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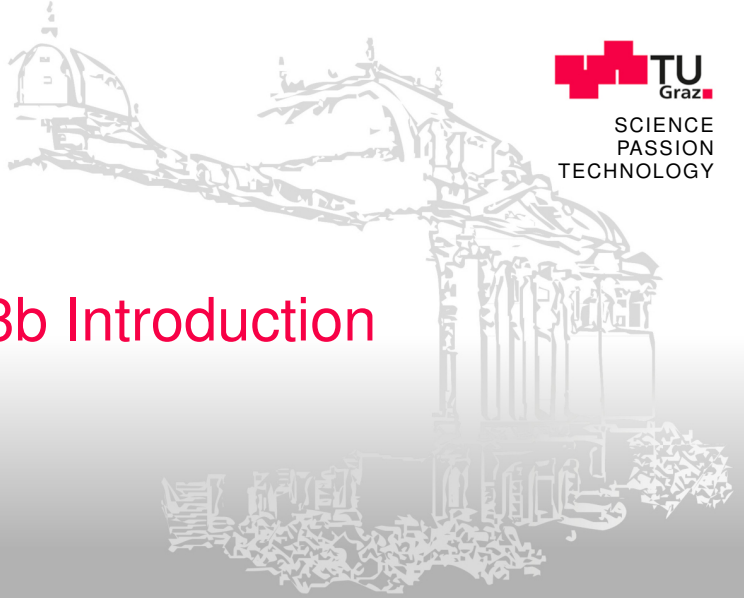

CON — Task 3b Introduction

Matthias Fischer, Constantin Piber

Your Task

- Receive HTTP/1.1 requests from clients
- Answer requests:
  - Reject invalid packets
  - Parse the request and send the requested file
- Test with browser: `http://localhost:8000`

For this, edit the file `http.cpp`. The Function `handle_connection` is automatically called by the framework.

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How do packets arrive here?

- Network as a stack: flexible but complex
- Internet Protocol Suite
- From lowest to highest layer:
  1. Link: Physical (e.g. Ethernet)
  2. Internet: Between networks (e.g. IP)
  3. Transport: Connections (e.g. TCP)
  4. Application: Inter-Program (e.g. HTTP)

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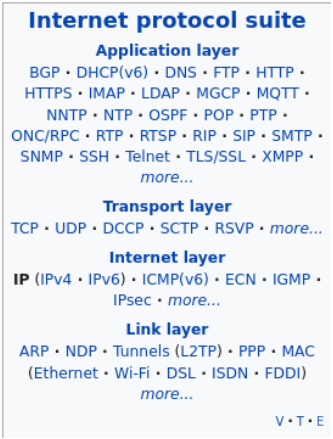

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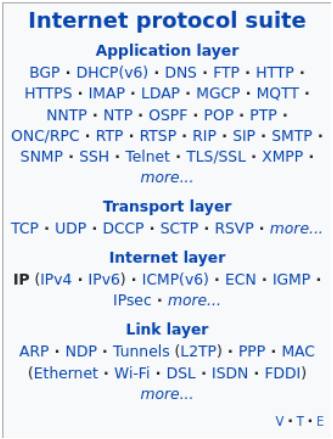

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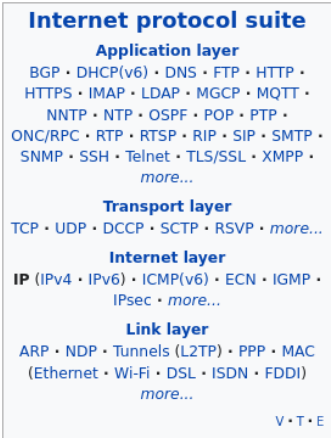

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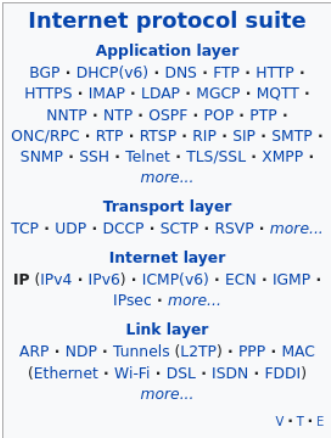

