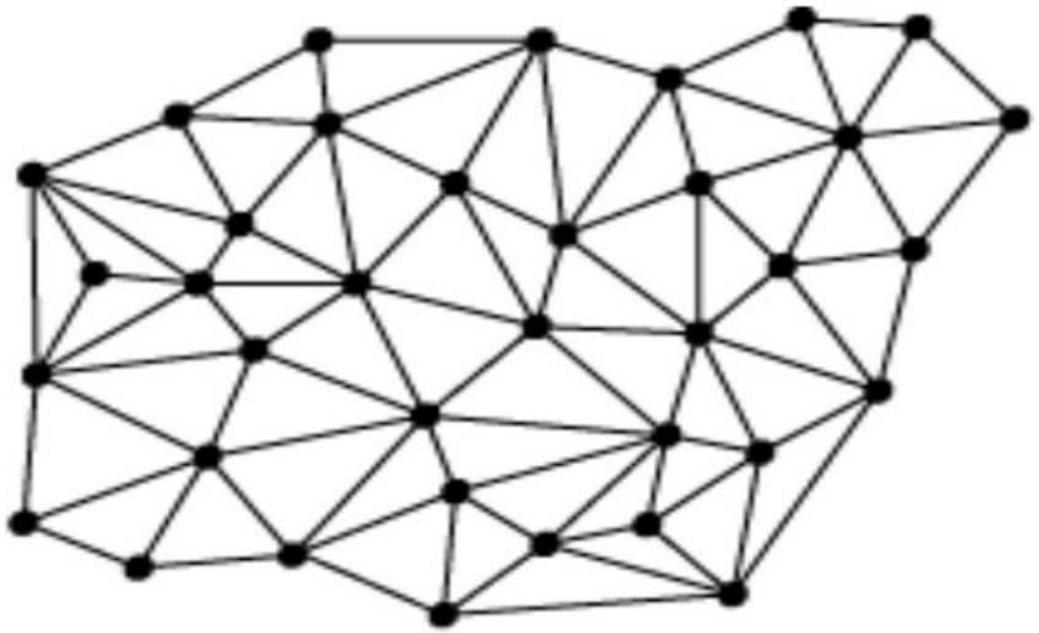
Distributed System Course

2021-22-GICI41SSD-Distributed System



Academic Year: 2021-2022   Lecturer: SOK Kimheng

Information

Course	**Distributed System**	**48h, 12 Weeks, 4h/week (3 Groups = 96h)**
	Week 1	**Information, Self-Study Skill, Introduction**
General Distributed System	Week 2	Distributed Communication (TCP/IP, Socket, RPC, REST, gRPC, OMQ)
	Week 3	Clock, Timestamp
	Week 4	Fault Tolerance (Two general problem, Byzantine General Problem)
	Week 5	Consensus Algorithm (Paxos, ZooKeeper, Raft)
	Week 6	**Quiz**
Blockchain	Week 7	Basic Cryptography
	Week 8	Blockchain and Bitcoin (Proof of Work)
	Week 9	Ethereum and Smart Contract (Proof of Stake)
	Week 10	Hyperledger and Self-Sovereign Identity
	Week 11	Security
	Week 12	**Final Exam**

Distributed System Course

2021-22-GICI41SSD-Distributed System

Week2:

Distributed Communication

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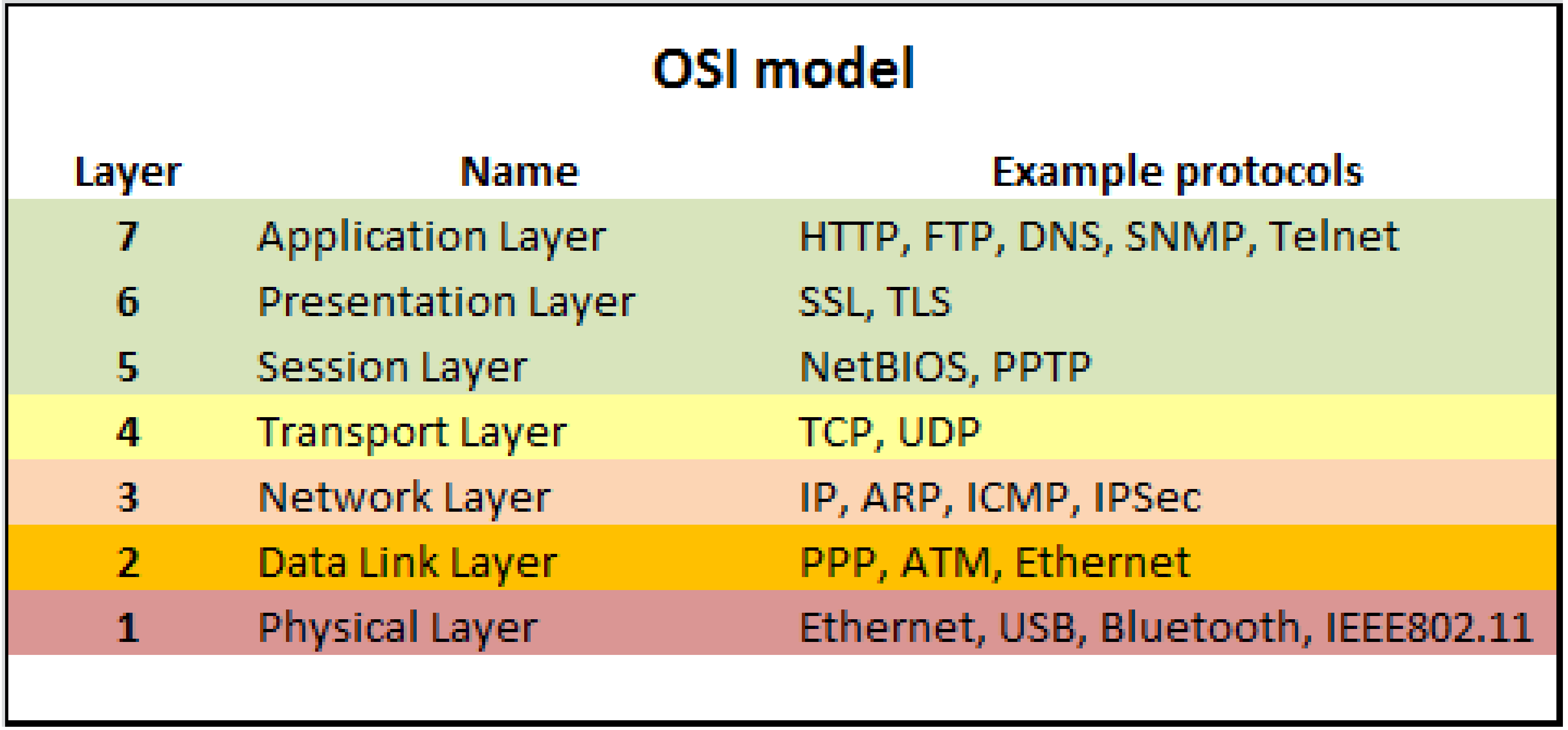
Agenda

1. OSI Model
2. TCP/IP
3. HTTP Protocol
4. Socket and RPC
5. Rest
6. gRPC
7. ZeroMQ

Distributed Communication

OSI Model

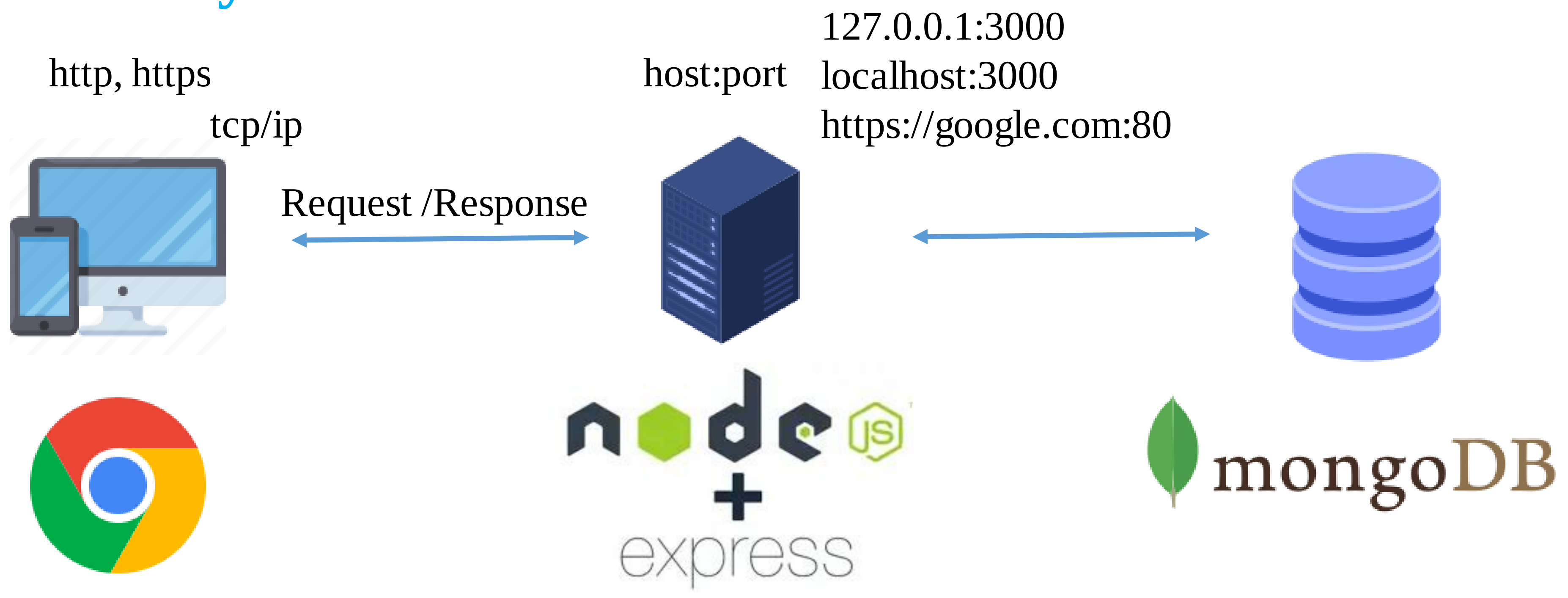


OSI model

Layer	Name	Example protocols
7	Application Layer	HTTP, FTP, DNS, SNMP, Telnet
6	Presentation Layer	SSL, TLS
5	Session Layer	NetBIOS, PPTP
4	Transport Layer	TCP, UDP
3	Network Layer	IP, ARP, ICMP, IPSec
2	Data Link Layer	PPP, ATM, Ethernet
1	Physical Layer	Ethernet, USB, Bluetooth, IEEE802.11

