VPN Freedom Hacking

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Privacy and surveillance

Arendt and Habermas pointed out two aspects of the private: personal space - space of intimacy, and space which enables associations of individuals and their action.

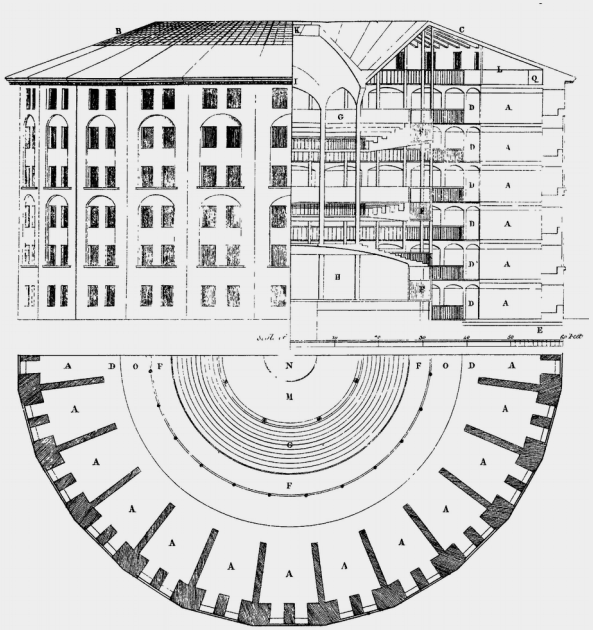
Privacy is a limit on (government or corporate) power - the more someone knows about us, the more power they can have over us.

Privacy is linked with freedom and autonomy (control over our lives).

Privacy is key to freedom of thought and also key to protecting speaking unpopular messages. Privacy helps protect our ability to associate with other people and engage in political activity.

Therefore privacy today is a value, a precondition of human freedom and emancipation.

Privacy and surveillance



The idea of surveillance as a means of executing power over individuals was first introduced by Bentham in his work describing the idea of prison Panopticon. Surveillance and control could be directed in two ways: against individual or against authority (government). The idea of the control of the state authority has been introduced in 1791 in Bentham's essay Of Publicity.

His idea has been directed against non-transparency and secrecy of authority, but today is often used as an argument against privacy of individuals. It came to the conversion of the principle of transparency, and the consequence is that individuals who want to protect their privacy are often faced with allegations of hiding and consecutive immorality. "To be good citizens ... is to be measurable and predictable consumers" (Gareth Palmer).

Privacy and surveillance

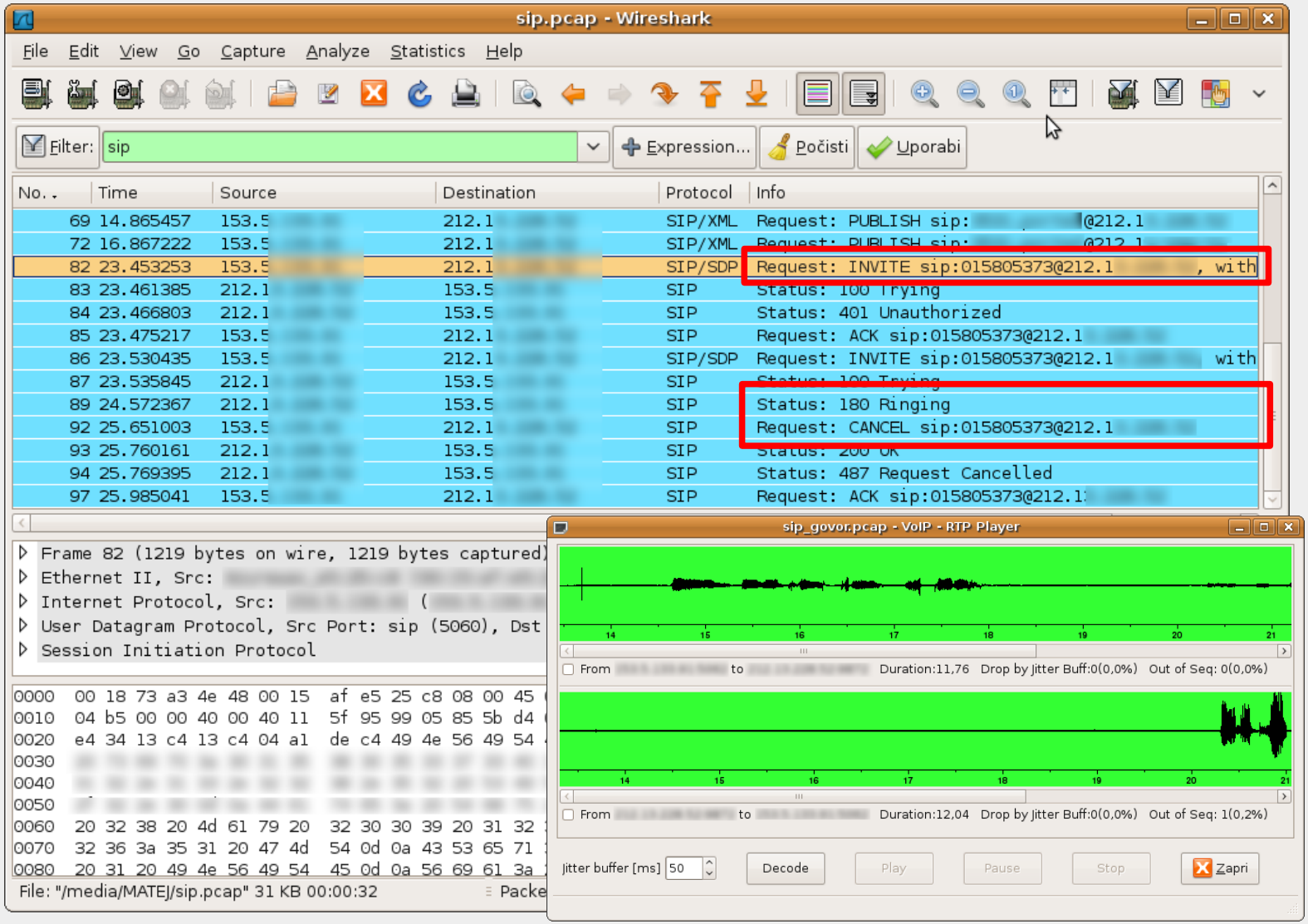
Is internet a "technology of freedom" or is panopticism already built-in it?

We cannot overlook the close connection between surveillance and technology. Information technology has a high significance for national security, freedom and democracy.

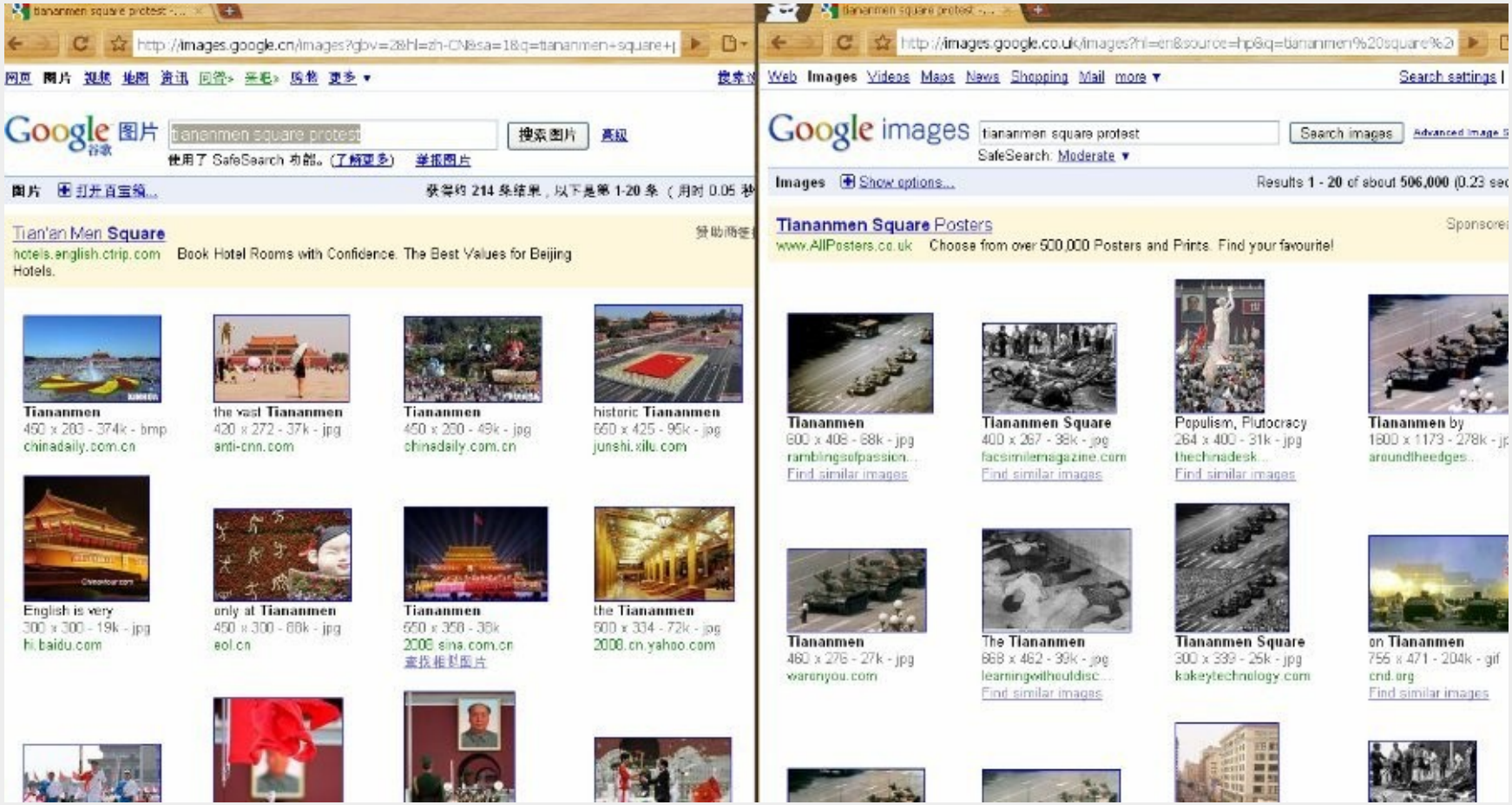
Today technology today is designed for surveillance. The technologies of surveillance are widespread and are socially acceptable. (Personal) information today has a great value; the information society is a surveillance society.