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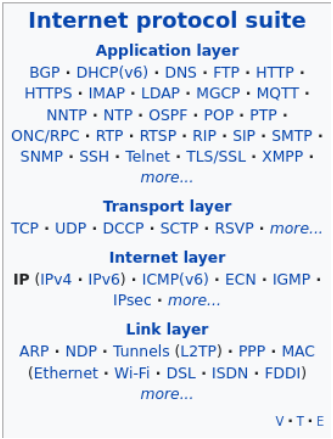

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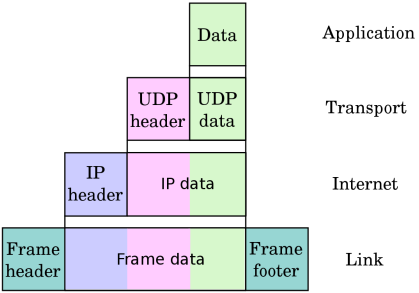

Figure: Example: UDP over IP over Ethernet. [1]

[1] Source https://commons.wikimedia.org/wiki/File:UDP_encapsulation.svg

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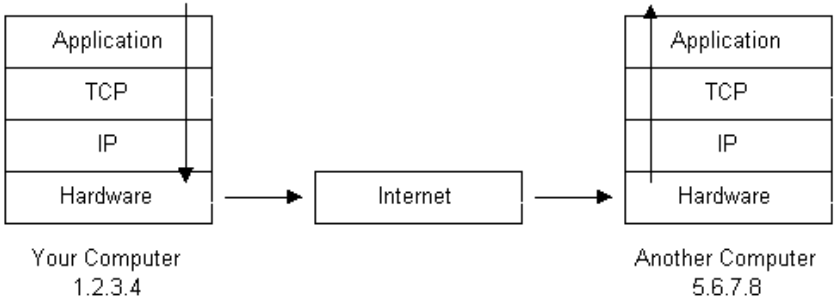


Figure: Example: Two Computers, TCP over IP over Ethernet. [1]

[1] Source https://medium.com/@anna7/internet-protocol-layers-in-internet-protocol-suite-tcp-ip-abe038c0adde

About network stability

Why do we need to `read` multiple times? – Slow networks! Big requests!

About network stability

Why do we need to `read` multiple times? – Slow networks! Big requests!

Why do we need to `write` multiple times? – The operating system handles slow connections for us *but* can be interrupted

HTTP

- Base HTTP is request & response protocol

HTTP

- Base HTTP is request & response protocol
- Client requests with method: `GET`, `HEAD`, `OPTIONS`, `POST`, `PUT`, `DELETE`, `TRACE`, `CONNECT`, `PATCH`
- Download data from server, or send data to server
- Example:

```
GET /index.html HTTP/1.1
...
```

HTTP

- Base HTTP is request & response protocol
- Server responds: `200 OK`, `400 Bad Request`, ...
- Codes: `1xx` informational response, `2xx` success, `3xx` redirection, `4xx` client errors, `5xx` server errors
- Example:

```
HTTP/1.1 200 OK
...
```

HTTP

- Base HTTP is request & response protocol
- Some requests and responses include a body
- Uploading data to the server, or downloading data from the server

HTTP

- Base HTTP is request & response protocol
- Both directions use headers to send metadata, e.g. `Host`, `Connection`, `Content-Type`, `Content-Length`, `Range`
- Client-Headers tell: Who, from where, ...
- Server-Headers answer: What, How much data, ...

HTTP

- Full Example:

```
GET /lorem.txt HTTP/1.1
Host: localhost:12345
```

```
HTTP/1.1 200 OK
Connection: close
Content-Type: text/plain
Content-Length: 17

lorem ipsum dolor
```

HTTP

```
❯ make run
./server
Server startup ok - listening on port 8000.
Incoming connection from 127.0.0.1:47690...
Requesting file ./webroot/lorem.txt
HEADER Host: localhost:12345
Request headers OK.
Sending file from start=0 to end=17
```

```
❯ nc localhost 8000
GET /lorem.txt HTTP/1.1
Host: localhost:12345

HTTP/1.1 200 OK
Connection: close
Accept-Ranges: bytes
Content-Length: 17
Content-Type: text/plain

lorem ipsum dolor
```