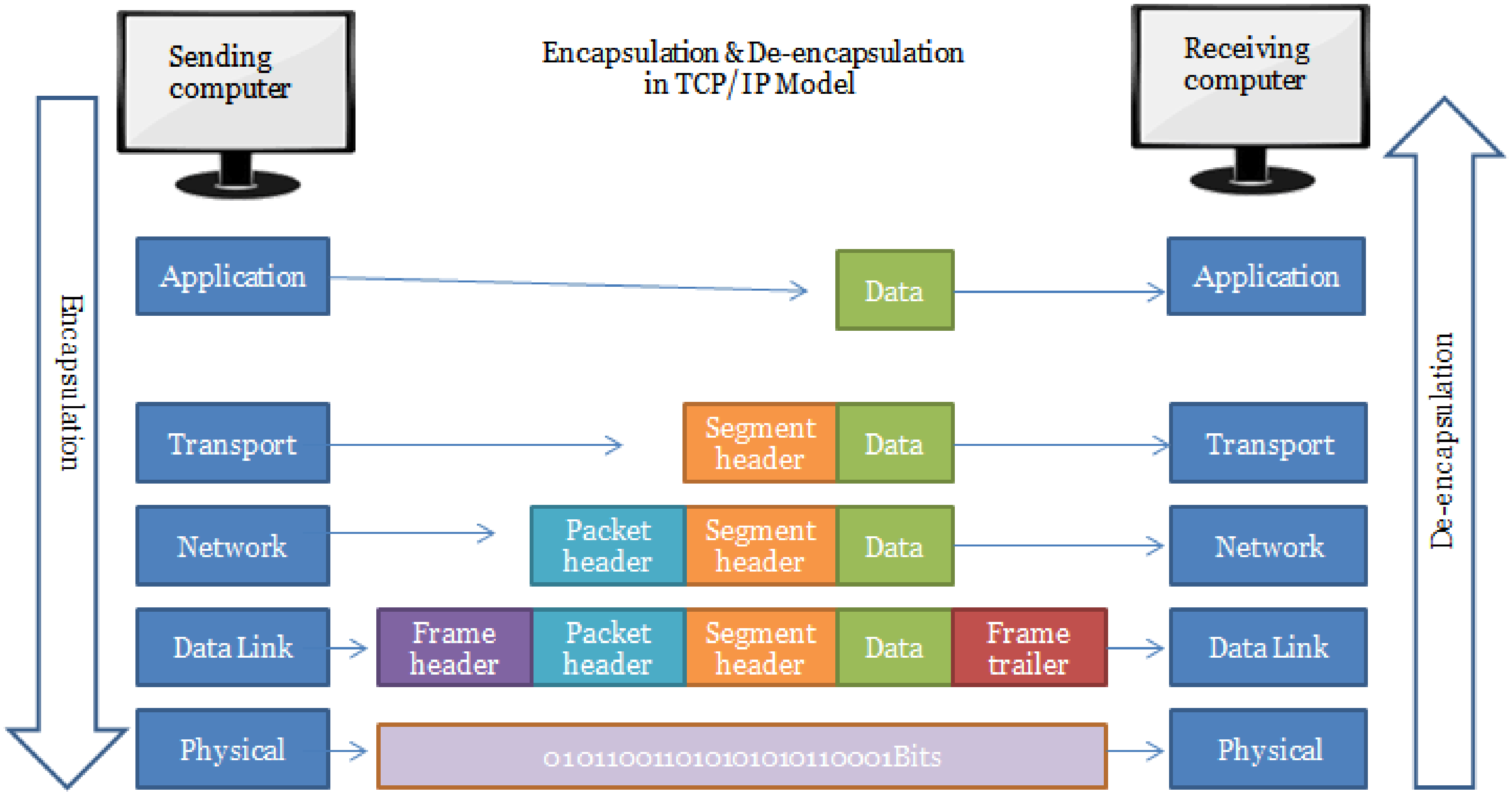
Distributed Communication

Centralized System



Distributed Communication

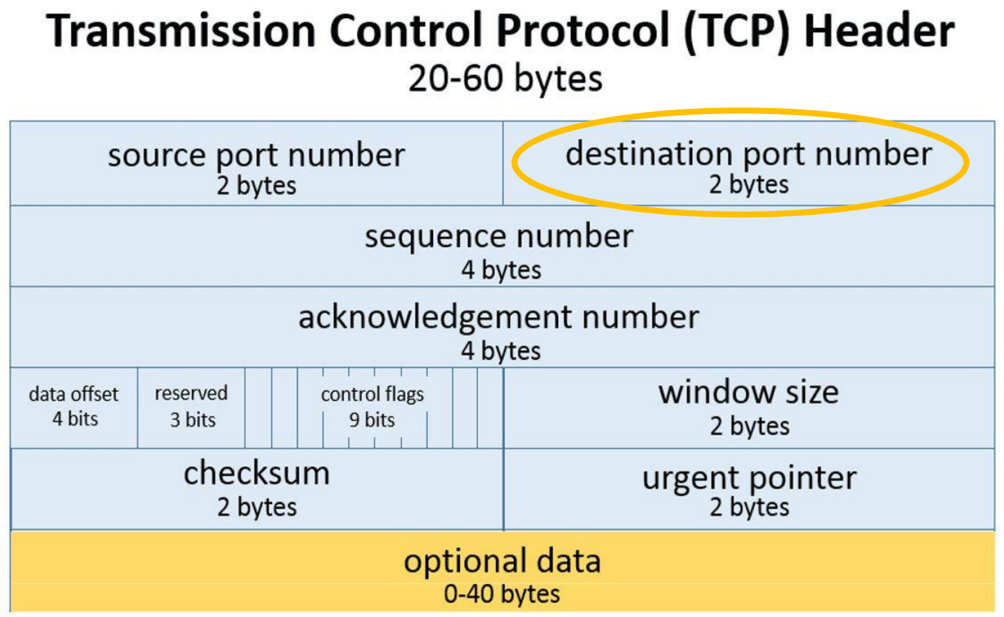
Data encapsulation

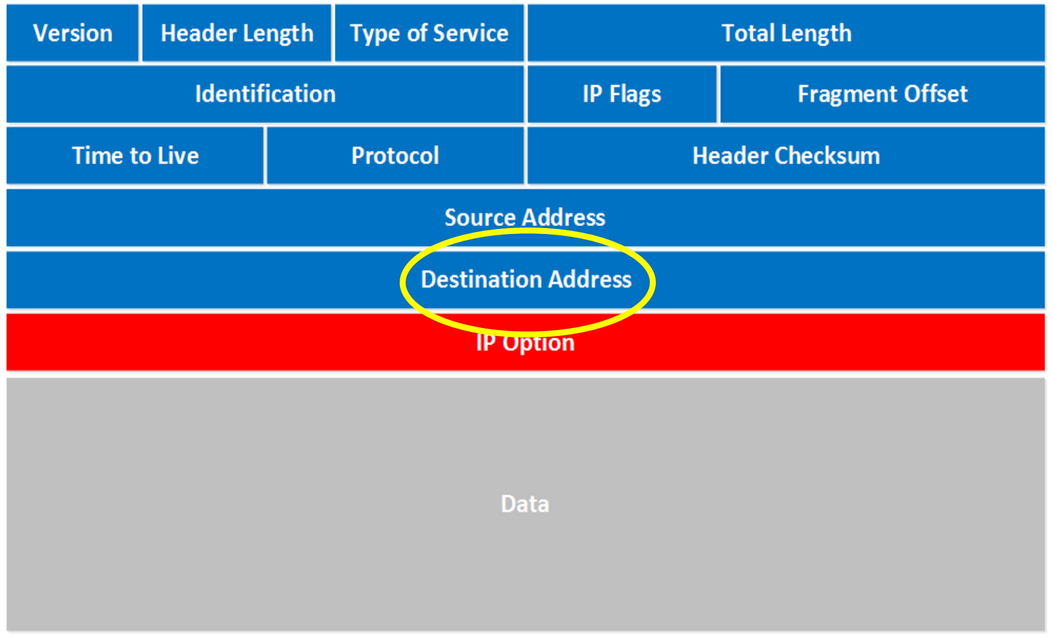


Distributed Communication

TCP/IP

127.0.0.1:3000





Distributed Communication

Port (logical)

- 2 Bytes, 16 bits, 65536 possible value
- Standard port
  - FTP (21), SSH (22), SMTP (25), DNS (53), HTTP (80), HTTPS (443)
- Well known ports : 0 –1023
- Registered ports : 1024 – 49151
- Dynamic / Private ports: 49152 - 65535

Distributed Communication

Protocol

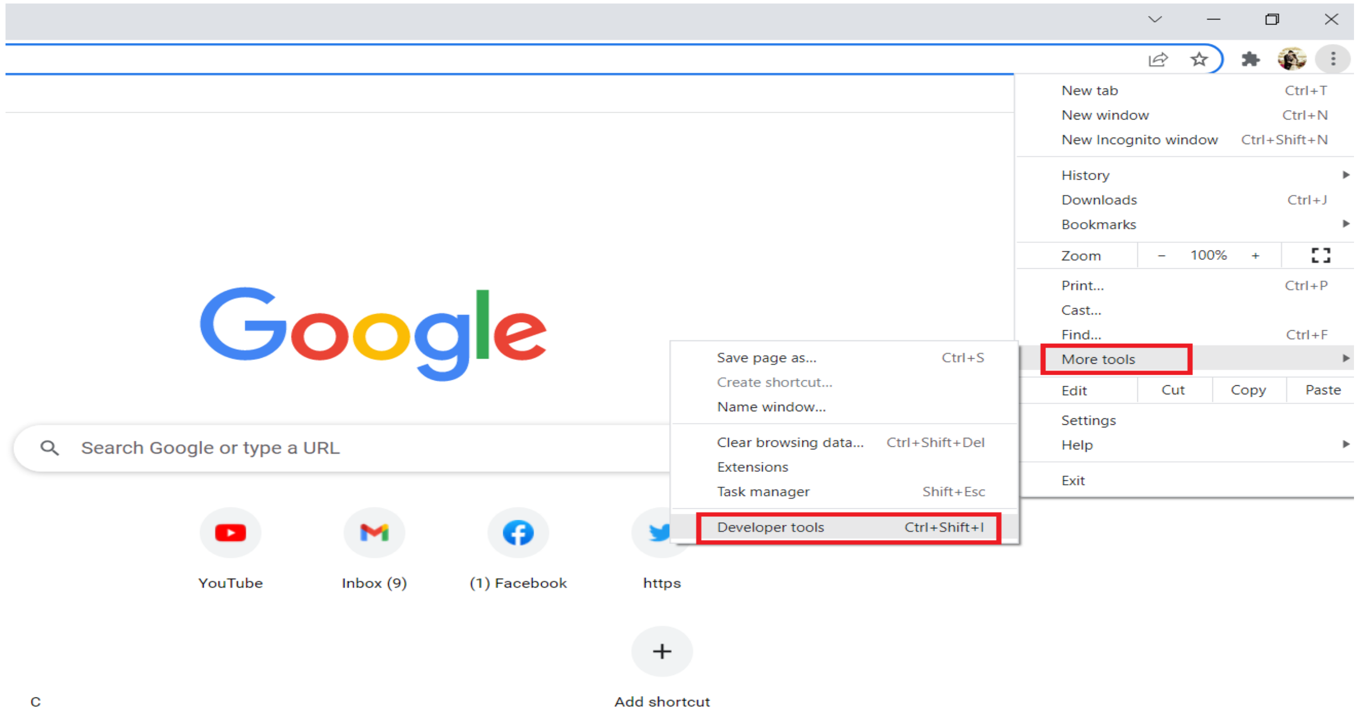
- A defined set of standards that computers must follow in order to communicate properly.

Port

- Is a 16-bit number that's used to direct traffic to specific services running on the network computer.

Distributed Communication

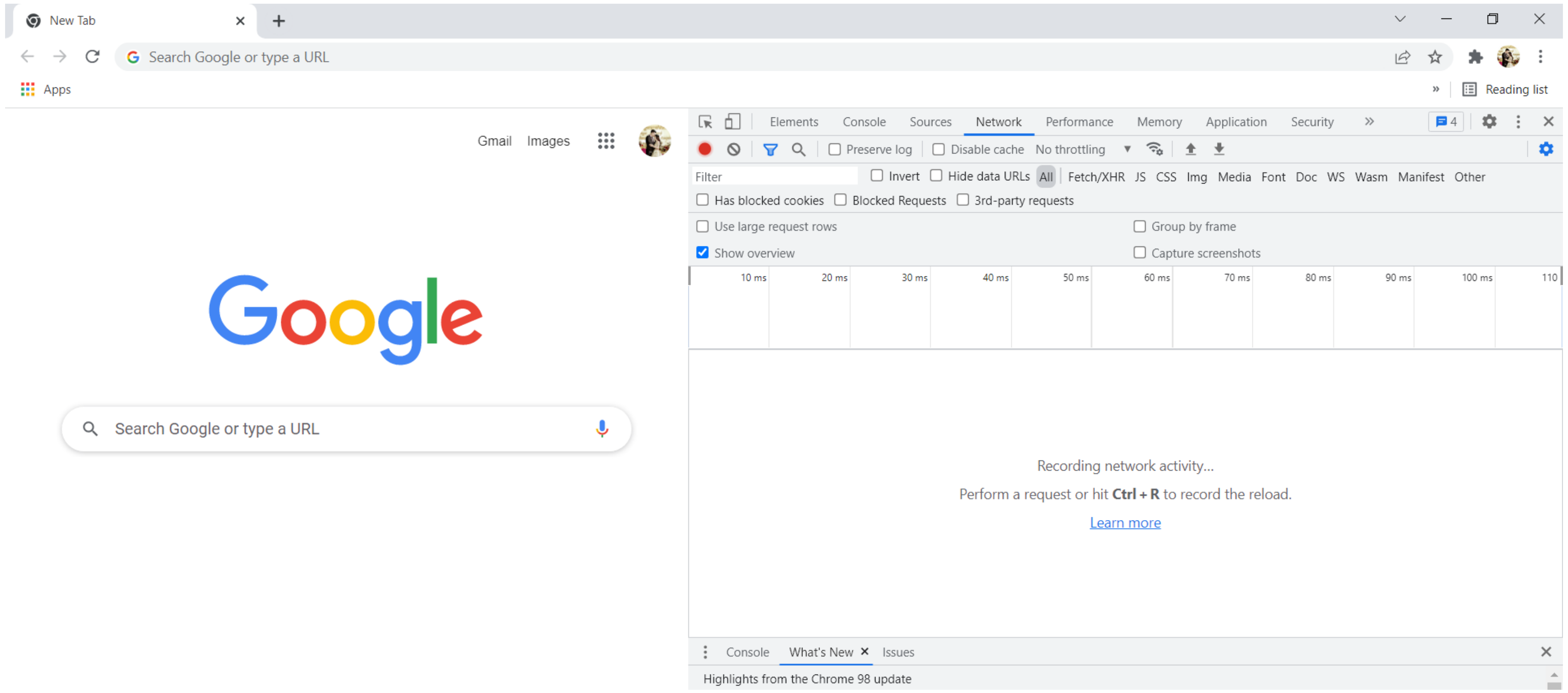
HTTP Protocol



Go to "Developer tools" in browser

Distributed Communication

HTTP Protocol



Recording network activity...

Perform a request or hit **Ctrl + R** to record the reload.

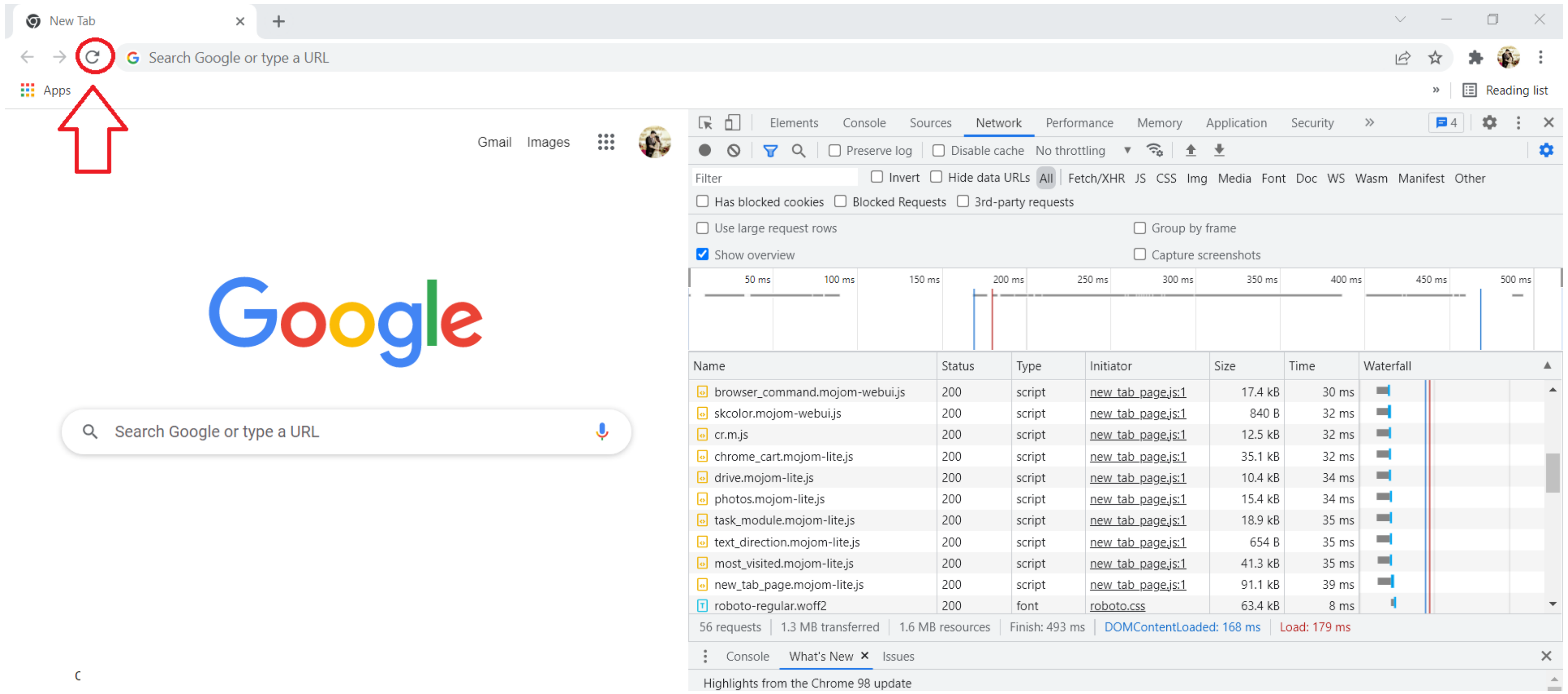
Learn more

Highlights from the Chrome 98 update

Go to "Network" menu

Distributed Communication

HTTP Protocol



[✓ Show overview]

