Security and Authentication in IP

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- OpenVPN (discussed later) tunnels over the transport layer SSL/TLS

Security and Authentication in IP

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Security and Authentication in IP

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Exercise Read about the vulnerabilities in PPTP

Security and Authentication in IP

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Note that SSL is no longer recommended as it has flaws in the protocols

You should only use TLS, preferably versions 1.2 or later

Security and Authentication in IP

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The key is then used to encrypt subsequent data sent over the TCP connection

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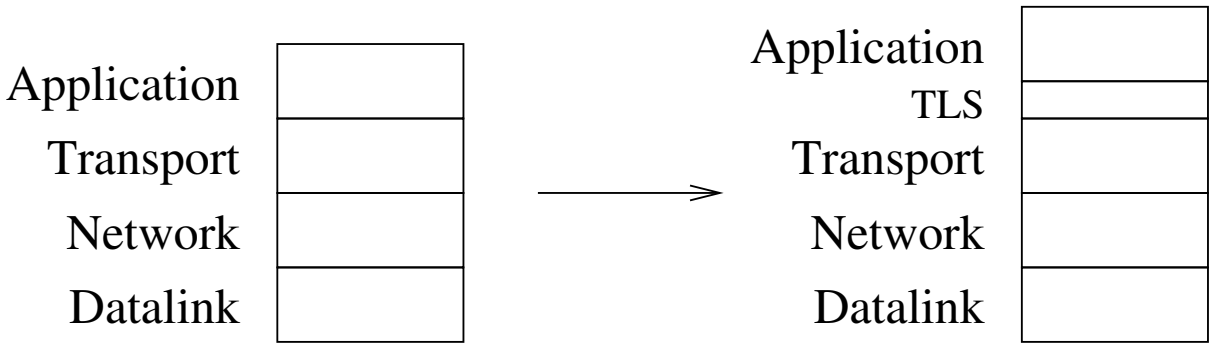
Sometimes called a *shim* layer as it sits between two other layers



TLS Shim

Security and Authentication in IP

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The client can authenticate the server through the use of public-key certificates

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Exercise Examine your browser to see which certification authorities it uses

Security and Authentication in IP

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Which is why login and password is still widely used to authenticate clients to the server

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Their program can then read and write via the secure connection they get from this instead of reading and writing directly from the TCP socket

Security and Authentication in IP

```
s = socket(PF_INET, SOCK_STREAM, 0); // TCP socket
...
// Initiate TCP connection to server
connect(s, (struct sockaddr *)&addr, ... );
...
read(s, buf, 1024); // read data
...
```

Security and Authentication in IP

```
s = socket(PF_INET, SOCK_STREAM, 0); // TCP socket
...
connect(s, (struct sockaddr *)&caddr, ... );
...
ssl = SSL_new(ctx); // context contains info about ciphers
SSL_set_fd(ssl, s); // associate socket with ssl struct
...
SSL_connect(ssl); // do the SSL handshake
...
if SSL_get_verify_result(ssl) != X509_V_OK { // authenticate
... bad certificate ...
}
...
SSL_read(ssl, buf, 1024); // read data
...
```

Security and Authentication in IP

TLS

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Security and Authentication in IP

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- SMTPS for SMTP (the protocol used to send email)
- IMAPS for IMAP (the protocol used to read email)
- Etc.

This is a relatively easy way of making secure protocols from insecure ones: just find the parts of code that read and write from IP sockets and change them to use TLS

Security and Authentication in IP

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Most people regard TLS as a transport layer

Security and Authentication in IP

TLS

Exercise Read about STARTTLS, a protocol to negotiate a TLS connection, as used by SMTP and IMAP

Exercise Contrast HTTPS with SHTTP, which is an extension of HTTP to include security

Exercise Read about HTTP/2, the latest version of HTTP, that encourages the use of TLS

Security and Authentication in IP

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We should also mention QUIC (again) at this point

