.so.6		
...		
7ffff7fde000-7ffff7fff000 rw-p [stack]		

Parent: `close`

```
socket(AF_INET, SOCK_STREAM, IPPROTO_IP) = 3
```

```
bind(3,  
    {sa_family=AF_INET,  
      sin_port=htons(80),  
      sin_addr=inet_addr("0.0.0.0")},  
    16) = 0
```

```
listen(3, 0) = 0
```

```
accept(3, NULL, NULL) = 4
```

```
fork() = 43
```

```
close(4) = 0
```

```
fork()
```

```
= 0
```

Parent: close

PROCESS (parent)	
PID PPID	42 1
Real User ID Effective User ID Saved User ID	1000 1000 1000
FD 0 FD 1 FD 2 FD 3 FD 4 ... FD 1024	/dev/pts/1 /dev/pts/1 /dev/pts/1 socket:[31337] socket:[31338] ... FD 1024
55555554000-55555555000 r--p /bin/program 55555555000-55555556000 r-xp /bin/program ... 7ffff7da6000-7ffff7dc8000 r--p /lib/.../libc.so.6 7ffff7dc8000-7ffff7f40000 r-xp /lib/.../libc.so.6 ... 7ffff7fde000-7ffff7fff000 rw-p [stack]	

PROCESS (child)	
PID PPID	43 42
Real User ID Effective User ID Saved User ID	1000 1000 1000
FD 0 FD 1 FD 2 FD 3 FD 4 ... FD 1024	/dev/pts/1 /dev/pts/1 /dev/pts/1 socket:[31337] socket:[31338] ... FD 1024
55555554000-55555555000 r--p /bin/program 55555555000-55555556000 r-xp /bin/program ... 7ffff7da6000-7ffff7dc8000 r--p /lib/.../libc.so.6 7ffff7dc8000-7ffff7f40000 r-xp /lib/.../libc.so.6 ... 7ffff7fde000-7ffff7fff000 rw-p [stack]	

Parent: close

PROCESS (parent)	
PID PPID	42 1
Real User ID Effective User ID Saved User ID	1000 1000 1000
FD 0 FD 1 FD 2 FD 3 FD 4 ... FD 1024	/dev/pts/1 /dev/pts/1 /dev/pts/1 socket:[31337]
55555554000-55555555000 r--p /bin/program 55555555000-55555556000 r-xp /bin/program ... 7ffff7da6000-7ffff7dc8000 r--p /lib/.../libc.so.6 7ffff7dc8000-7ffff7f40000 r-xp /lib/.../libc.so.6 ... 7ffff7fde000-7ffff7fff000 rw-p [stack]	

PROCESS (child)	
PID PPID	43 42
Real User ID Effective User ID Saved User ID	1000 1000 1000
FD 0 FD 1 FD 2 FD 3 FD 4 ... FD 1024	/dev/pts/1 /dev/pts/1 /dev/pts/1 socket:[31337] socket:[31338]
55555554000-55555555000 r--p /bin/program 55555555000-55555556000 r-xp /bin/program ... 7ffff7da6000-7ffff7dc8000 r--p /lib/.../libc.so.6 7ffff7dc8000-7ffff7f40000 r-xp /lib/.../libc.so.6 ... 7ffff7fde000-7ffff7fff000 rw-p [stack]	

Child: `close`

```
socket(AF_INET, SOCK_STREAM, IPPROTO_IP) = 3
```

```
bind(3,  
    {sa_family=AF_INET,  
      sin_port=htons(80),  
      sin_addr=inet_addr("0.0.0.0")},  
    16) = 0
```

```
listen(3, 0) = 0
```

```
accept(3, NULL, NULL) = 4
```

```
fork() = 43
```

```
close(4) = 0
```

```
fork() = 0
```

```
close(3) = 0
```

Child: close

PROCESS (parent)	
PID PPID	42 1
Real User ID Effective User ID Saved User ID	1000 1000 1000
FD 0 FD 1 FD 2 FD 3 FD 4 ... FD 1024	/dev/pts/1 /dev/pts/1 /dev/pts/1 socket:[31337]
55555554000-55555555000 r--p /bin/program 55555555000-55555556000 r-xp /bin/program ... 7ffff7da6000-7ffff7dc8000 r--p /lib/.../libc.so.6 7ffff7dc8000-7ffff7f40000 r-xp /lib/.../libc.so.6 ... 7ffff7fde000-7ffff7fff000 rw-p [stack]	

PROCESS (child)	
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Child: close

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Parent: accept

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      sin_addr=inet_addr("0.0.0.0")},  
    16) = 0
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listen(3, 0) = 0
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```
accept(3, NULL, NULL) = 4
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fork() = 43
```

```
close(4) = 0
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```
accept(3, NULL, NULL) = 4
```

```
fork() = 0
```

```
close(3) = 0
```

Parent: accept

PROCESS (parent)	
PID PPID	42 1
Real User ID Effective User ID Saved User ID	1000 1000 1000
FD 0 FD 1 FD 2 FD 3 FD 4 ... FD 1024	/dev/pts/1 /dev/pts/1 /dev/pts/1 socket:[31337] socket:[31339] ... FD 1024
55555554000-55555555000 r--p /bin/program 55555555000-55555556000 r-xp /bin/program ... 7ffff7da6000-7ffff7dc8000 r--p /lib/.../libc.so.6 7ffff7dc8000-7ffff7f40000 r-xp /lib/.../libc.so.6 ... 7ffff7fde000-7ffff7fff000 rw-p [stack]	

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PID PPID	43 42
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FD 0 FD 1 FD 2 FD 3 FD 4 ... FD 1024	/dev/pts/1 /dev/pts/1 /dev/pts/1 socket:[31338] socket:[31338] ... FD 1024
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