Name	Status	Type	Initiator	Size	Time	Waterfall
browser_command.mojom-webui.js	200	script	new_tab_page.js:1	17.4 kB	30 ms	
skcolor.mojom-webui.js	200	script	new_tab_page.js:1	840 B	32 ms	
cr.m.js	200	script	new_tab_page.js:1	12.5 kB	32 ms	
chrome_cart.mojom-lite.js	200	script	new_tab_page.js:1	35.1 kB	32 ms	
drive.mojom-lite.js	200	script	new_tab_page.js:1	10.4 kB	34 ms	
photos.mojom-lite.js	200	script	new_tab_page.js:1	15.4 kB	34 ms	
task_module.mojom-lite.js	200	script	new_tab_page.js:1	18.9 kB	35 ms	
text_direction.mojom-lite.js	200	script	new_tab_page.js:1	654 B	35 ms	
most_visited.mojom-lite.js	200	script	new_tab_page.js:1	41.3 kB	35 ms	
new_tab_page.mojom-lite.js	200	script	new_tab_page.js:1	91.1 kB	39 ms	
roboto-regular.woff2	200	font	roboto.css	63.4 kB	8 ms	

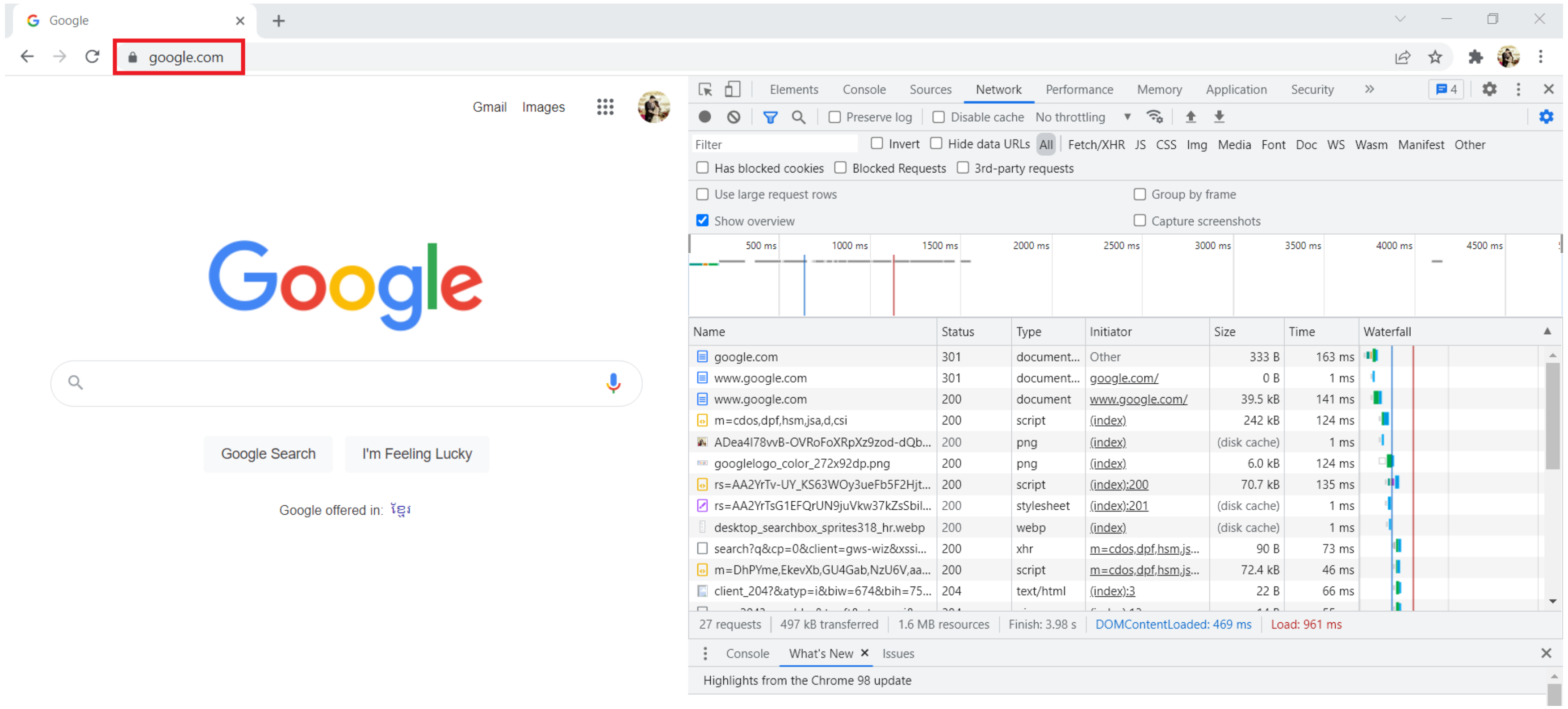
56 requests | 1.3 MB transferred | 1.6 MB resources | Finish: 493 ms | DOMContentLoaded: 168 ms | Load: 179 ms

Highlights from the Chrome 98 update

Refresh the page

Distributed Communication

HTTP Protocol



google.com

Name	Status	Type	Initiator	Size	Time
google.com	301	document...	Other	333 B	163 ms
www.google.com	301	document...	google.com/	0 B	1 ms
www.google.com	200	document	www.google.com/	39.5 kB	141 ms
m=cdos,dpf,hsm,jsa,d,csi	200	script	(index)	242 kB	124 ms
ADea4I78vvB-OVRoFoXRpXz9zod-dQb...	200	png	(index)	(disk cache)	1 ms
googlelogo_color_272x92dp.png	200	png	(index)	6.0 kB	124 ms
rs=AA2YrTv-UY_KS63WOy3ueFb5F2Hjt...	200	script	(index):200	70.7 kB	135 ms
rs=AA2YrTsG1EFQrUN9juVkw37kZsSbil...	200	stylesheet	(index):201	(disk cache)	1 ms
desktop_searchbox_sprites318_hr.webp	200	webp	(index)	(disk cache)	1 ms
search?q&cp=0&client=gws-wiz&xssi...	200	xhr	m=cdos,dpf,hsm,js...	90 B	73 ms
m=DhPYme,EkevXb,GU4Gab,NzU6V,aa...	200	script	m=cdos,dpf,hsm,js...	72.4 kB	46 ms
client_204?&atyp=i&biw=674&bih=75...	204	text/html	(index):3	22 B	66 ms

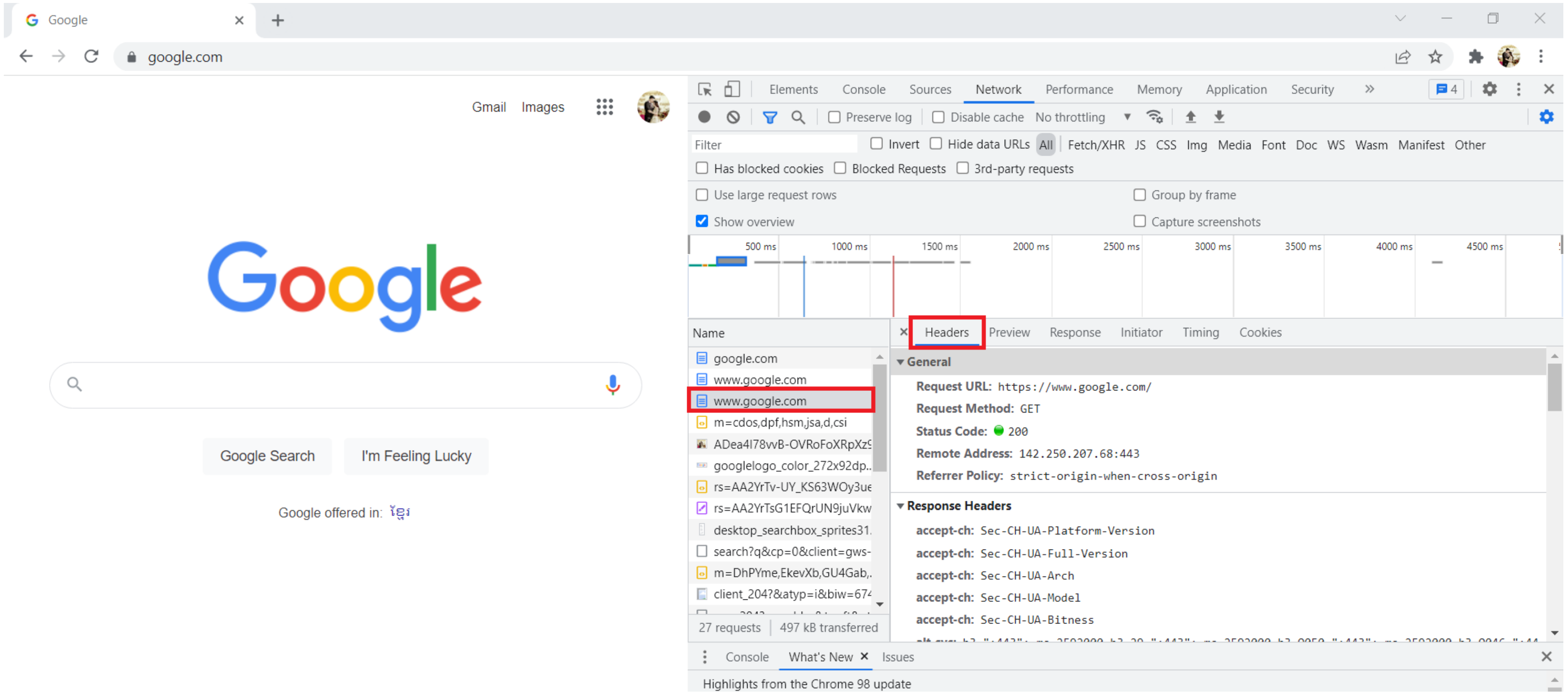
27 requests | 497 kB transferred | 1.6 MB resources | Finish: 3.98 s | DOMContentLoaded: 469 ms | Load: 961 ms

Highlights from the Chrome 98 update

Type "google.com"

Distributed Communication

HTTP Protocol



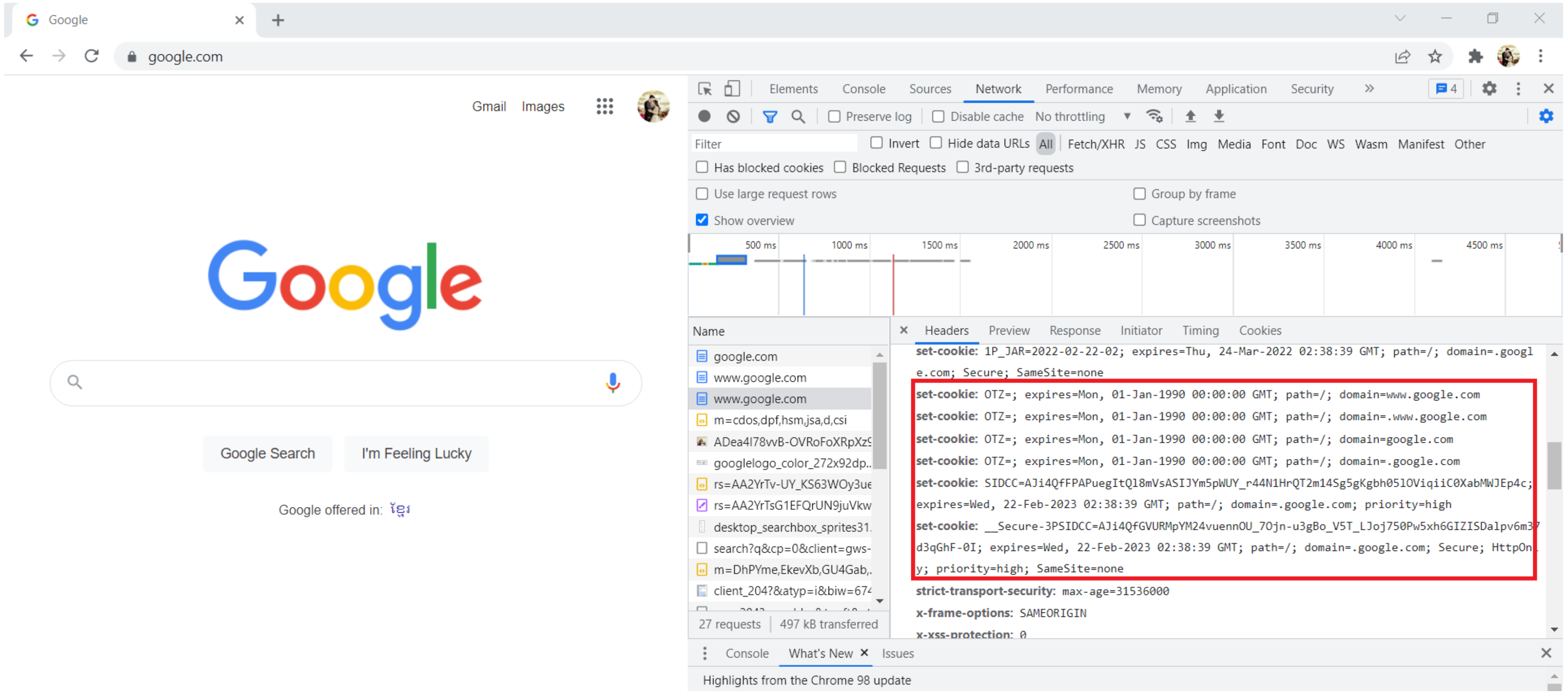
```
google.com
www.google.com
www.google.com
m=cdos,dpf,hsm,jsa,d,csi
ADea4I78vvB-OVRoFoXRpXz
googlelogo_color_272x92dp..
rs=AA2YrTv-UY_KS63WOy3ue
rs=AA2YrTsG1EFQrUN9juVkw
desktop_searchbox_sprites31.
search?q&cp=0&client=gws-
m=DhPYme,EkevXb,GU4Gab,.
client_204?&atyp=i&biw=674
27 requests | 497 kB transferred
```

```
▼ General
  Request URL: https://www.google.com/
  Request Method: GET
  Status Code: ● 200
  Remote Address: 142.250.207.68:443
  Referrer Policy: strict-origin-when-cross-origin
▼ Response Headers
  accept-ch: Sec-CH-UA-Platform-Version
  accept-ch: Sec-CH-UA-Full-Version
  accept-ch: Sec-CH-UA-Arch
  accept-ch: Sec-CH-UA-Model
  accept-ch: Sec-CH-UA-Bitness
```