We live in a society which, on the one hand, recognizes individuality and privacy, but on the other, we are also witnessing an increase in surveillance. With use of technology, individuals are becoming more and more transparent.

Eavesdropping



Censorship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English is very
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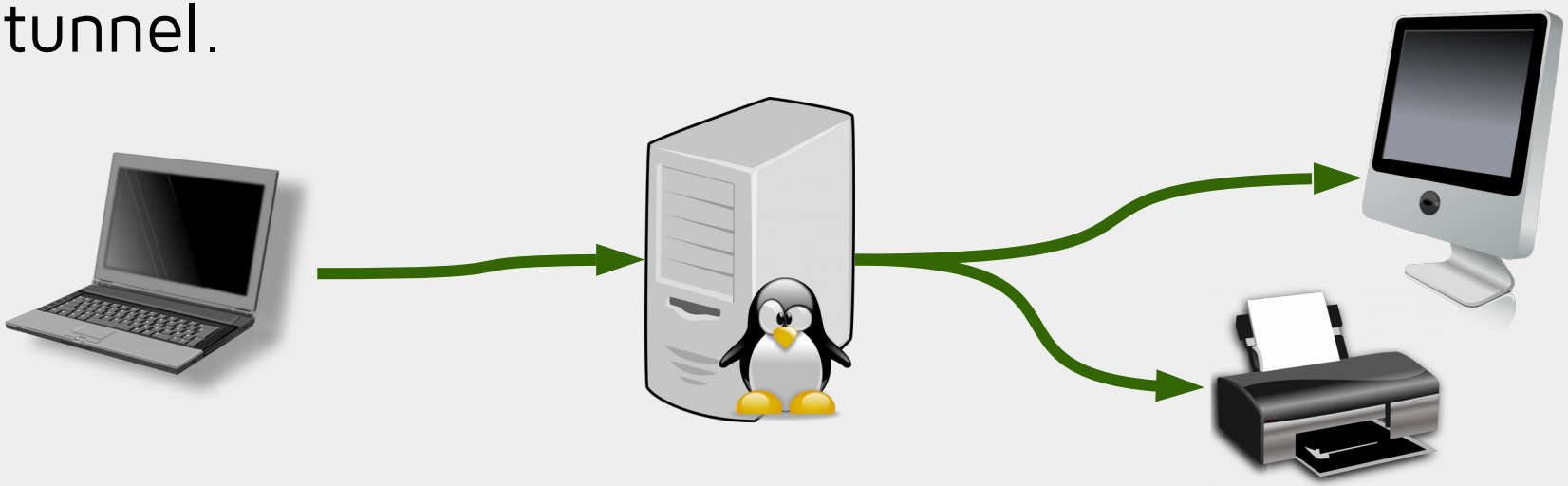
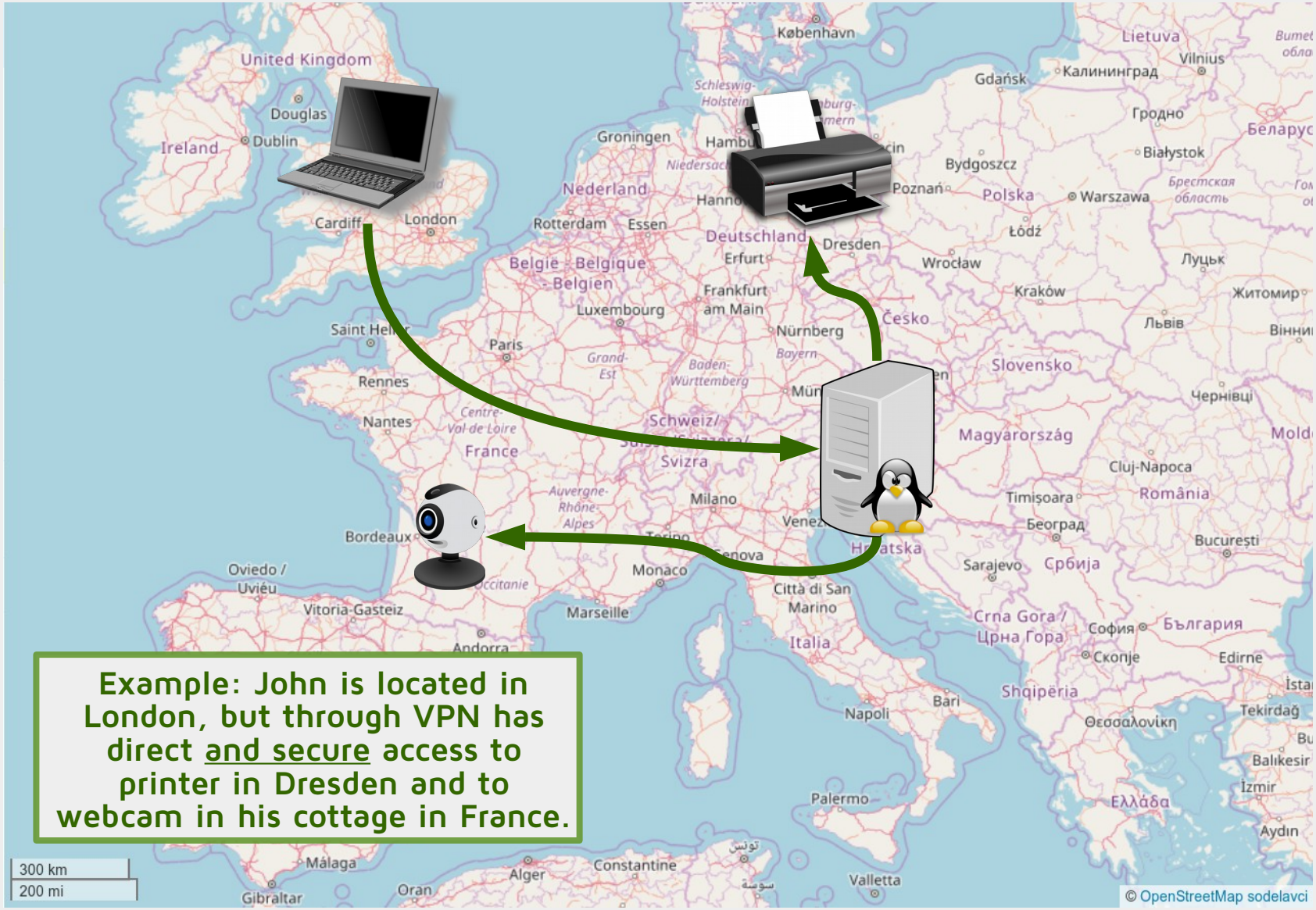
What is VPN?

A virtual private network or VPN is a way of connecting a computer to a remote network or remote computer through secure (encrypted) tunnel.