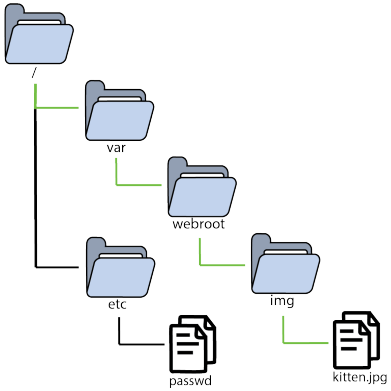
Figure: Example request

Webroot escape attacks

- The server “serves” static files, i.e. lets clients request files from the disk
- Privacy: Only allow access to public folder (webroot)
- Client requests relative path, server must make sure it is inside webroot while resolving full path
- Relative path elements: current directory `./`, parent directory `../`

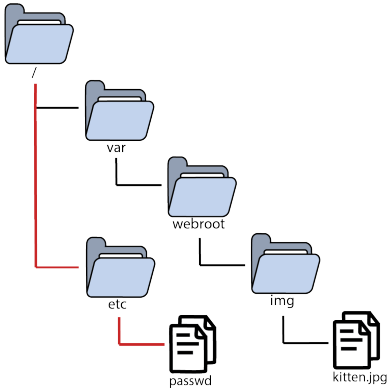
Webroot escape attacks

- webroot: `/var/webroot`
- valid access:
  - `/index.html` → `/var/webroot/index.html`
  - `/img/kitten.jpg` → `/var/webroot/img/kitten.jpg`
  - `/img/../lorem.txt` → `/var/webroot/lorem.txt`



Webroot escape attacks

- webroot: `/var/webroot`
- invalid access:
  - `/../../etc/passwd` → ~~`/etc/passwd`~~
  - `/img/../../personal.txt` → ~~`/var/personal.txt`~~



Webroot escape attacks

```
❯ ./server
Server startup ok - listening on port 8000.
Incoming connection from 127.0.0.1:48144...
Requesting file ./webroot/../secret.txt
webroot path: /var/webroot :: request path: /var/secret.txt
HEADER Host: localhost:12345
Request headers OK.
Sending file from start=0 to end=18
```

```
❯ nc localhost 8000
GET /../secret.txt HTTP/1.1
Host: localhost:12345

HTTP/1.1 200 OK
Connection: close
Accept-Ranges: bytes
Content-Length: 18
Content-Type: text/plain

Super secret file
```

Figure: Requesting a file outside webroot

Webroot escape attacks

Preventing such attacks:

- Use `realpath` to resolve request and webroot and compare
- Reject requests with relative path elements

Tips

- Read data line by line
- *Always* assume an invalid request!
- Use the hints in the footnotes – `man` pages!
- Start server using `make run`, check for leaks with `make valgrind`
- Test your implementation using `netcat`
- Print debug data about the request, its parts and function calls
- Close both the connection *and* the file at the end, deallocate memory

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Useful functions

C

- Compare strings: `strcmp` / `strcasecmp` (case insensitive)
- Find character: `strchr` (first) / `strrchr` (last)
- Allocate space dynamically: `malloc` (and `free` after use)
- Convert string to number: `atol` (to long) / `strtol` (more control)

Useful functions

C

- Copy data: `memcpy` (data) / `strcpy` (strings) / `strncpy` (max length)
- Files: `stat` (file information) / `fopen` (open file) / `fseek` (move in file) / `fread` (read from file) / `fclose` (close file)
- Output: `printf` (write to stdout) / `dprintf` (write to connection)

Useful functions

C++

- Strings Class: `std::basic_string`
- Read file: `std::basic_ifstream`
- Convert string to number: `std::stol`
- Memory: `new` / `new[]`, `delete` / `delete[]`

`std::string` members: `size`, `append`, `substr`, `find_first_of`, etc.

Code Examples

All examples can be found on the course website and on discord.
We want to reads in words (separated by space), split each word by `:` and reply to client.

- `ping_simple.cpp` Simplistic implementation, no multi-read
- `ping.cpp` Do multiple reads to get all data
- `ping_cpp.cpp` C++ implementation of the above

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Examples

Questions?