Click on the resource and see information in the "Headers"

Distributed Communication

HTTP Protocol



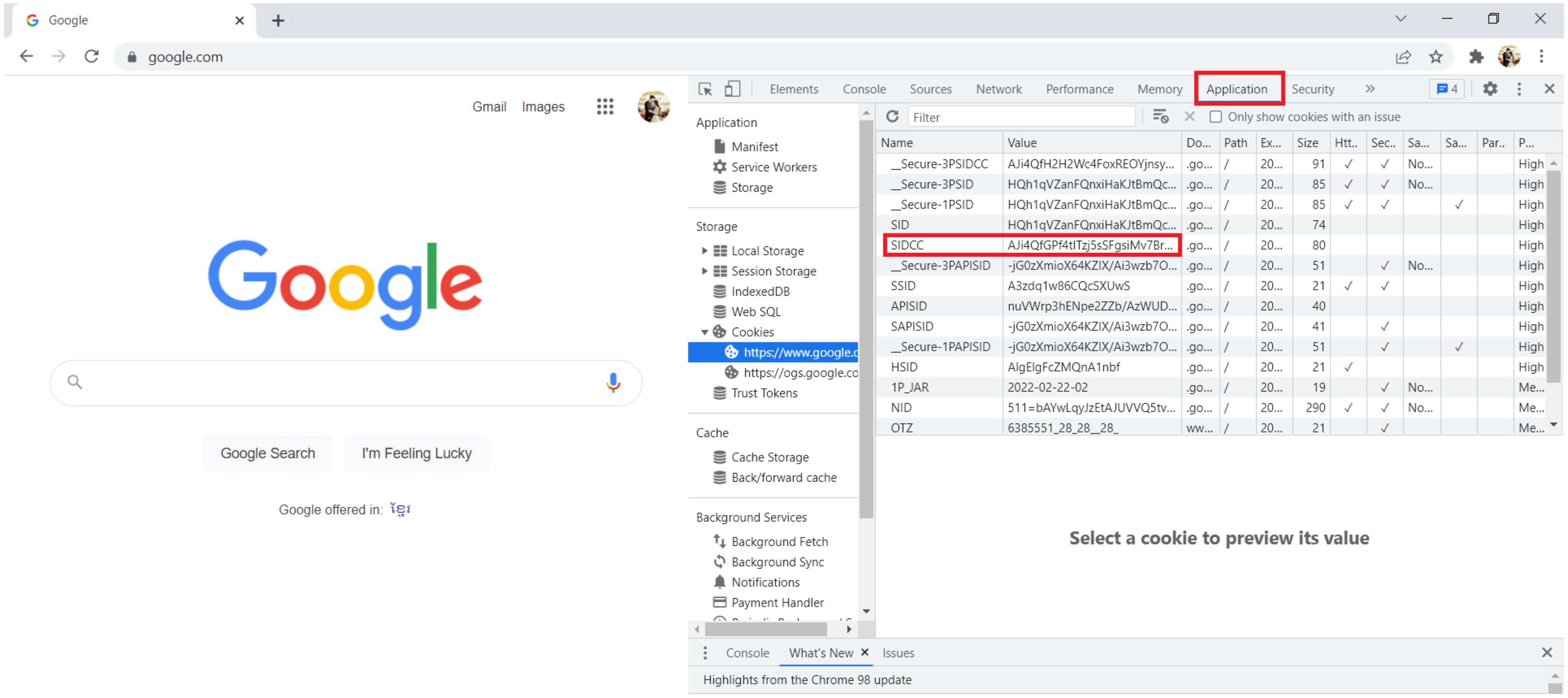
```
set-cookie: 1P_JAR=2022-02-22-02; expires=Thu, 24-Mar-2022 02:38:39 GMT; path=/; domain=.googl
e.com; Secure; SameSite=none
set-cookie: OTZ=; expires=Mon, 01-Jan-1990 00:00:00 GMT; path=/; domain=www.google.com
set-cookie: OTZ=; expires=Mon, 01-Jan-1990 00:00:00 GMT; path=/; domain=.www.google.com
set-cookie: OTZ=; expires=Mon, 01-Jan-1990 00:00:00 GMT; path=/; domain=google.com
set-cookie: OTZ=; expires=Mon, 01-Jan-1990 00:00:00 GMT; path=/; domain=.google.com
set-cookie: SIDCC=AJi4QfFPAPuegItQl8mVsASIJYm5pWUY_r44N1HrQT2m14Sg5gKgbh05lOViqiiC0XabMWJEp4c;
expires=Wed, 22-Feb-2023 02:38:39 GMT; path=/; domain=.google.com; priority=high
set-cookie: __Secure-3PSIDCC=AJi4QfGVURMpYM24vuennOU_7Ojn-u3gBo_V5T_LJoj750Pw5xh6GIZISDalpv6m37
d3qGhF-0I; expires=Wed, 22-Feb-2023 02:38:39 GMT; path=/; domain=.google.com; Secure; HttpOnl
y; priority=high; SameSite=none
strict-transport-security: max-age=31536000
x-frame-options: SAMEORIGIN
x-xss-protection: 0
```

Google
google.com
Gmail Images
Google Search I'm Feeling Lucky
Google offered in: ខ្មែរ
Elements Console Sources Network Performance Memory Application Security
Preserve log Disable cache No throttling
Filter Invert Hide data URLs All Fetch/XHR JS CSS Img Media Font Doc WS Wasm Manifest Other
Has blocked cookies Blocked Requests 3rd-party requests
Use large request rows Group by frame
Show overview Capture screenshots
Name
google.com
www.google.com
www.google.com
Headers Preview Response Initiator Timing Cookies
27 requests 497 kB transferred
Console What's New Issues
Highlights from the Chrome 98 update

"set-cookie" in response header

Distributed Communication

HTTP Protocol



Application
- Manifest
- Service Workers
- Storage

Storage
- Local Storage
- Session Storage
- IndexedDB
- Web SQL
- Cookies
  - https://www.google.c
  - https://ogs.google.co
- Trust Tokens

Cache
- Cache Storage
- Back/forward cache

Background Services
- Background Fetch
- Background Sync
- Notifications
- Payment Handler

Only show cookies with an issue

Name	Value	Do...	Path	Ex...	Size	Htt..	Sec..	Sa...	Sa...	Par..	P...
__Secure-3PSIDCC	AJi4QfH2H2Wc4FoxREOYjnsy...	.go...	/	20...	91	✓	✓	No...			High
__Secure-3PSID	HQh1qVZanFQnxiHaKJtBmQc...	.go...	/	20...	85	✓	✓	No...			High
__Secure-1PSID	HQh1qVZanFQnxiHaKJtBmQc...	.go...	/	20...	85	✓	✓		✓		High
SID	HQh1qVZanFQnxiHaKJtBmQc...	.go...	/	20...	74						High
SIDCC	AJi4QfGPf4tITzj5sSFgsiMv7Br...	.go...	/	20...	80						High
__Secure-3PAPISID	-jG0zXmioX64KZIX/Ai3wzb7O...	.go...	/	20...	51		✓	No...			High
SSID	A3zdq1w86CQcSXUwS	.go...	/	20...	21	✓	✓				High
APISID	nuVWrp3hENpe2ZZb/AzWUD...	.go...	/	20...	40						High
SAPISID	-jG0zXmioX64KZIX/Ai3wzb7O...	.go...	/	20...	41		✓				High
__Secure-1PAPISID	-jG0zXmioX64KZIX/Ai3wzb7O...	.go...	/	20...	51		✓		✓		High
HSID	AlgElgFcZMQnA1nbf	.go...	/	20...	21	✓					High
1P_JAR	2022-02-22-02	.go...	/	20...	19		✓	No...			Me...
NID	511=bAYwLqyJzEtAJUVVQ5tv...	.go...	/	20...	290	✓	✓	No...			Me...
OTZ	6385551_28_28__28_	ww...	/	20...	21		✓				Me...

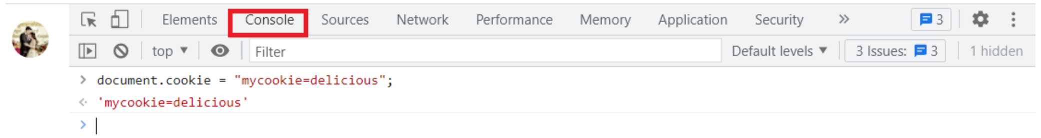
Select a cookie to preview its value

Highlights from the Chrome 98 update

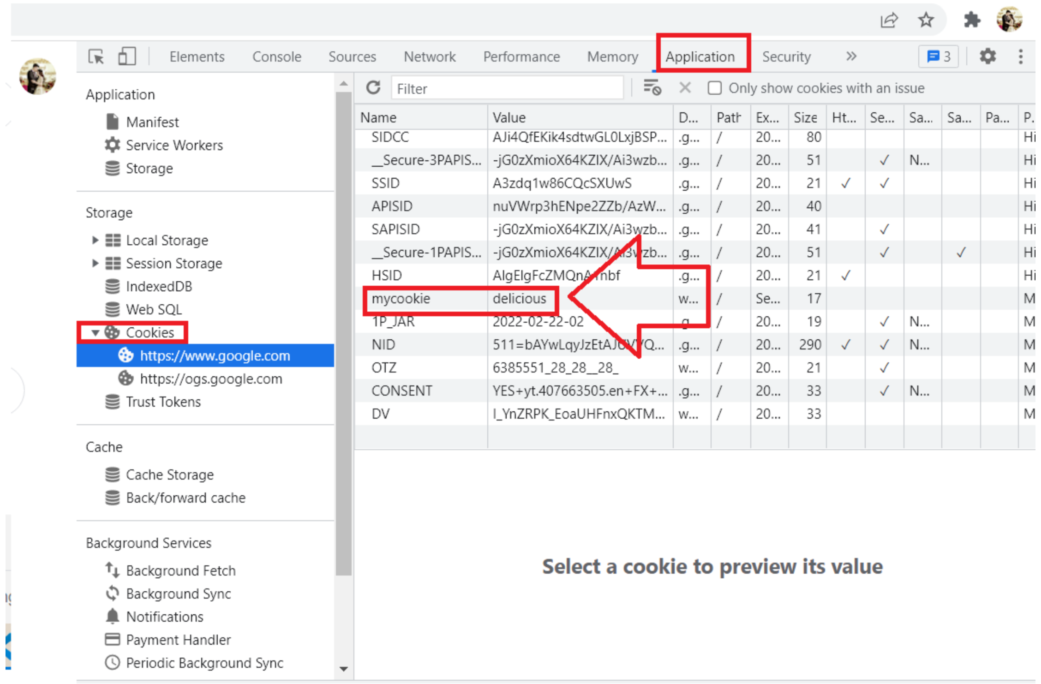
Look for the cookie in "Application > Cookies"

Distributed Communication

HTTP Protocol



```
> document.cookie = "mycookie=delicious";
< 'mycookie=delicious'
> |
```



Name	Value	D...	Path	Ex...	Size	Ht...	Se...	Sa...	Sa...	Pa...	P.
SIDCC	AJi4QfEKik4sdtwGL0LxjBSP...	.g...	/	20...	80						Hi
__Secure-3PAPIS...	-jG0zXmioX64KZIX/Ai3wzb...	.g...	/	20...	51		✓	N...			Hi
SSID	A3zdq1w86CQcSXUwS	.g...	/	20...	21	✓	✓				Hi
APISID	nuVWrp3hENpe2ZZb/AzW...	.g...	/	20...	40						Hi
SAPISID	-jG0zXmioX64KZIX/Ai3wzb...	.g...	/	20...	41		✓				Hi
__Secure-1PAPIS...	-jG0zXmioX64KZIX/Ai3wzb...	.g...	/	20...	51		✓		✓		Hi
HSID	AlgElgFcZMQnA[illegible]nbf	.g...	/	20...	21	✓					Hi
mycookie	delicious	w...	/	Se...	17						M
1P_JAR	2022-02-22-02	.g...	/	20...	19		✓	N...			M
NID	511=bAYwLqyJzEtAJ[illegible]Q...	.g...	/	20...	290	✓	✓	N...			M
OTZ	6385551_28_28__28_	w...	/	20...	21		✓				M
CONSENT	YES+yt.407663505.en+FX+...	.g...	/	20...	33		✓	N...			M
DV	I_YnZRPK_EoaUHFnxQKTM...	w...	/	20...	33						M

Create custom cookie from "console"

> document.cookie

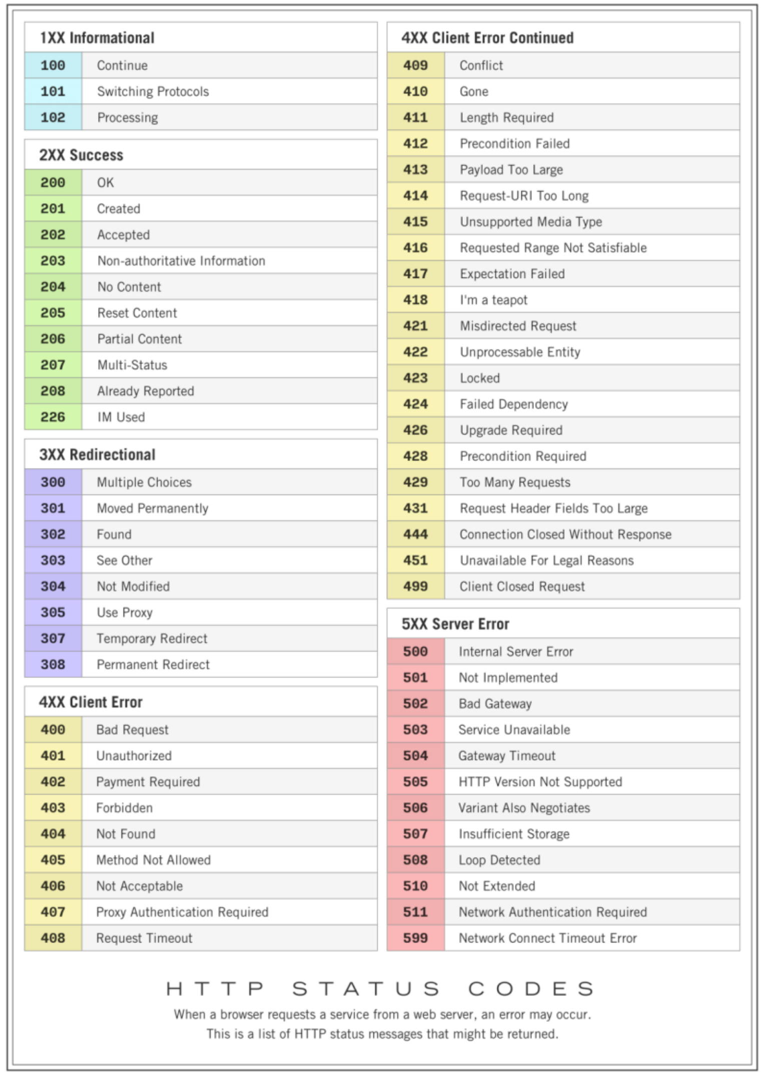
> document.cookie = "myCookie=Delicious"