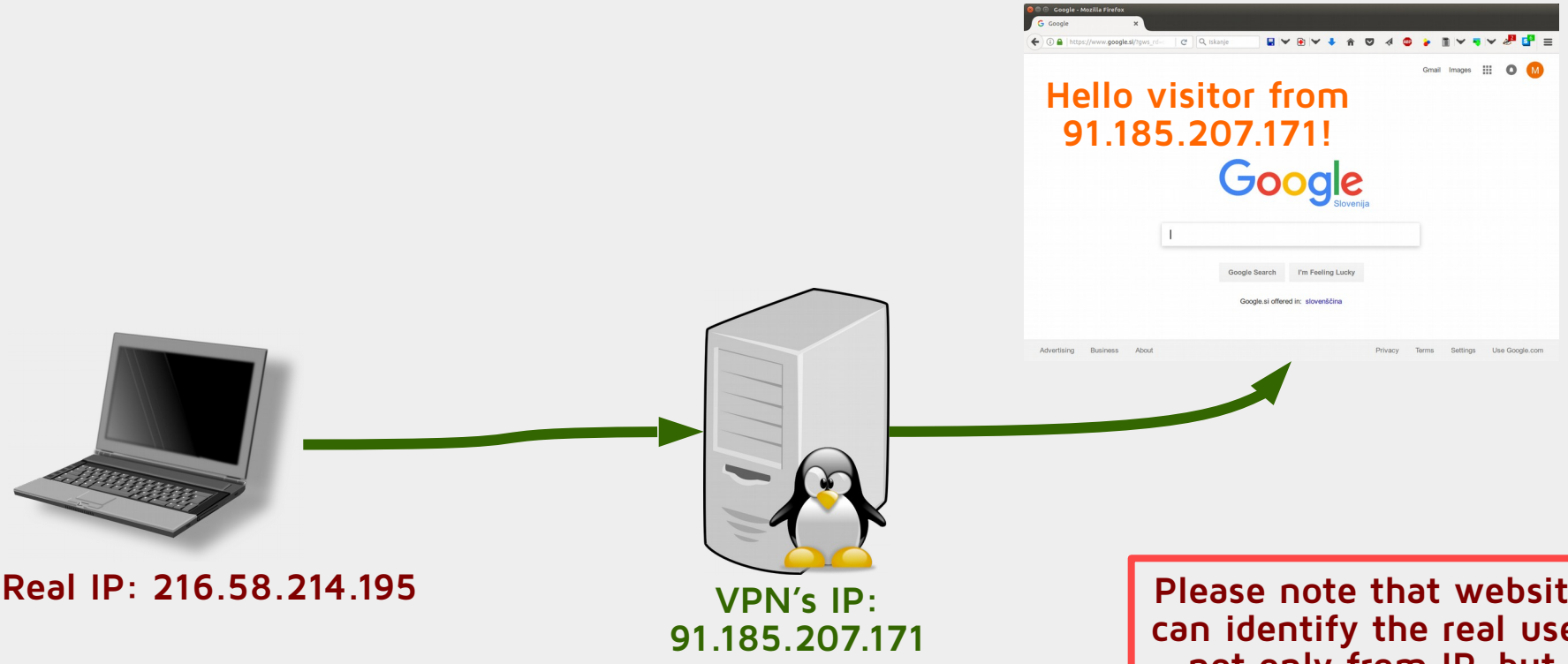
Through secure tunnel user can have direct access to the remote network, remote computers or other remote devices regardless of their physical location.

Access to remote networks or devices



Hiding real IP address

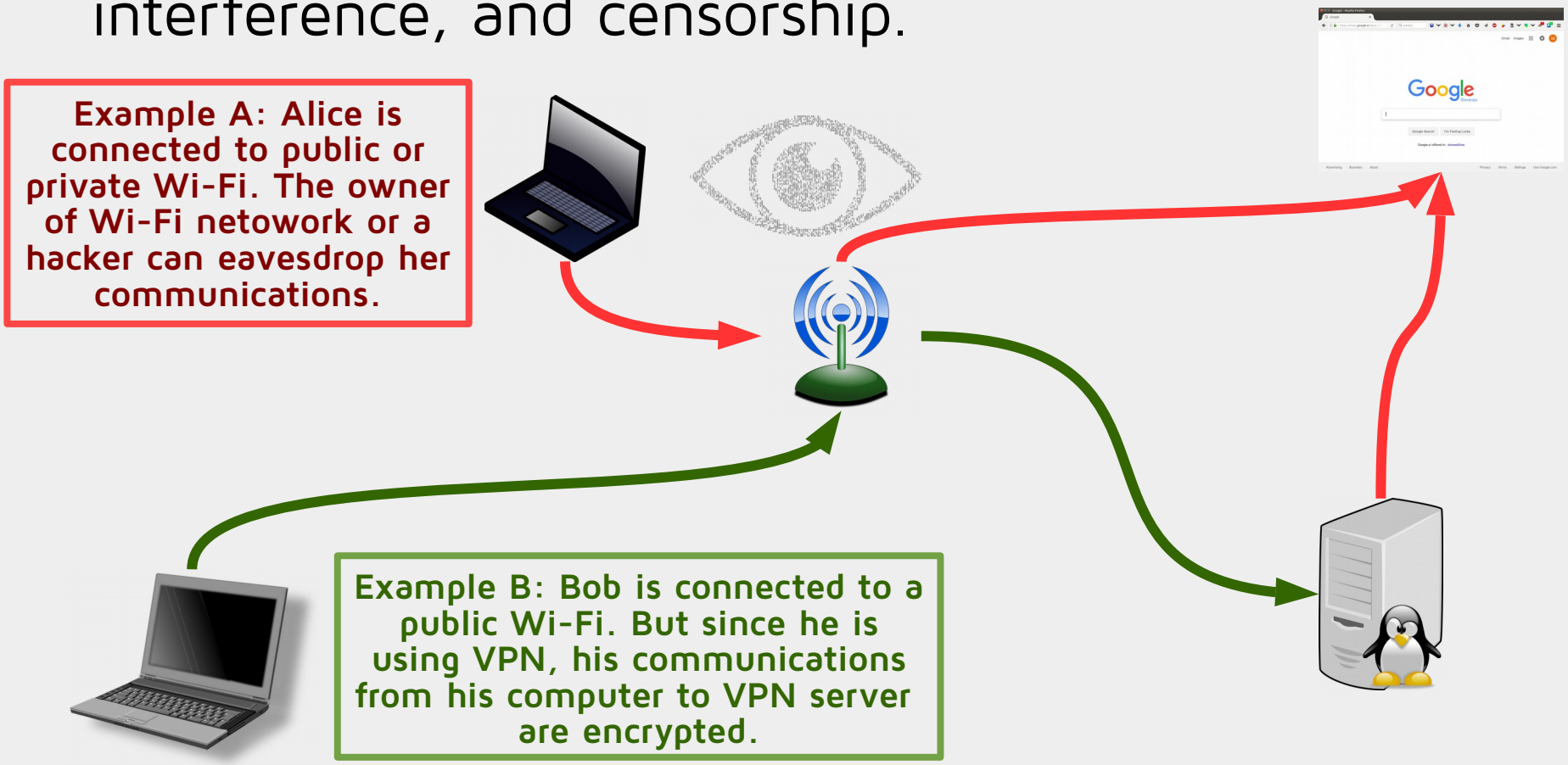
If user is using VPN server as a gateway to the internet, website he is visiting does not see his real IP address, but IP address of VPN server.



Please note that website can identify the real user not only from IP, but also from cookies and with other measures.

Protection from hacker's snooping

Since VPN establishes a secure tunnel between two or more devices, VPNs are often used to protect network traffic from snooping, interference, and censorship.

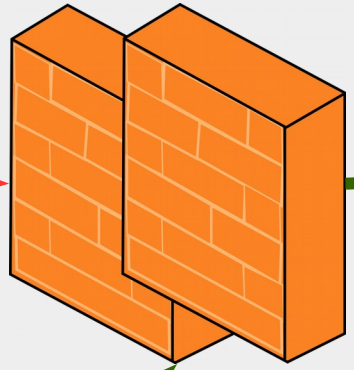


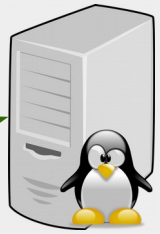
Protection from government snooping

Protection from blocking

Example A: Alice is behind firewall and has restricted access to some websites or internet services.

Secure tunnel between user and VPN server is established.

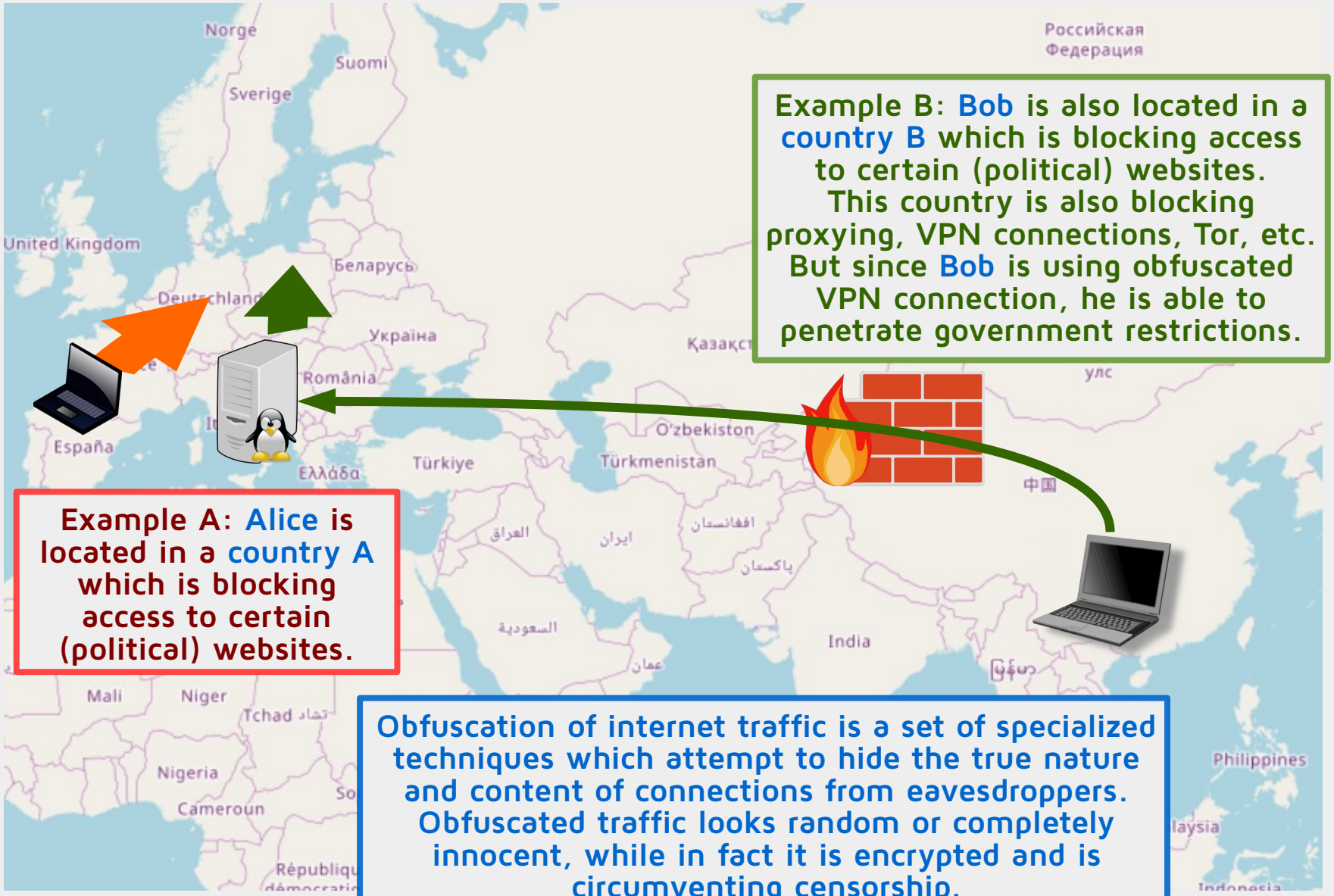




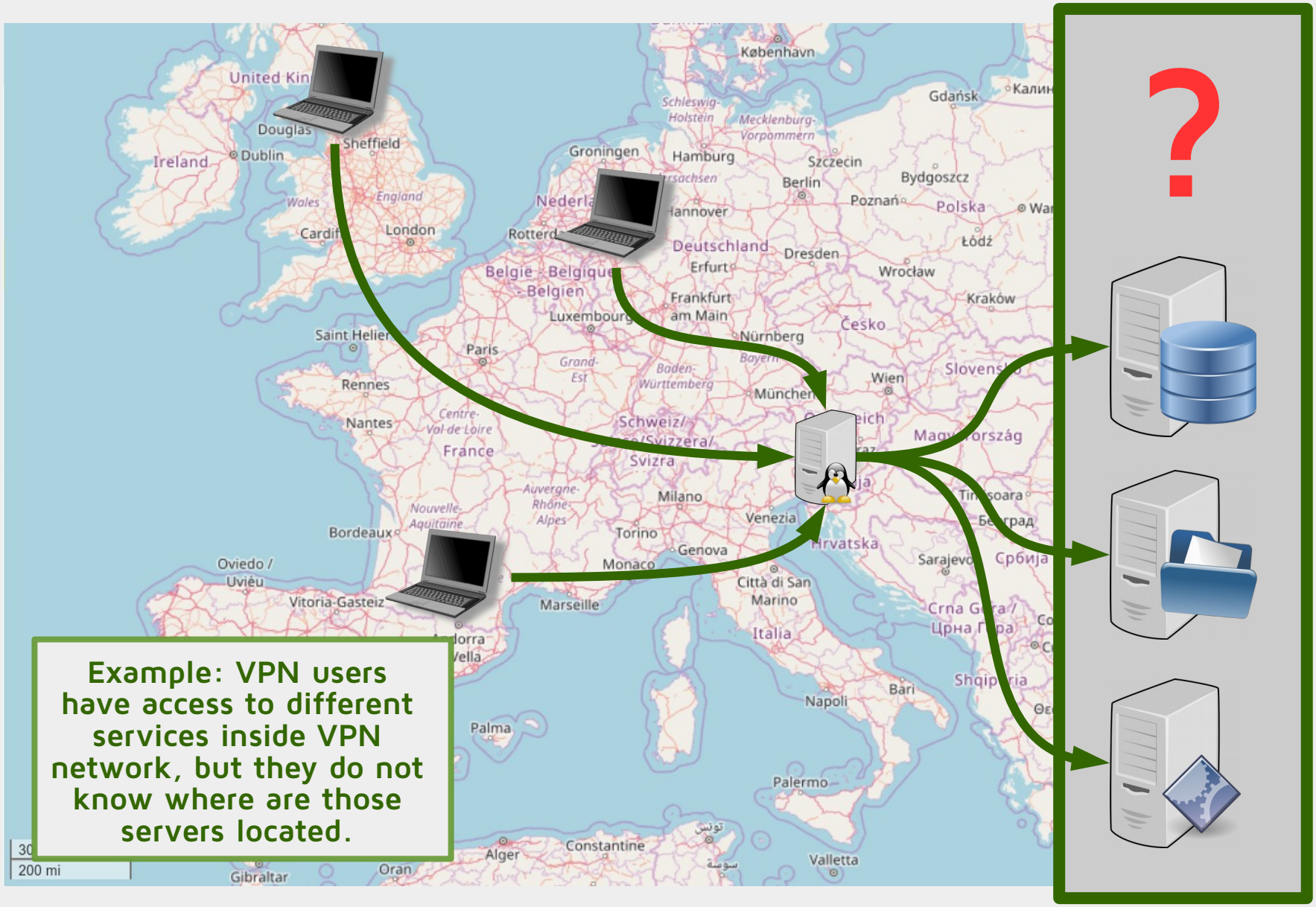
User has unrestricted access to Internet.

Example B: Bob is also behind firewall, but since he is using VPN, his communications »penetrate« firewall restrictions and he has access to free Internet.

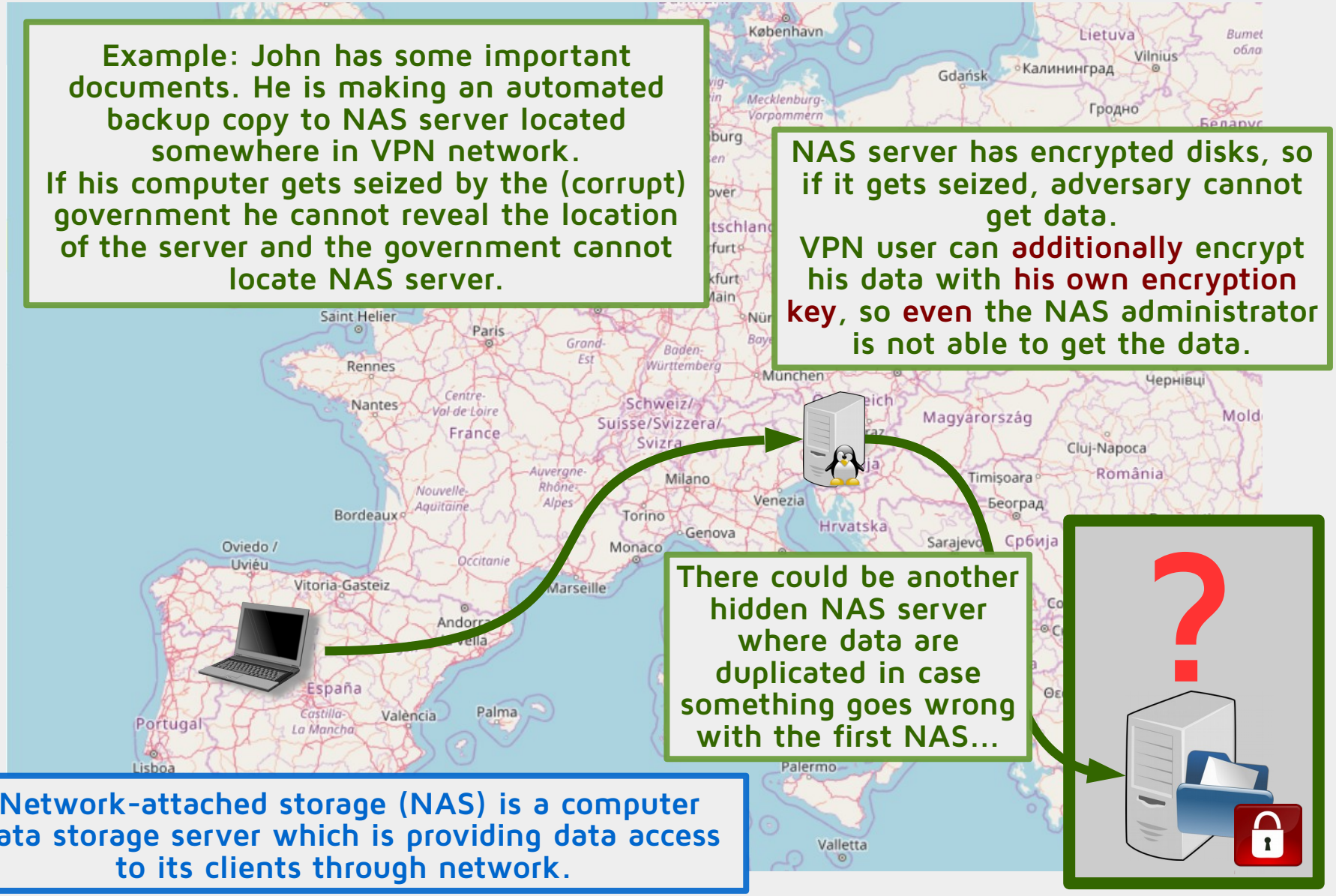
Protection from government censorship



Hidden services



Example: Hidden NAS server



Connection notifications

Example: Alice is journalist and her laptop was stolen. Since she is not using password, attacker is able to connect to VPN using her keys...