Check to see the cookies in "Application > Cookie"

Distributed Communication

HTTP Protocol

1XX
INFORMATIONAL
2XX
SUCCESS
3XX
REDIRECTION
4XX
CLIENT ERROR
5XX
SERVER ERROR



1XX Informational	
100	Continue
101	Switching Protocols
102	Processing

2XX Success	
200	OK
201	Created
202	Accepted
203	Non-authoritative Information
204	No Content
205	Reset Content
206	Partial Content
207	Multi-Status
208	Already Reported
226	IM Used

3XX Redirectional	
300	Multiple Choices
301	Moved Permanently
302	Found
303	See Other
304	Not Modified
305	Use Proxy
307	Temporary Redirect
308	Permanent Redirect

4XX Client Error	
400	Bad Request
401	Unauthorized
402	Payment Required
403	Forbidden
404	Not Found
405	Method Not Allowed
406	Not Acceptable
407	Proxy Authentication Required
408	Request Timeout

4XX Client Error Continued	
409	Conflict
410	Gone
411	Length Required
412	Precondition Failed
413	Payload Too Large
414	Request-URI Too Long
415	Unsupported Media Type
416	Requested Range Not Satisfiable
417	Expectation Failed
418	I'm a teapot
421	Misdirected Request
422	Unprocessable Entity
423	Locked
424	Failed Dependency
426	Upgrade Required
428	Precondition Required
429	Too Many Requests
431	Request Header Fields Too Large
444	Connection Closed Without Response
451	Unavailable For Legal Reasons
499	Client Closed Request

5XX Server Error	
500	Internal Server Error
501	Not Implemented
502	Bad Gateway
503	Service Unavailable
504	Gateway Timeout
505	HTTP Version Not Supported
506	Variant Also Negotiates
507	Insufficient Storage
508	Loop Detected
510	Not Extended
511	Network Authentication Required
599	Network Connect Timeout Error

HTTP STATUS CODES

When a browser requests a service from a web server, an error may occur.
This is a list of HTTP status messages that might be returned.

Distributed Communication

Socket

The instantiation of an end-point in a potential TCP connection.

Socket status

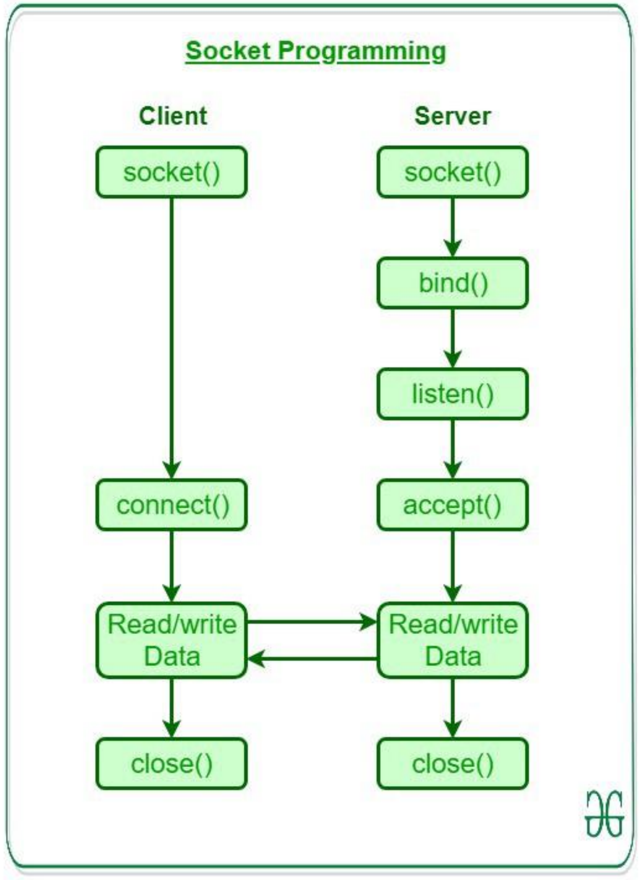
Depend on Operating System. Those status are:

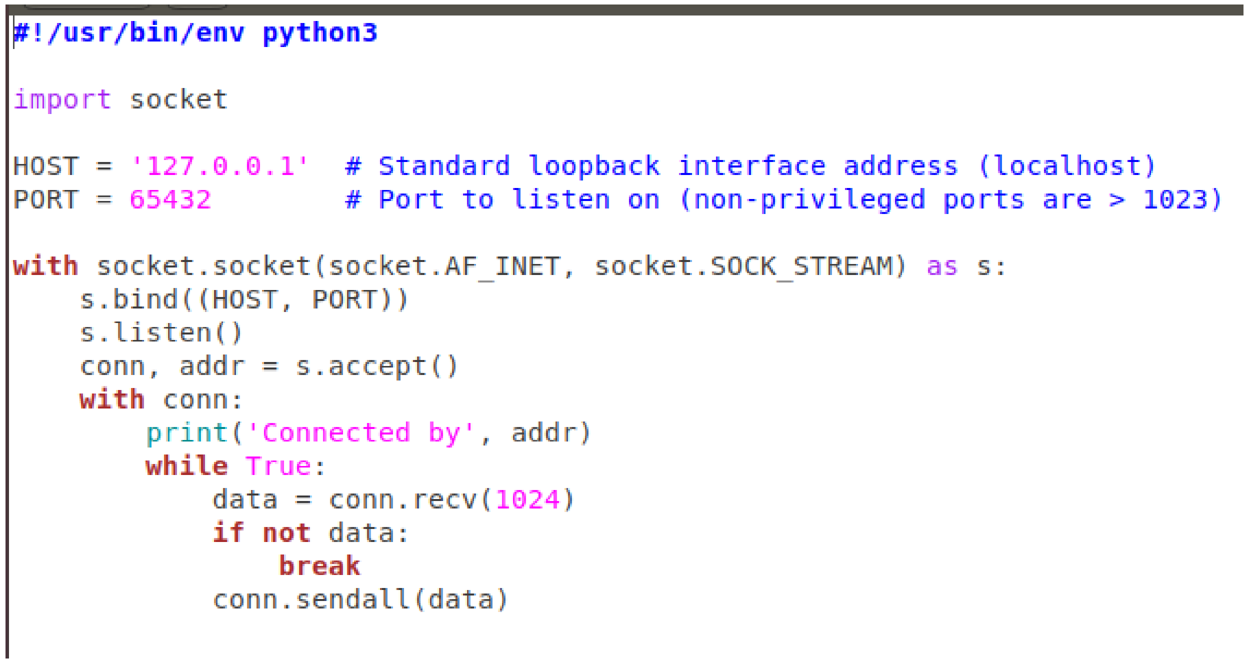
- LISTEN: listening for incoming connection.
- SYN_SENT: synchronization request sent, but not yet establish connection yet.
- SYN_RECEIVED: The socket in the LISTEN state received the syn request and send SYN/ACK back.
- ESTABLISHED: The connect is established, and both client server can communicate.
- FIN/WAIT: The FIN request sent, but not yet received the ACK from other.
- CLOSE/WAIT: The connection has been closed at the TCP layer, but the application that open socket still not released its hold on the socket yet.
- CLOSED: The connection has been fully terminated, no further communication is possible.

Ref: Linux socket https://man7.org/linux/man-pages/man2/socket.2.html

Distributed Communication

Socket programming

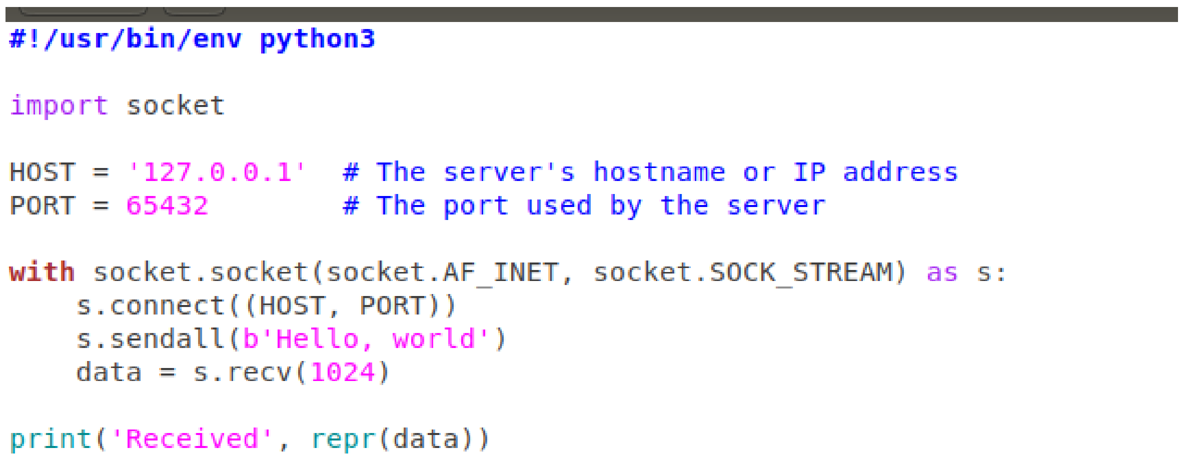




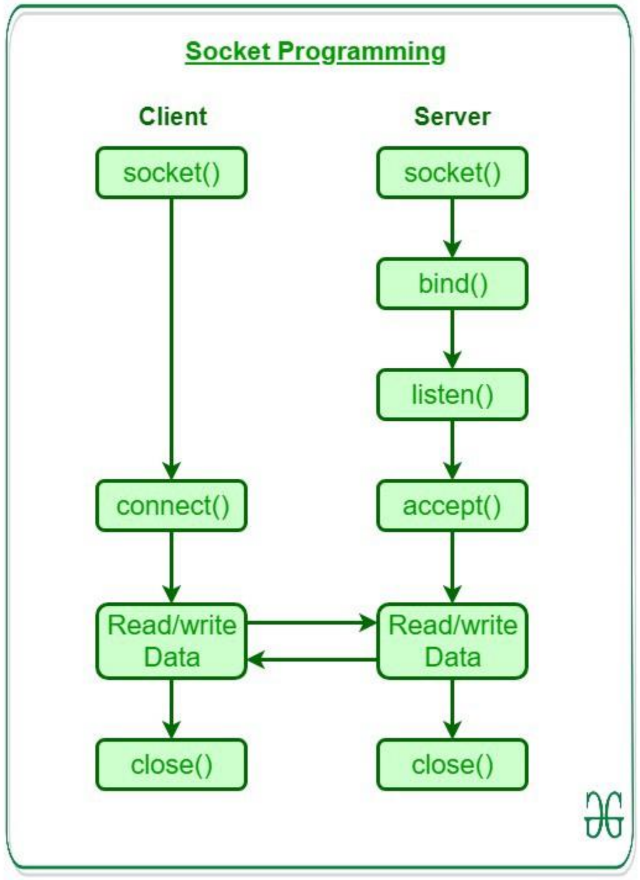
```
#!/usr/bin/env python3

import socket

HOST = '127.0.0.1'  # Standard loopback interface address (localhost)
PORT = 65432        # Port to listen on (non-privileged ports are > 1023)

with socket.socket(socket.AF_INET, socket.SOCK_STREAM) as s:
    s.bind((HOST, PORT))
    s.listen()
    conn, addr = s.accept()
    with conn:
        print('Connected by', addr)
        while True:
            data = conn.recv(1024)
            if not data:
                break
            conn.sendall(data)
```

Distributed Communication

Socket programming

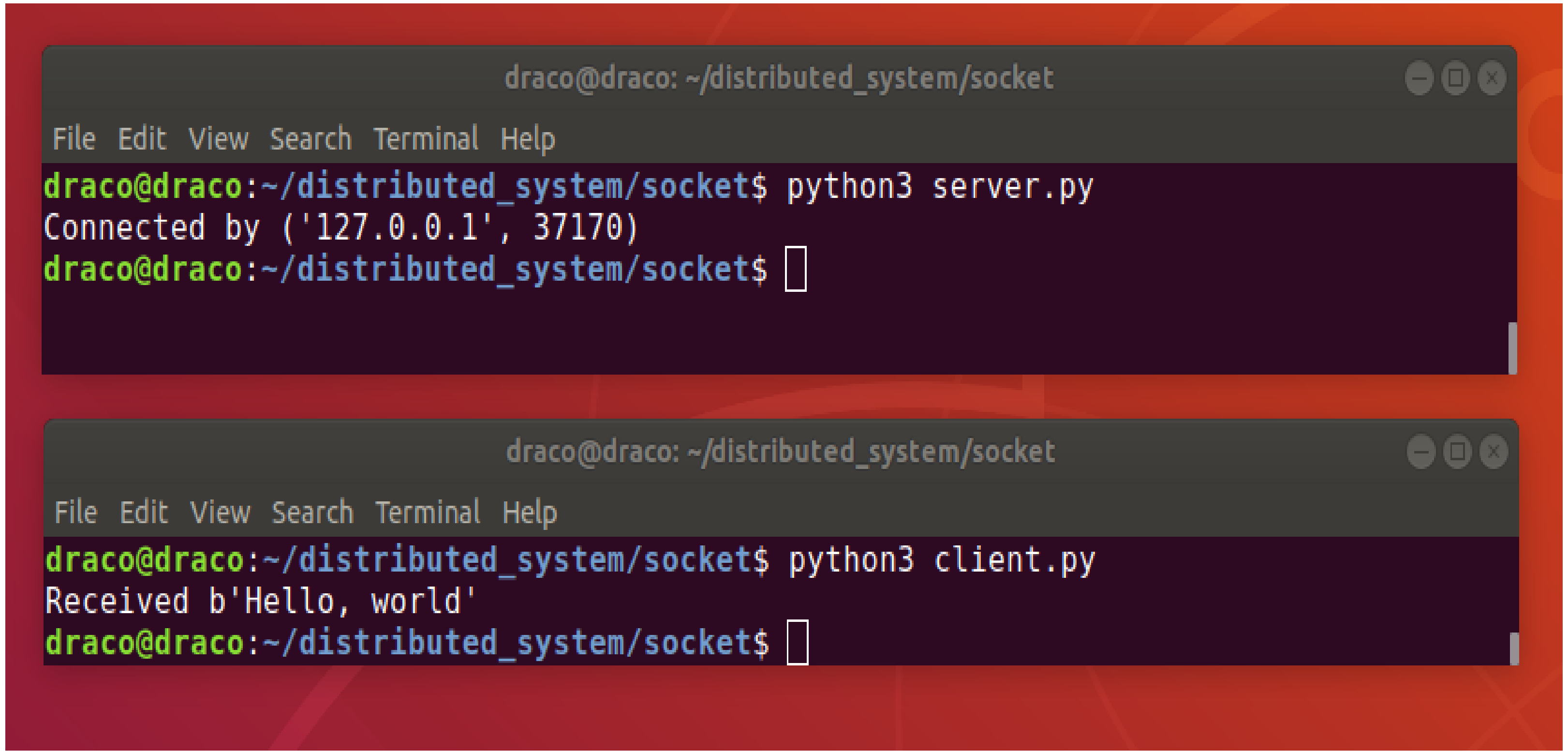


```
#!/usr/bin/env python3

import socket

HOST = '127.0.0.1'  # The server's hostname or IP address
PORT = 65432        # The port used by the server

with socket.socket(socket.AF_INET, socket.SOCK_STREAM) as s:
    s.connect((HOST, PORT))
    s.sendall(b'Hello, world')
    data = s.recv(1024)

print('Received', repr(data))
```