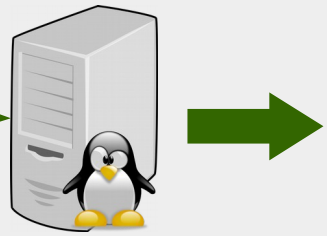
When VPN server detects connection, Alice is notified about that via e-mail and Signal message.

Server notifies her that new connection with her VPN keys has been made, when it was made and from which IP address.

Regarding user connection and user disconnection to VPN notifications, there are four options:

- there are absolutely no notifications for a given user account;

- user connects and disconnects could be logged to a database on the server, user can receive an e-mail or user can receive a Signal message.

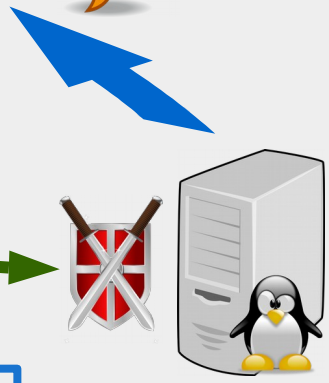


(Internet)

Intrusion detection (*not implemented yet*)

Example: Alice is journalist and has been targeted by government malware. Her computer has been targeted with NSA's Quantum Insert attack.

VPN server is analysing all Alice's traffic (with her consent!).
If IDS (Intrusion Detection System) detects Quantum Insert pattern in Alice's network traffic, Alice is notified about that.



(Internet)

Intrusion Detection System (IDS) is a network security technology used for detecting attacks against a target application or computer.

Additional services

It is possible to have additional services inside VPN network. For example:

- hidden NAS (for secure backups);
- internal websites (accessible only inside VPN network);
- private bridges to other networks (for instance secure remote access to your home network);
- secure access to remote (private) printers;
- etc.

Why your own infrastructure?

Research of VPN apps for Android from 2016 (University of New South Wales and the University of Berkeley):

- they tested 283 VPN apps from Google Play Store;
- 18 percent of the apps **failed to encrypt** users' traffic;
- 38 per cent of the apps **injected malware or malvertising**;
- over 82 per cent of apps **requested to access sensitive data** such as user accounts and text messages;
- three quarters of the apps used third-party user tracking libraries, majority of them had several security issues (for instance did not prevent DNS leaking, etc.)

Secure VPN configuration

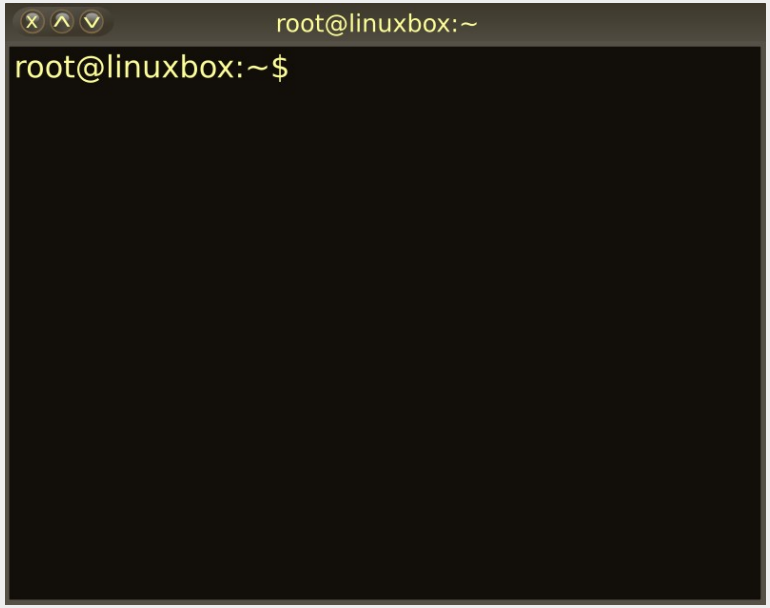
The Machine

Server is running in virtual machine. Host machine and network is outside our administration, but is regularly maintained.

Server is running under fully patched Debian operating system. Debian is Linux distribution which takes security very seriously and has many security mechanisms already built-in.

Remote console

Machine is accessible through virtual VNC console, which is accessible through encrypted reverse SSH tunel.



Full disk encryption

All hard disks are fully LUKS encrypted, so when machine is booted, system administrator needs to login to virtual VNC console and enter the password to unlock the disks.

```
Please unlock disk sda5_crypt: ************
```

Only after that, machine is booted.

If machine is seized, data on a disk cannot be gathered unless disks are unlocked.

Hardened SSH

Machine has SSH enabled for remote administration. SSH configuration is hardened.

Secure Shell (SSH) is a cryptographic network protocol for operating network services securely over an unsecured network.

```
/ssh/ssh_host_ed25519_key
gin no
odes yes
PermitEmptyPasswords no
Ciphers chacha20-poly1305@openssh.com,aes256-gcm@openssh.com,
aes128-gcm@openssh.com,aes256-ctr,aes128-ctr
MACs hmac-sha2-512-etm@openssh.com,hmac-sha2-256-etm@openssh.
com,umac-128-etm@openssh.com,hmac-sha2-512,hmac-sha2-256,hmac-
ripemd160
KexAlgorithms curve25519-sha256@libssh.org,ecdh-sha2-nistp521,
ecdh-sha2-nistp384,ecdh-sha2-nistp256,diffie-hellman-group-
exchange-sha256
```

Firewall and brute force protection

Machine has also firewall, which allows access to SSH from a list of trusted IP addresses only.

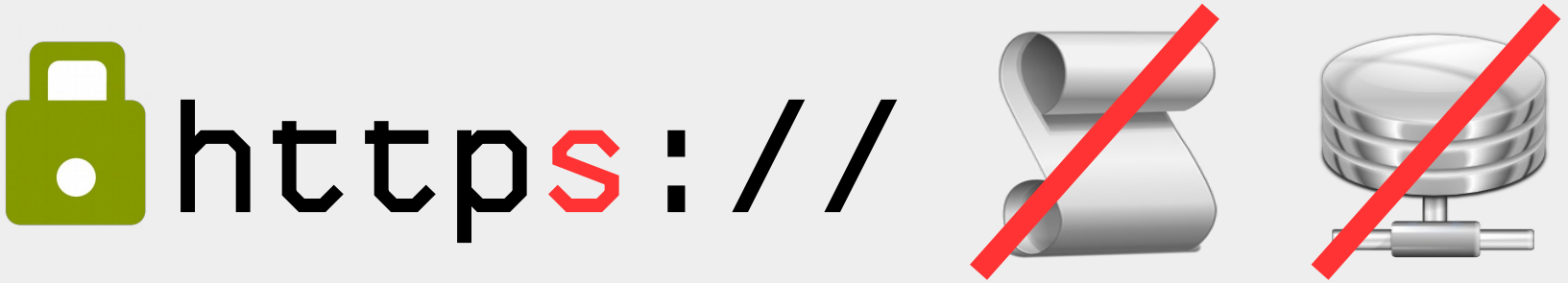
We are additionally using mechanisms to limit brute force authentication attempts to SSH (from trusted IP addresses!).

Website

Machine is running website with a lot of legitimate content.

All content is static, i.e. there is no server side scripting and no database in backend, which greatly reduces the possible attack surface.

Web server is configured in such a way that all web browsers are automatically redirected from HTTP to secure HTTPS connection.



Website

Web server is also serving several security headers, which restrict modern browsers from running into easily preventable vulnerabilities.

We are continuously running security tests on our website in order to maintain the highest level of its security.

https://observatory.mozilla.org/analyze.html?host=*yourhost.org*

OpenVPN

Server is running carefully configured OpenVPN server. We have implemented:

- use of highly secure cryptographic protocols and algorithms (TLS 1.2+, 4096 Diffie-Hellman parameters, long prime numbers, TLS authentication, HMAC authentication, additional checks for cryptographic keys, etc.);
- all cryptographic keys are off-site generated;
- clients inside VPN network can see each other, but have static IP addresses;
- we are running our own DNS server which is serving DNS requests for VPN clients (to prevent DNS leaking).

OpenVPN has been security reviewed

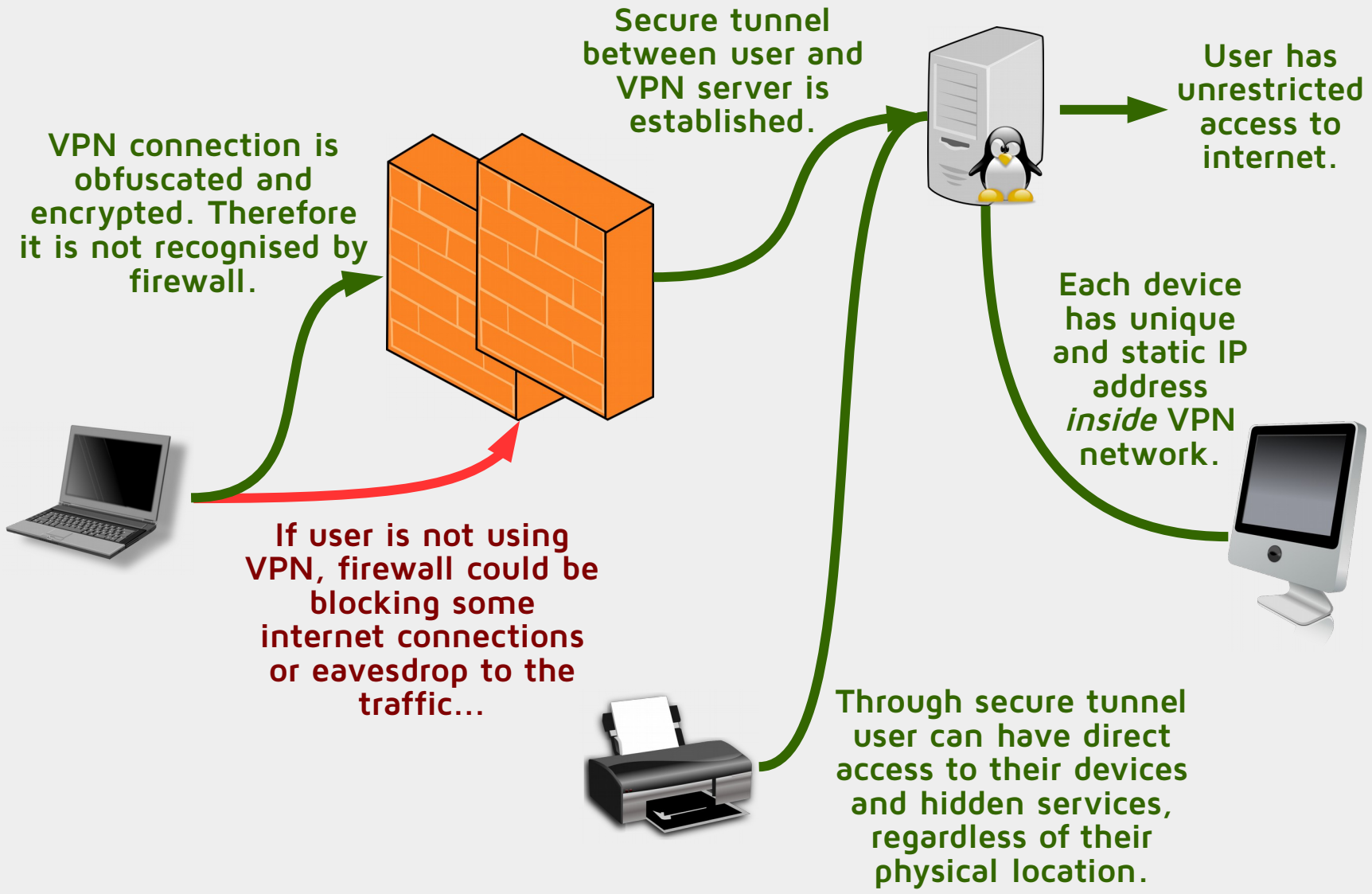
A security review led by from reputable expert on cryptography dr. Matthew Green from Johns Hopkins University has audited OpenVPN 2.4's code from December 2016 till February 2017.

The review found "no major vulnerabilities".

Another security audit has been run by QuarksLab in the beginning of 2017.

Security audit found two bugs, but both were fixed before the report has been published.

OpenVPN - Basic setup



OpenVPN – Blocking and censorship resistance

VPN server is also trying to hide VPN traffic:

- all communication are fully encrypted and are going over TCP protocol;
- we are using port sharing technique – OpenVPN and HTTPS web server are running on the same IP address and on the same port.

This enables us to penetrate many firewalls, prevent traffic blocking and additionally hides VPN traffic among HTTPS traffic.

However, attacker which would use deep packet inspection would be able to identify VPN traffic. That is why we are actively developing advanced traffic obfuscation techniques.

Traffic obfuscation

We have implemented and tested two traffic obfuscation technologies.

We are using traffic obfuscation in order to prevent government censors to detect someone is using VPN traffic, and then blocking VPN connections.

One obfuscation technology is Iodine, which tunnels VPN connection over DNS protocol.

Another approach was developed by us and is using HTTPS protected websockets.

Iodine (TCP over DNS)

When we have covert connection with Iodine established, we run OpenVPN connection inside it.

WebSockets

WebSocket is a protocol for creating a fast two-way channel between a web browser and a server.

HTTPS encrypted WebSocket connections look like ordinary HTTPS traffic.

However, inside WebSocket channel we can open OpenVPN channel...

```
location /vpn/ {
    proxy_pass http://127.0.0.1:2000;
    proxy_http_version 1.1;
    proxy_set_header Upgrade $http_upgrade;
    proxy_set_header Connection "upgrade";
}
```

WSVPN (WebSocket VPN)

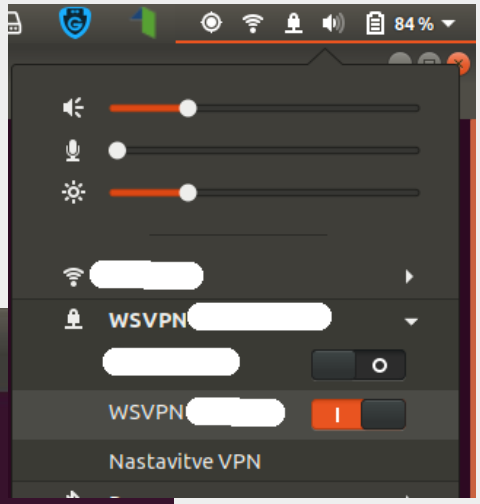
```
screen python wsvpn-1.9.py -m server -l
ws://127.0.0.1:2000/vpn/ -u localhost:8081
-d

[2018-12-02 18:02:45,655 INFO] Connecting to upstream ws://localhost:8081/
[2018-12-02 18:02:45,657 INFO] Connected to upstream
[2018-12-02 18:02:45,658 INFO] Start upstream loop
[2018-12-02 18:02:52,727 INFO] WS client disconnected
[2018-12-02 18:02:54,540 WARNING] WS client disconnected
[2018-12-02 18:02:54,542 WARNING] Upstream disconnected
```

```
sudo python wsvpn-1.9.py -m client -l
127.0.0.1:1000 -u wss://x.x.x.x:443/vpn/ -r

[2018-12-18 10:50:39,554 INFO] WSVPN VPN Websocket Proxy v1.9
[2018-12-18 10:50:39,554 INFO] Copyright (c) 2017,2018 M***, G***, M***
[2018-12-18 10:50:39,556 INFO] Running cmd: ***
[2018-12-18 10:50:39,561 INFO] Running cmd: ***
[2018-12-18 10:50:39,566 INFO] Creating new SSL certificate
[2018-12-18 10:50:39,639 INFO] Using certificate: ./localhost.crt
[2018-12-18 10:50:39,639 INFO] Using private key: ./localhost.key
[2018-12-18 10:50:39,640 INFO] Client listening on tcp://127.0.0.1:1000
[2018-12-18 10:50:39,640 INFO] Will proxy requests to wss://x.x.x.x:443/vpn/
```

WSVPN (WebSocket VPN)




```
matej@cryptomania: ~
Datoteka  Uredi  Pogled  Poišči  Terminal  Pomoč
matej@cryptomania:~$ ./wsvpn.sh
Running WSVPN...
After runnig the script, connect to WSVPN service.
[2019-12-02 14:33:14,774 INFO] WSVPN VPN Websocket Proxy v1.9
[2019-12-02 14:33:14,774 INFO] Copyright (c) 2017,2018 Matej Kovacic, Gasper Zejn,
Matjaz Rihtar
[2019-12-02 14:33:14,777 INFO] Running cmd: ip route
[2019-12-02 14:33:14,781 INFO] Running cmd: ip route add [redacted] via 192.168
.160.1
[2019-12-02 14:33:14,785 INFO] Creating new SSL certificate
[2019-12-02 14:33:15,014 INFO] Using certificate: /home/matej/[redacted].crt
[2019-12-02 14:33:15,014 INFO] Using private key: /home/matej/[redacted].key
[2019-12-02 14:33:15,015 INFO] Client listening on tcp://127.0.0.1:1000
[2019-12-02 14:33:15,015 INFO] Will proxy requests to wss://[redacted]
```

WSVPN device

User first needs to run WSVPN software, which opens HTTPS encrypted websocket connection to the server, and than run VPN client.

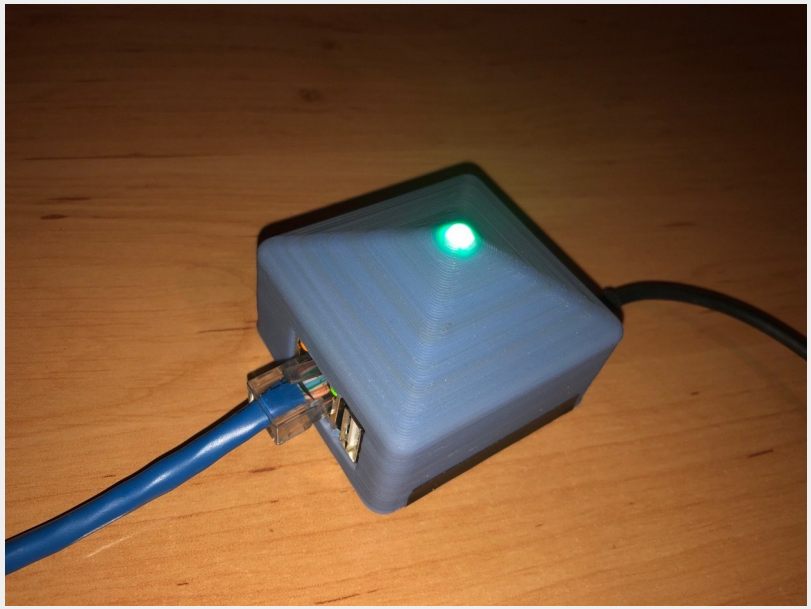
This is a little unhandy for most users.