Distributed Communication

Socket programming


draco@draco: ~/distributed_system/socket
File Edit View Search Terminal Help

```
draco@draco:~/distributed_system/socket$ python3 server.py
Connected by ('127.0.0.1', 37170)
draco@draco:~/distributed_system/socket$
```

draco@draco: ~/distributed_system/socket
File Edit View Search Terminal Help

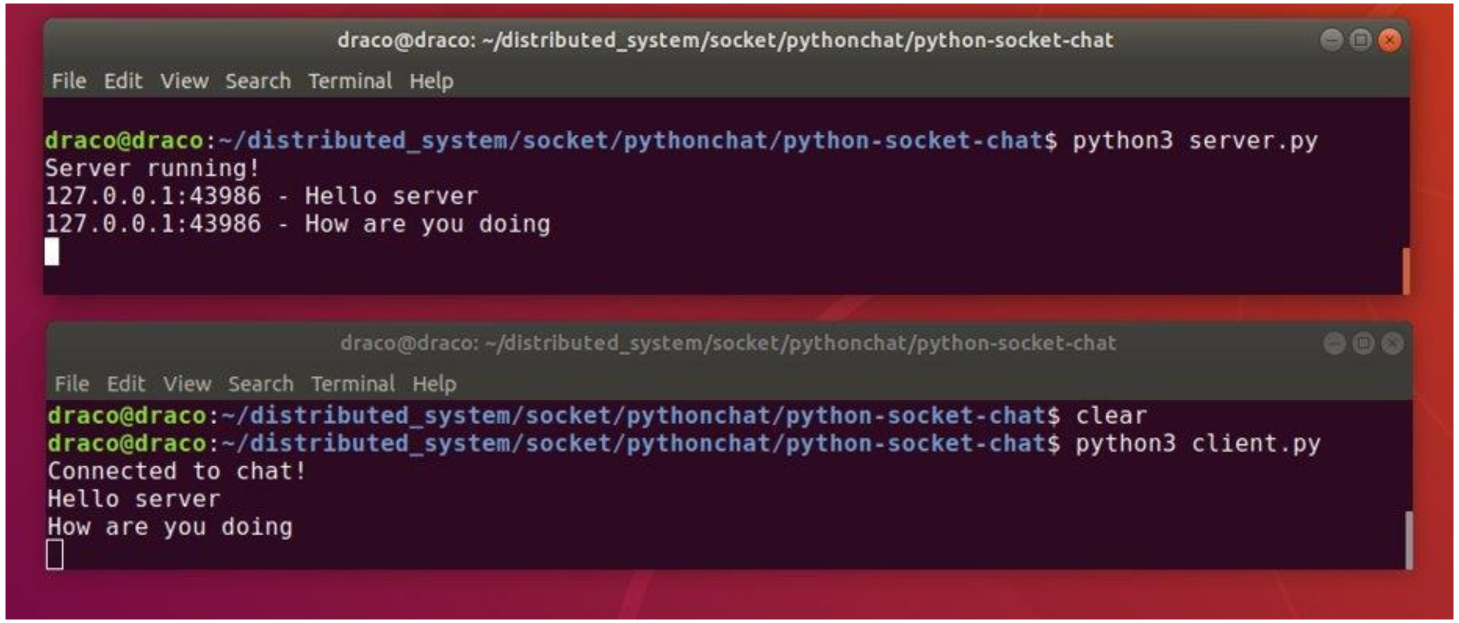
```
draco@draco:~/distributed_system/socket$ python3 client.py
Received b'Hello, world'
draco@draco:~/distributed_system/socket$
```

Practice

Socket programming

Choose any programming language you like, c, python, java, nodejs

1. Write a chat program between two users.
2. Write a simple chatroom for multiple players. Ex: 1 room 3 users


draco@draco: ~/distributed_system/socket/pythonchat/python-socket-chat
File Edit View Search Terminal Help

```
draco@draco:~/distributed_system/socket/pythonchat/python-socket-chat$ python3 server.py
Server running!
127.0.0.1:43986 - Hello server
127.0.0.1:43986 - How are you doing
```

draco@draco: ~/distributed_system/socket/pythonchat/python-socket-chat
File Edit View Search Terminal Help

```
draco@draco:~/distributed_system/socket/pythonchat/python-socket-chat$ clear
draco@draco:~/distributed_system/socket/pythonchat/python-socket-chat$ python3 client.py
Connected to chat!
Hello server
How are you doing
```

Distributed Communication

REST: Representational State Transfer

- REST is good for CRUD operation (Create, Read, Update, Delete)
- Endpoint URL: https://domain/api/resource
- HTTP Methods: POST, GET, PUT, DELETE

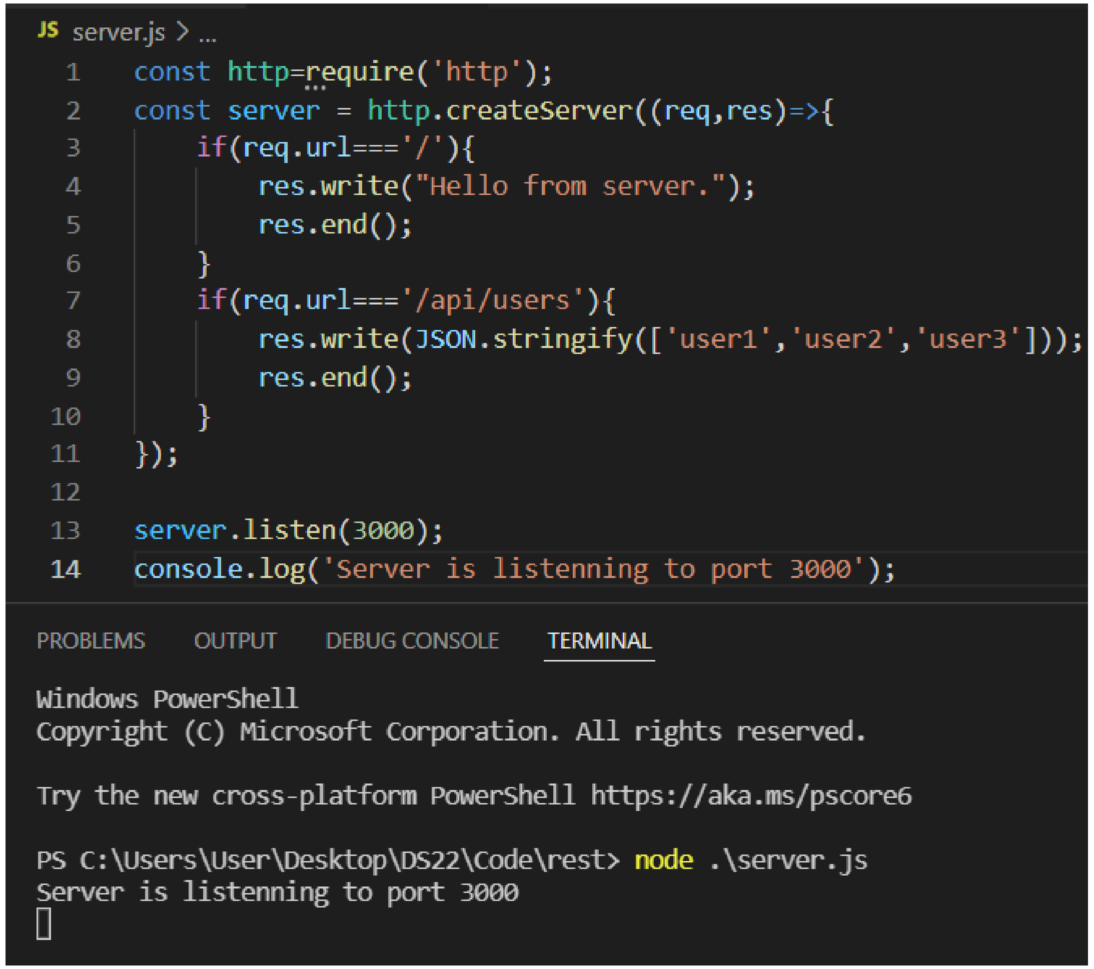
Ex:

POST /api/users //With a body payload

GET /api/users/id

Distributed Communication

Example with http library


server.js > ...

```javascript
const http=require('http');
const server = http.createServer((req,res)=>{
    if(req.url==='/'){
        res.write("Hello from server.");
        res.end();
    }
    if(req.url==='/api/users'){
        res.write(JSON.stringify(['user1','user2','user3']));
        res.end();
    }
});

server.listen(3000);
console.log('Server is listenning to port 3000');
```

```
Windows PowerShell
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Try the new cross-platform PowerShell https://aka.ms/pscore6

PS C:\Users\User\Desktop\DS22\Code\rest> node .\server.js
Server is listenning to port 3000
```
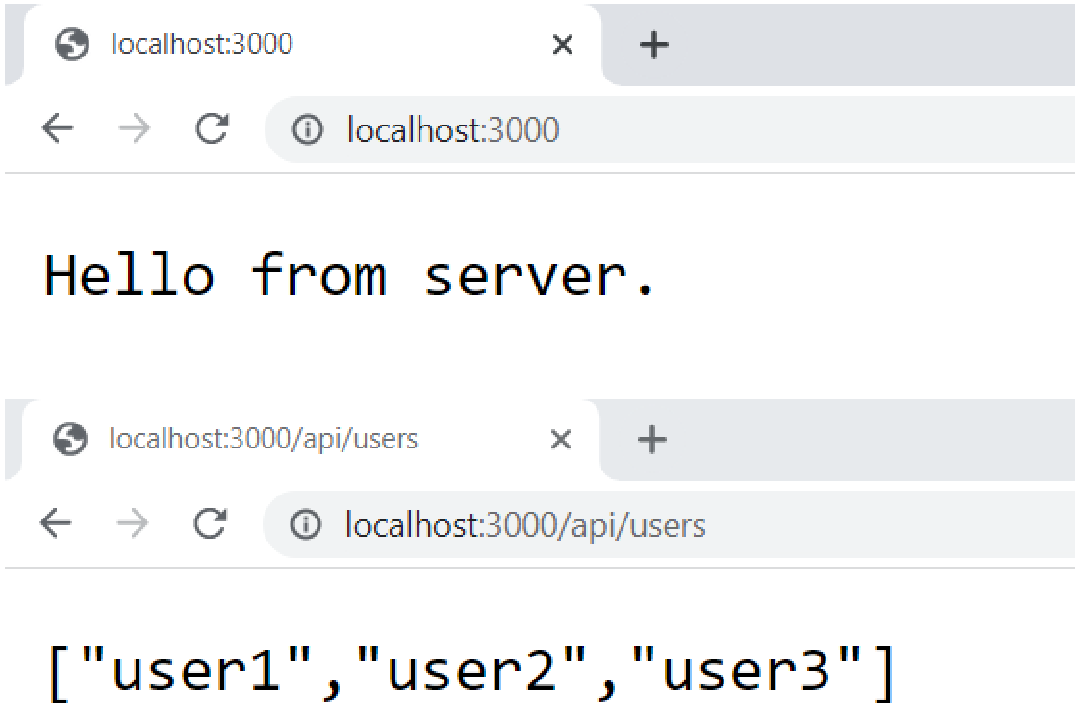


localhost:3000

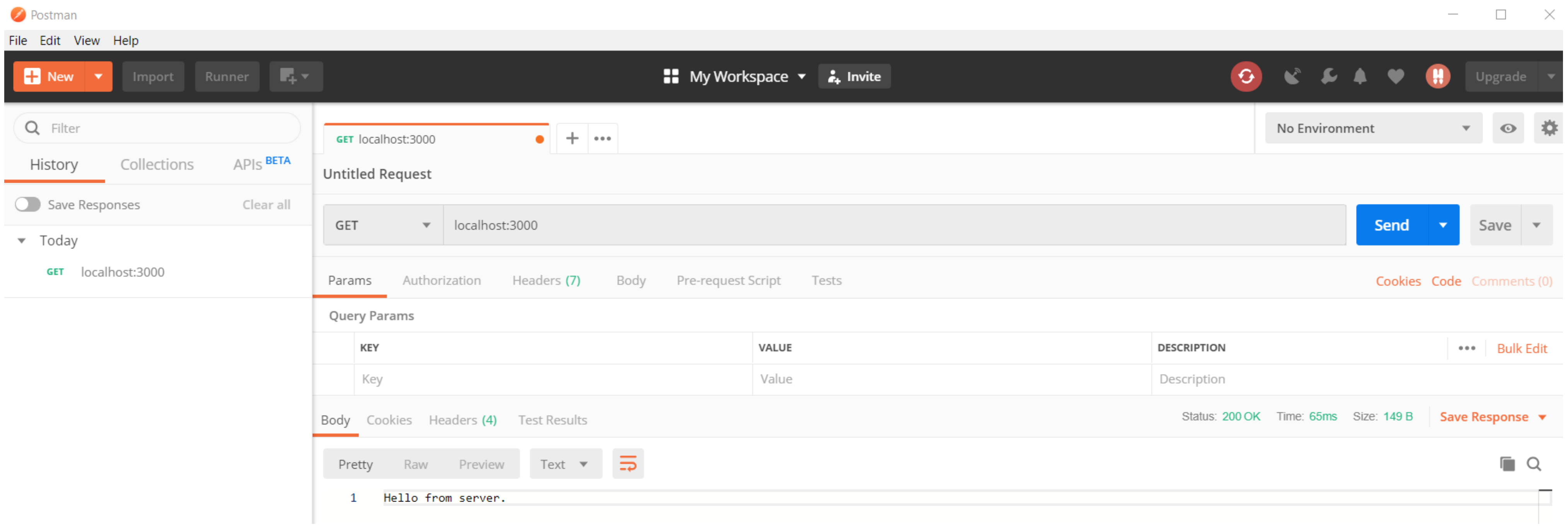
```
Hello from server.
```

localhost:3000/api/users

```
["user1","user2","user3"]
```

Distributed Communication

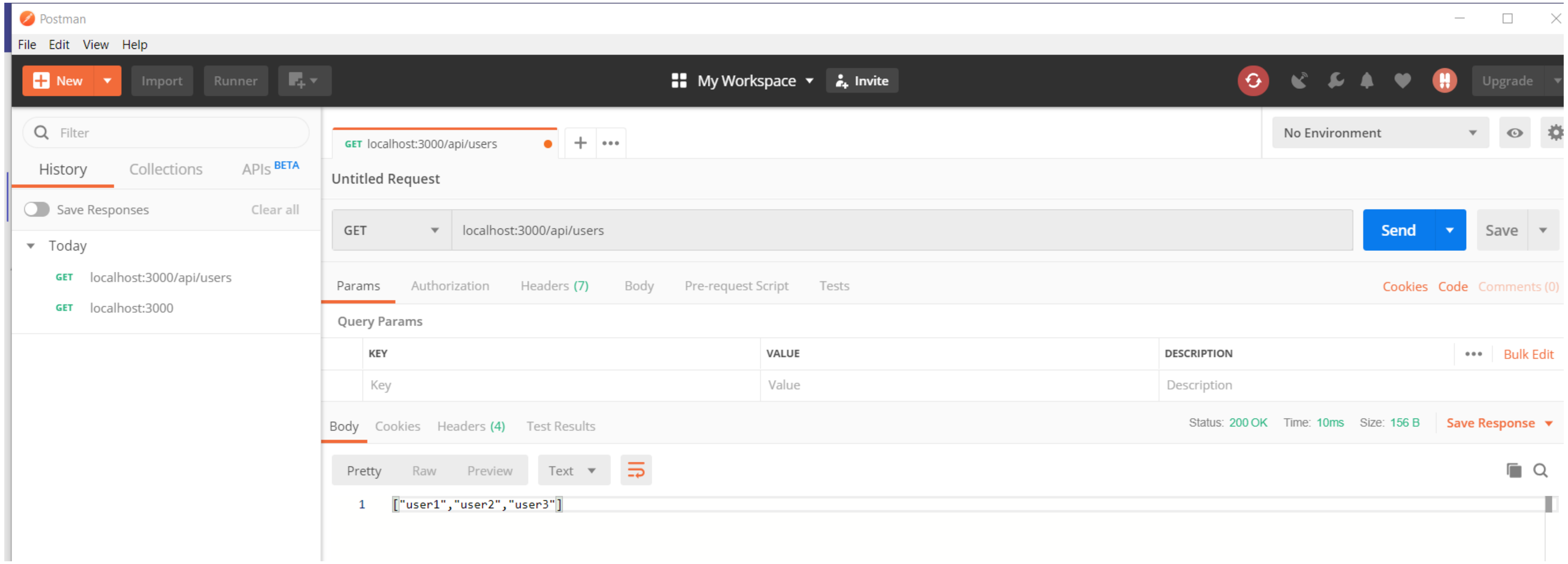
Example with http library



```
Hello from server.
```

Distributed Communication

Example with http library



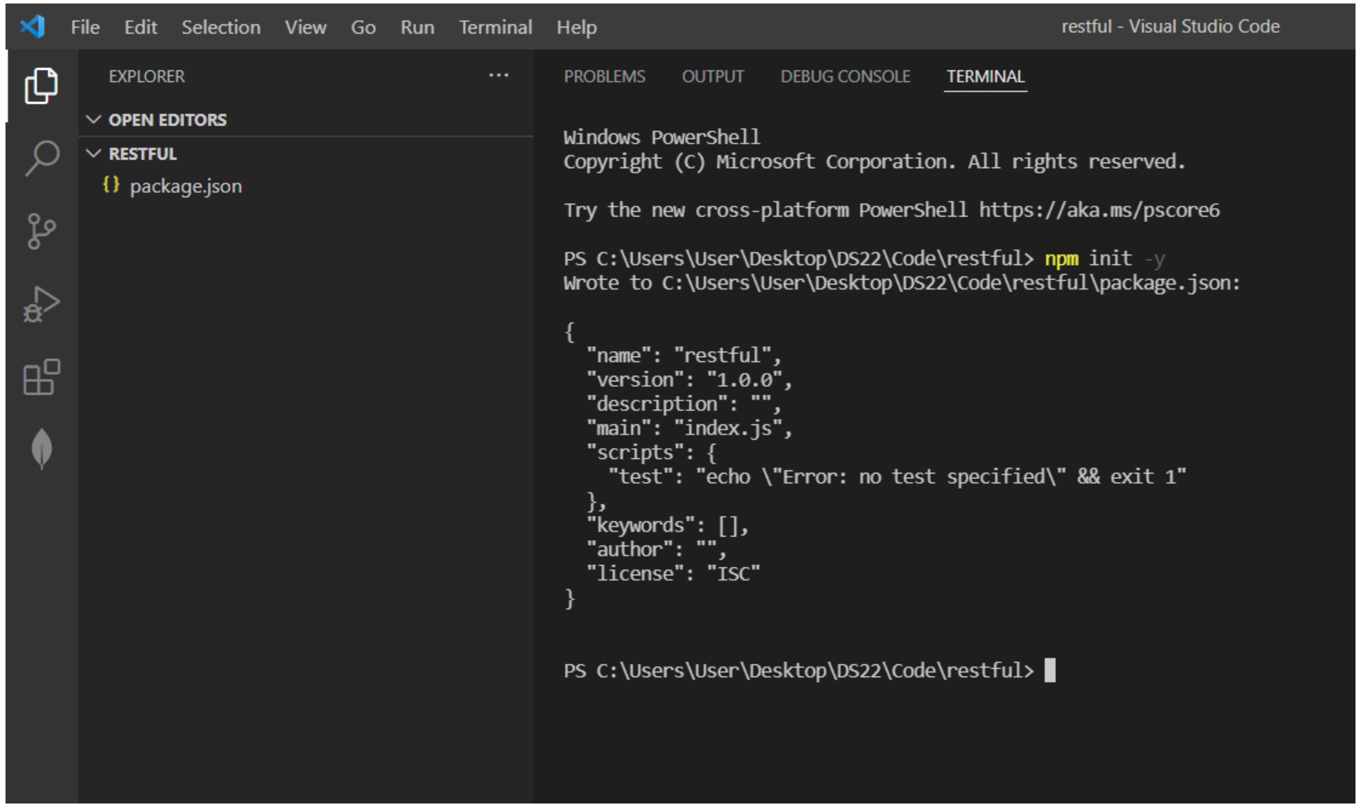
GET localhost:3000/api/users

Status: 200 OK Time: 10ms Size: 156 B

```
["user1","user2","user3"]
```

Distributed Communication

Example with express library



```
Windows PowerShell
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Try the new cross-platform PowerShell https://aka.ms/pscore6

PS C:\Users\User\Desktop\DS22\Code\restful> npm init -y
Wrote to C:\Users\User\Desktop\DS22\Code\restful\package.json:

{
  "name": "restful",
  "version": "1.0.0",
  "description": "",
  "main": "index.js",
  "scripts": {
    "test": "echo \"Error: no test specified\" && exit 1"
  },
  "keywords": [],
  "author": "",
  "license": "ISC"
}


PS C:\Users\User\Desktop\DS22\Code\restful>
```
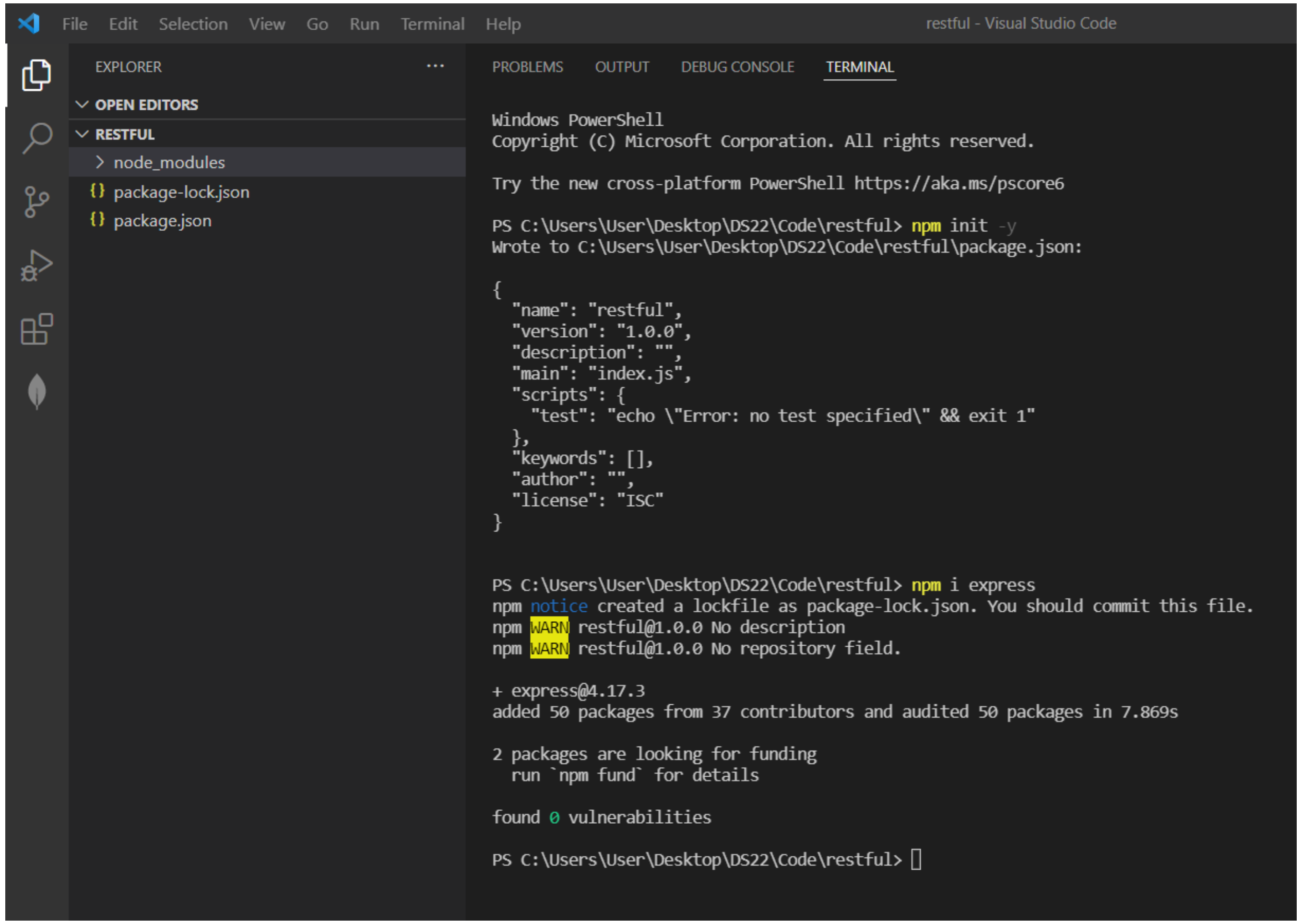

- Create new project folder "restful"
- Go to terminal
- > npm init –y
- > npm i express

Distributed Communication

Example with express library



```
Windows PowerShell
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Try the new cross-platform PowerShell https://aka.ms/pscore6

PS C:\Users\User\Desktop\DS22\Code\restful> npm init -y
Wrote to C:\Users\User\Desktop\DS22\Code\restful\package.json:

{
  "name": "restful",
  "version": "1.0.0",
  "description": "",
  "main": "index.js",
  "scripts": {
    "test": "echo \"Error: no test specified\" && exit 1"
  },
  "keywords": [],
  "author": "",
  "license": "ISC"
}


PS C:\Users\User\Desktop\DS22\Code\restful> npm i express
npm notice created a lockfile as package-lock.json. You should commit this file.
npm WARN restful@1.0.0 No description
npm WARN restful@1.0.0 No repository field.

+ express@4.17.3
added 50 packages from 37 contributors and audited 50 packages in 7.869s

2 packages are looking for funding
  run `npm fund` for details

found 0 vulnerabilities

PS C:\Users\User\Desktop\DS22\Code\restful>
```
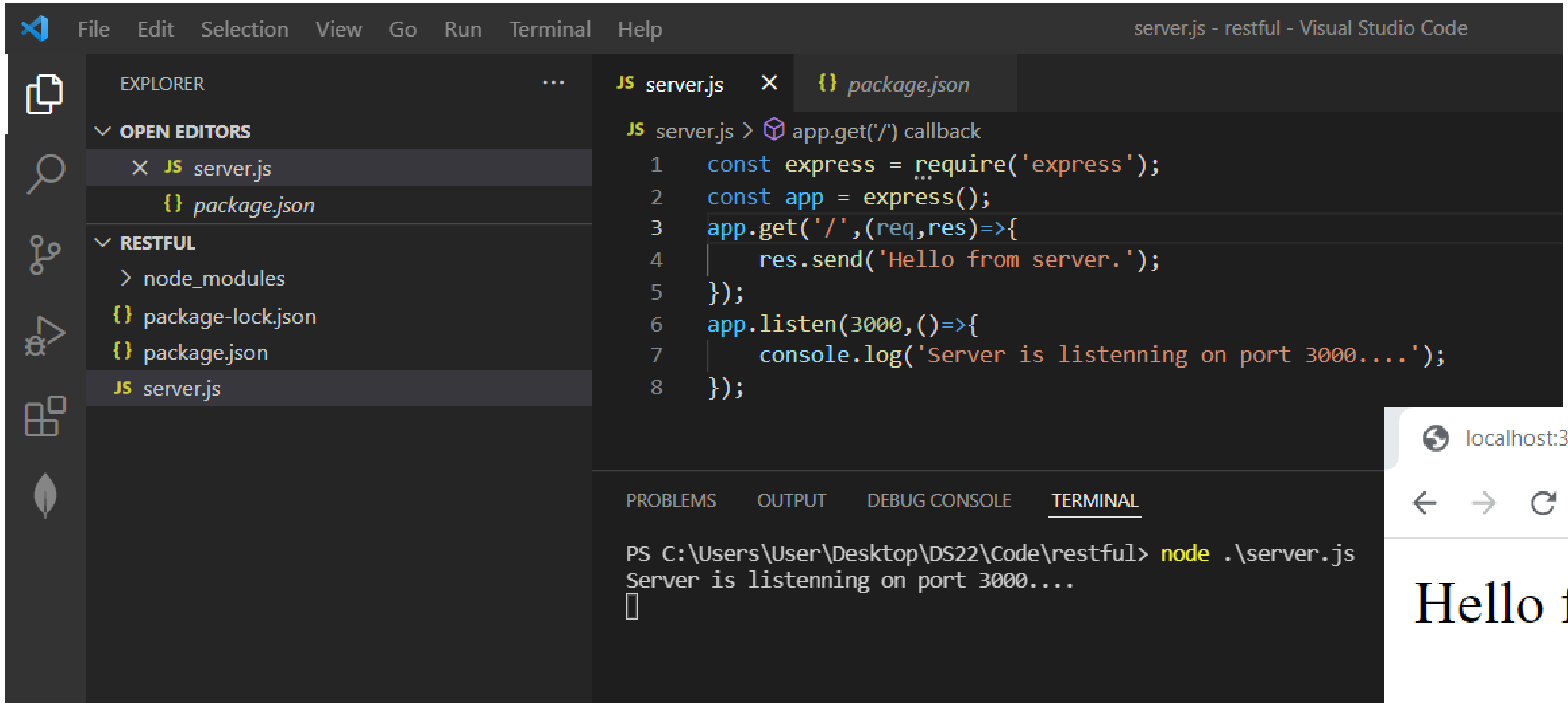