Therefore we developed a small hardware device (based on OrangePi), which acts as a WiFi access point.

When device is connected to the network, it automatically connects itself to our VPN server through obfuscated connection. This is indicated by the small green diode on the top of the device.

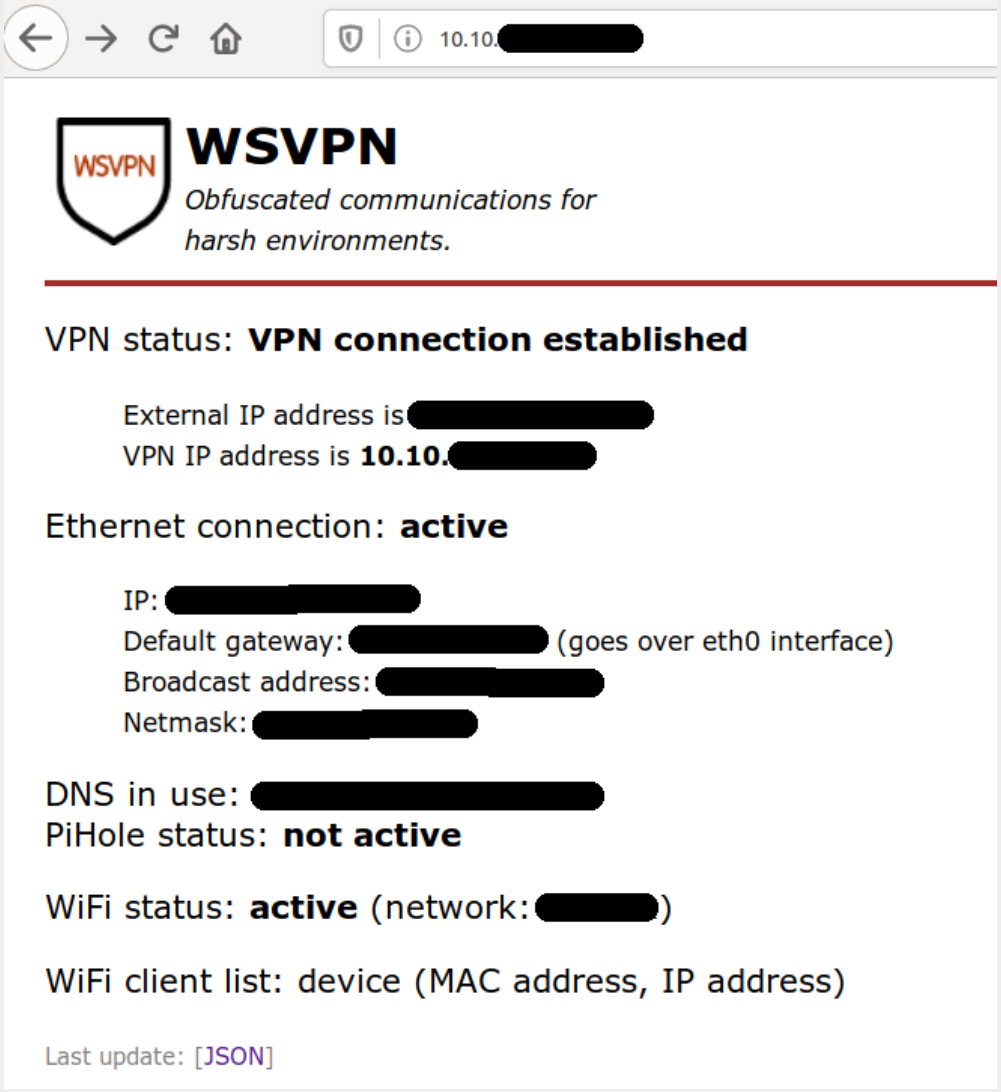
WSVPN device

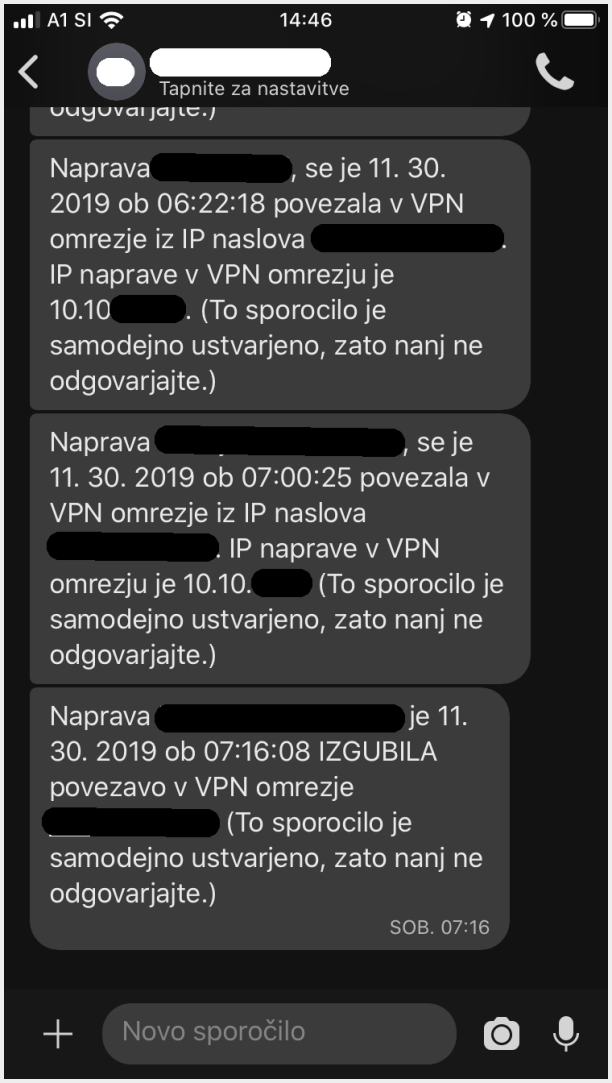
User then connects to WSVPN device via WiFi, and all his traffic is then automatically routed to our VPN server.



User therefore does not need any additional software on his/her devices. He or she just connect to WSVPN WiFi and has direct access to the uncensored internet through obfuscated VPN connection.

WSVPN device





WSVPN - Testing in China

Before:

- China authorities detect VPN connection. Usually they do not block it immediately, but they tend to slow it down, so it is unusable (server pings were above 11.000 ms).
- However, when there was some political event, connection to VPN server has not been possible at all (even HTTP connection was not working).

After:

- VPN connection is working, server pings are around 500 ms.

WSVPN - Testing in Uzbekistan

Before:

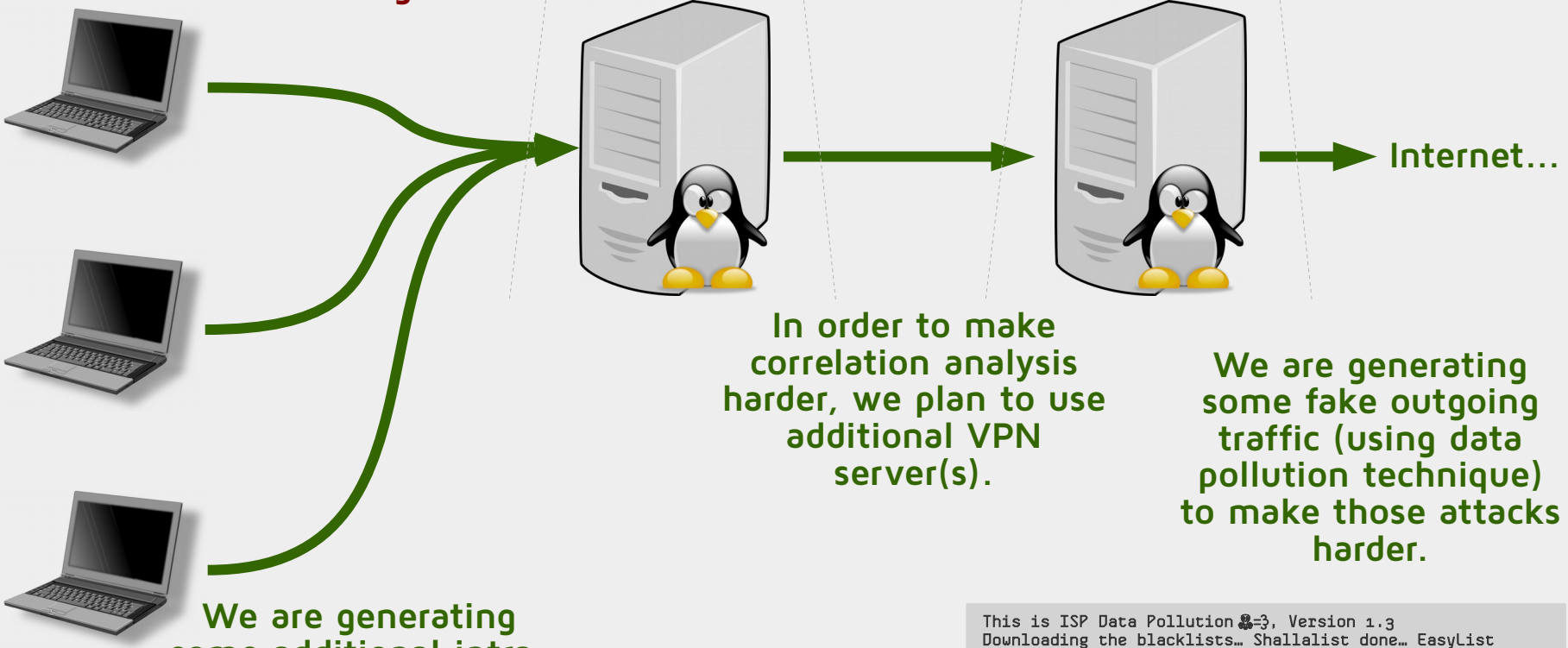
- VPN connection has not been possible, since during the authentication phase, government has been malforming internet traffic.