- Create new project folder "restful"
- Go to terminal
- > npm init –y
- > npm i express

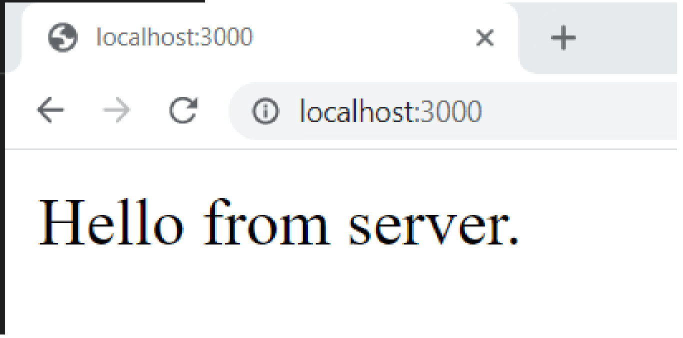
Distributed Communication

Example with express library


File Edit Selection View Go Run Terminal Help
server.js - restful - Visual Studio Code
EXPLORER
OPEN EDITORS
server.js
package.json
RESTFUL
node_modules
package-lock.json
package.json
server.js
server.js > app.get('/') callback
PROBLEMS OUTPUT DEBUG CONSOLE TERMINAL

```javascript
const express = require('express');
const app = express();
app.get('/',(req,res)=>{
    res.send('Hello from server.');
});
app.listen(3000,()=>{
    console.log('Server is listenning on port 3000....');
});
```

```
PS C:\Users\User\Desktop\DS22\Code\restful> node .\server.js
Server is listenning on port 3000....
```



Hello from server.

Distributed Communication

GRPC

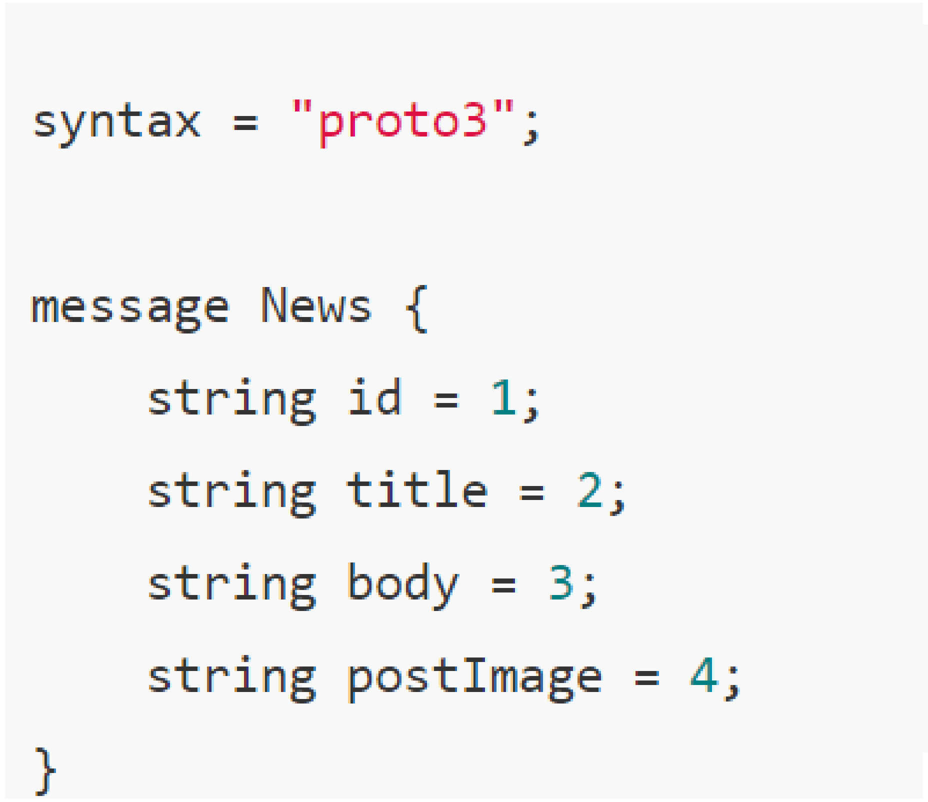
is an open-source remote procedure call(RPC) framework created by Google. It is an inter-process communication technology based on HTTP/2, that is used for client-server and duplex streaming of data, and this data streaming is highly efficient because of the use of protocol buffers.

Protocol Buffer is a library that helps us serialize structured data built by Google. It is platform-, and language-neutral, it currently supports generated code in Java, Python, Objective-C, and C++. The latest proto3 version supports more languages. The protocol buffers are where we define our service definitions and messages. This is written in IDL(Interface Definition Language) language, this will be like a contract or common interface between the client and server on what to expect from each other; the methods, types, and returns of what each operation would bear.

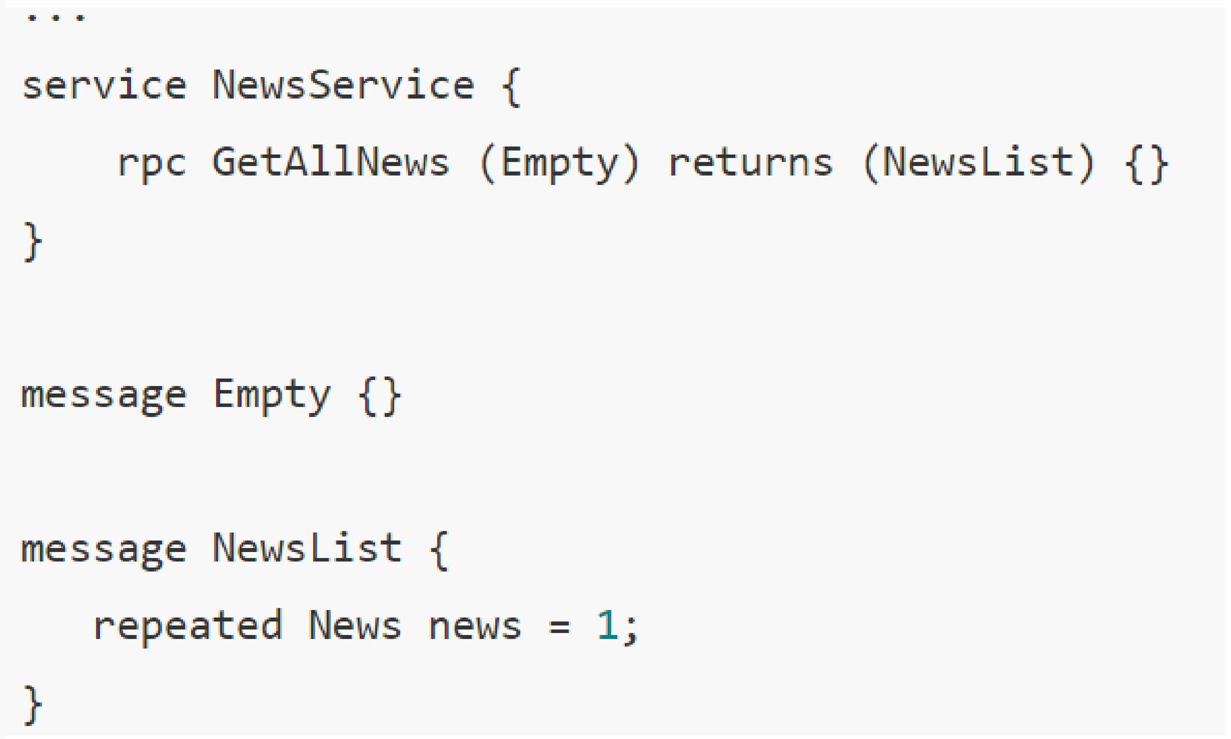
https://daily.dev/blog/build-a-grpc-service-in-nodejs
https://alfianlosari.medium.com/building-grpc-service-server-note-crud-api-with-node-js-bcc5478d5bdb

Distributed Communication

Proto File



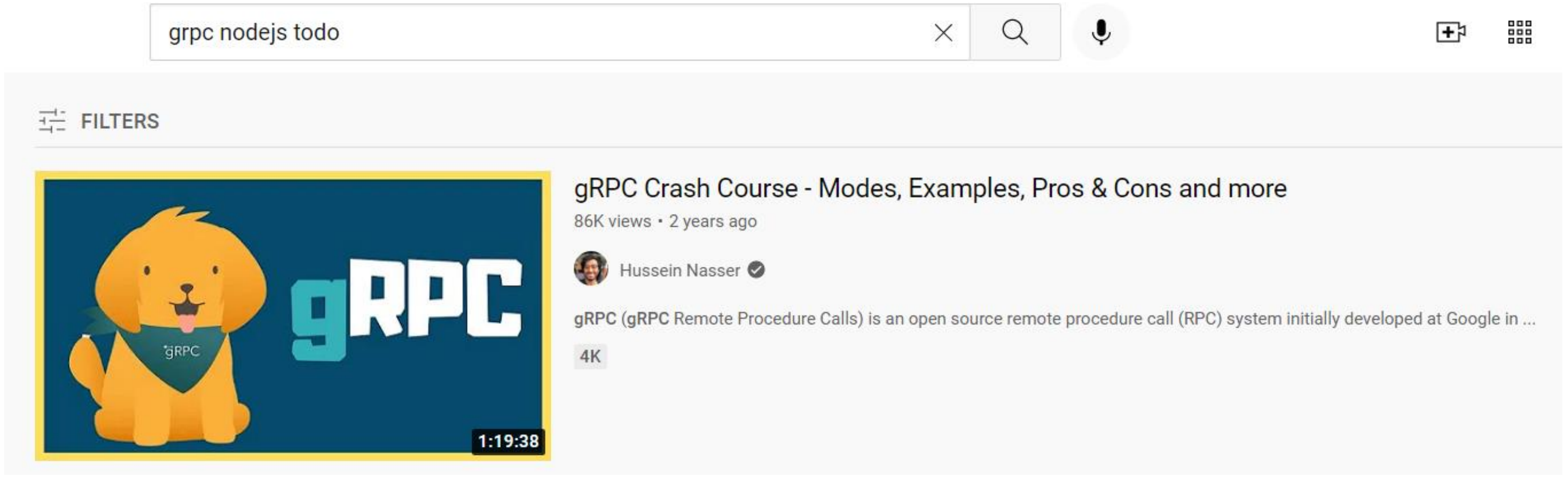
```
syntax = "proto3";

message News {
    string id = 1;
    string title = 2;
    string body = 3;
    string postImage = 4;
}
```



```
...
service NewsService {
    rpc GetAllNews (Empty) returns (NewsList) {}
}

message Empty {}

message NewsList {
   repeated News news = 1;
}
```

Distributed Communication

Exercise



grpc nodejs todo

FILTERS

gRPC Crash Course - Modes, Examples, Pros & Cons and more

86K views • 2 years ago

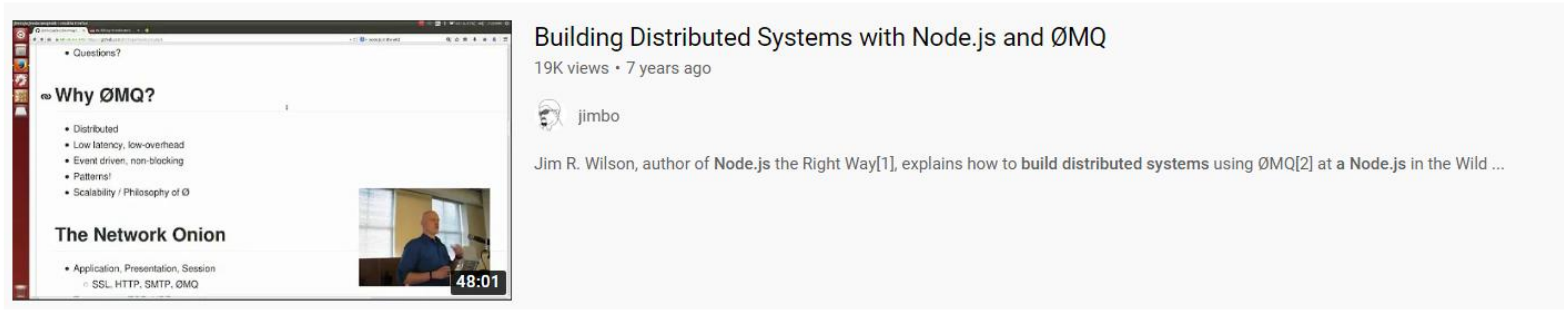
Hussein Nasser

gRPC (gRPC Remote Procedure Calls) is an open source remote procedure call (RPC) system initially developed at Google in ...

4K

Distributed Communication

ZeroMQ



- Questions?

Why ØMQ?

- Distributed
- Low latency, low-overhead
- Event driven, non-blocking
- Patterns!
- Scalability / Philosophy of Ø

The Network Onion

- Application, Presentation, Session
  - SSL, HTTP, SMTP, ØMQ

48:01

Building Distributed Systems with Node.js and ØMQ

19K views • 7 years ago

jimbo

Jim R. Wilson, author of **Node.js** the Right Way[1], explains how to **build distributed systems** using ØMQ[2] at **a Node.js** in the Wild ...