After

- VPN connection is now working.
- Connecting to VPN with WSVPN device is very easy and requires no additional software and zero configuration from user (except configuration for WiFi access).

OpenVPN – Advanced setup *(partially implemented)*

If there are few users (or only one), an attacker can monitor incoming connections on VPN server. These are encrypted, but an attacker can corelate them with outgoing connections and therefore unmask what user is doing.



In order to make correlation analysis harder, we plan to use additional VPN server(s).

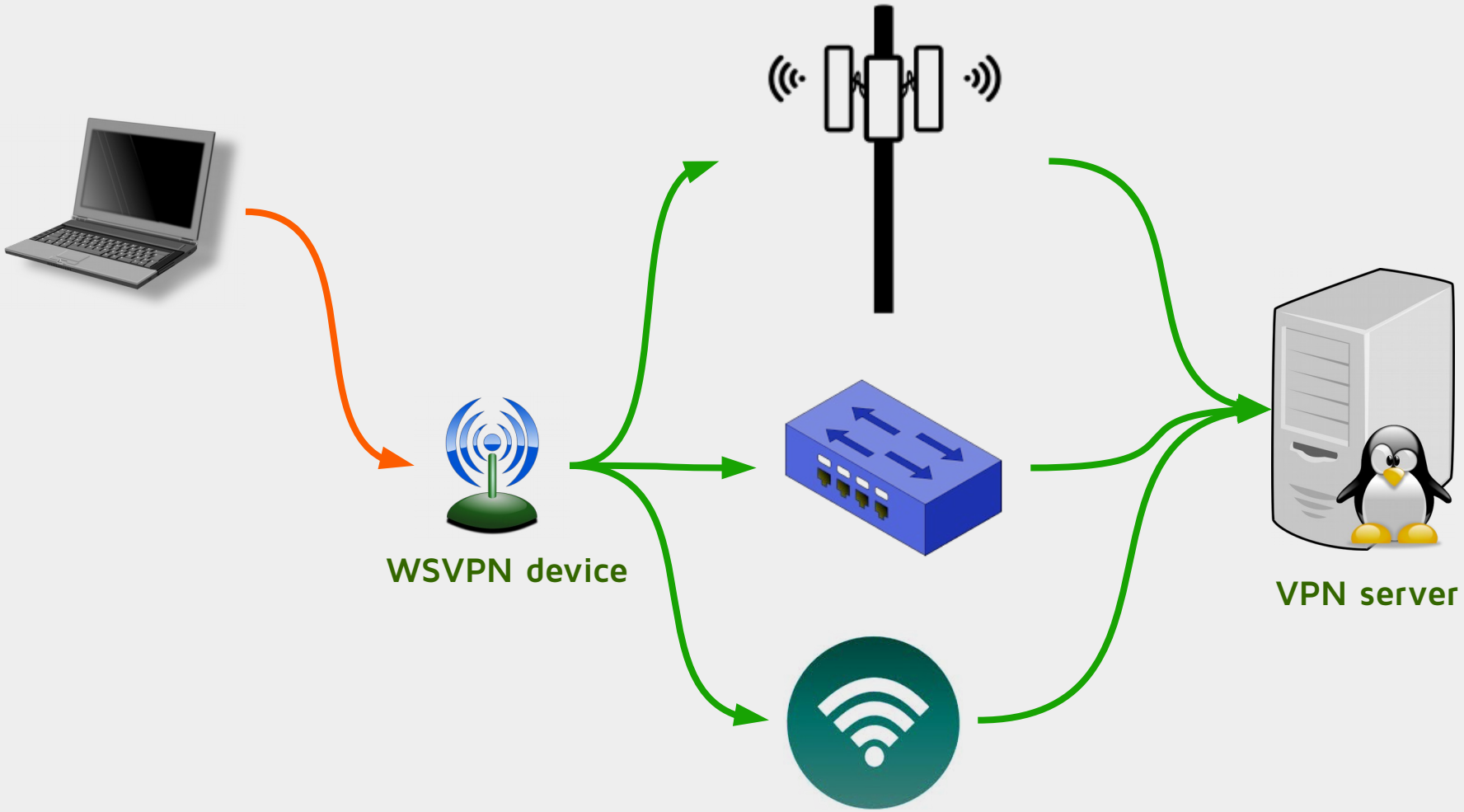
We are generating some fake outgoing traffic (using data pollution technique) to make those attacks harder.

We are generating some additional intra-VPN traffic to make those attacks harder.

```
This is ISP Data Pollution ☘=3, Version 1.3
Downloading the blacklists… Shallalist done… EasyList done.
Display format:
Downloading: website.com; NNNNN links [in library],
H(domain)= B bits [entropy]
Downloaded:  website.com: +LLL/NNNNN links [added],
H(domain)= B bits [entropy]
```

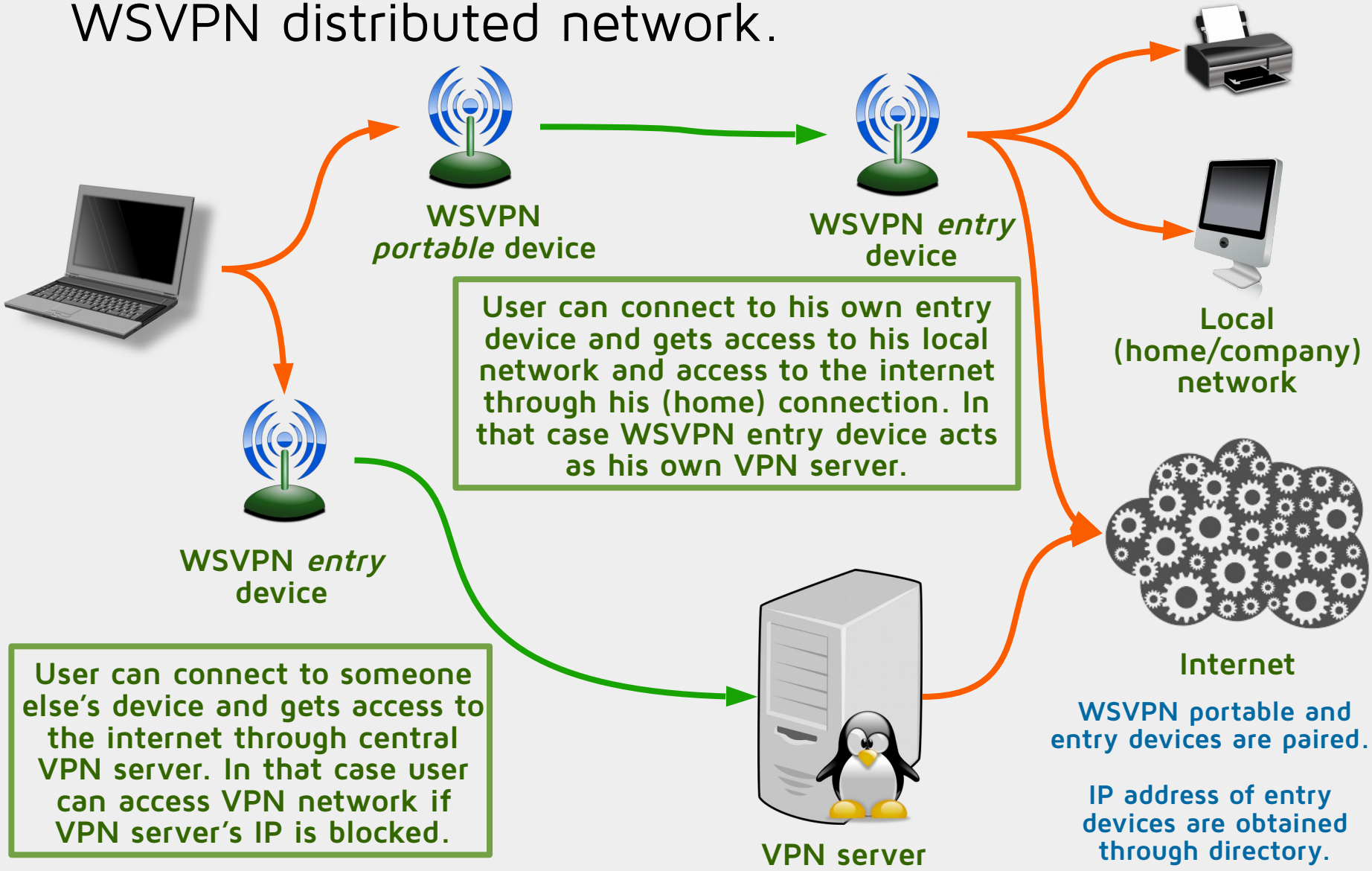
Further ideas

WSVPN device should support outgoing connections to ethernet, WiFi and 3G/4G.



Further ideas

WSVPN distributed network.



Questions?

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