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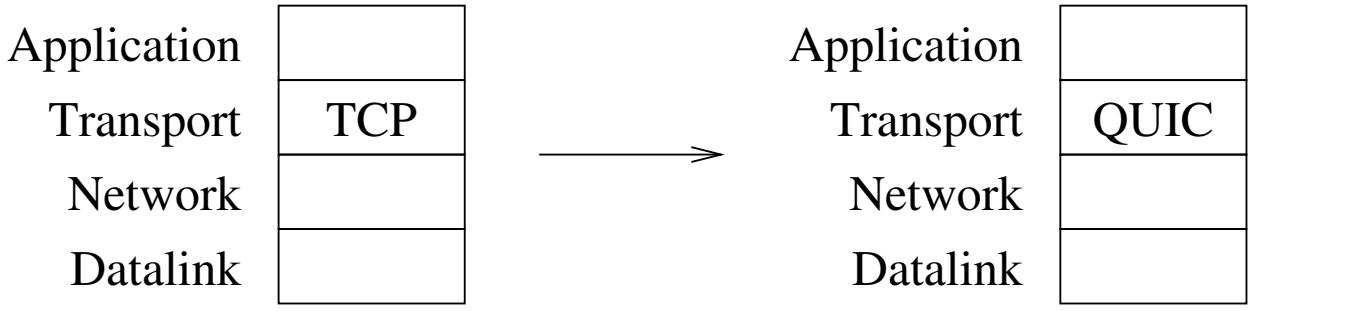

insecure, unauthenticated secure, authenticated

QUIC

Security and Authentication in IP

TLS

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Thus making QUIC faster to set up

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In the future, QUIC will the transport layer of the Web (HTTP/3), and possibly other applications, too (e.g., DNS)

Security and Authentication in IP

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Traffic analysis of communications is a powerful tool that has been used for decades

Security and Authentication in IP

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For example, `good.tumblr.com/home.html` and `bad.tumblr.com/home.html` with both `good.tumblr.com` and `bad.tumblr.com` having the same IP address

The server name is included in the HTTP request and the server uses this to determine which sub-site the client wants

Security and Authentication in IP

TLS

```
GET /home.html HTTP/1.1
Host: bad.tumblr.com
User-Agent: curl/7.60.0
Accept: */*
```

HTTP request for `home.html` on (virtual) server `bad.tumblr.com`

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HTTPS runs over TLS so this is hidden from an eavesdropper

Security and Authentication in IP

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But the TLS handshake (before the HTTP request) requires an authentication certificate from the server that is based on the server name

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Server Name Indication (SNI; RFC6066) is part of the HTTPS handshake that asks for a cerfificate for the server name (e.g., `bad.tumblr.com`) *in the clear*

As we don't yet have a shared secret key, this can't be encrypted

Security and Authentication in IP

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So accesses to such sub-sites are trackable:

- in the DNS lookup of the sub-site name
- in the HTTPS SNI handshake that contains the name of the sub-site

Security and Authentication in IP

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- in the DNS lookup of the sub-site name
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Although the *content* of the Web pages is always hidden, which sites are being accessed can be tracked

Security and Authentication in IP

TLS

People are working on filling these gaps

Security and Authentication in IP

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We have already mentioned DNS over HTTPS (DoH; RFC8484) that hides the DNS lookup

Security and Authentication in IP

TLS

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We have already mentioned DNS over HTTPS (DoH; RFC8484) that hides the DNS lookup

Exercise Read about Encrypted SNI (eSNI) that hides the handshake

Exercise Read about Oblivious DNS over HTTPS (ODoH) that hides the DNS request from the DNS server(!)

Exercise Why are sites like Reddit that also have many sub-sites not affected by this?

Security and Authentication in IP

Aside

Think about the ways your Internet use can be tracked (by ISPs or others, for the Investigatory Powers Act; or just general snooping by bad actors) or manipulated (by bad actors, including some ISPs)

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- Reading/manipulating your DNS requests (unless you use DoH or similar)
- Reading/manipulating your Server Name Indication traffic on TLS authentication certificates (unless you use eSNI)

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These costs are not huge, but you must make the choice of whether they are worthwhile

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Exercise Compare using transport layer security against network layer security

Security and Authentication in IP

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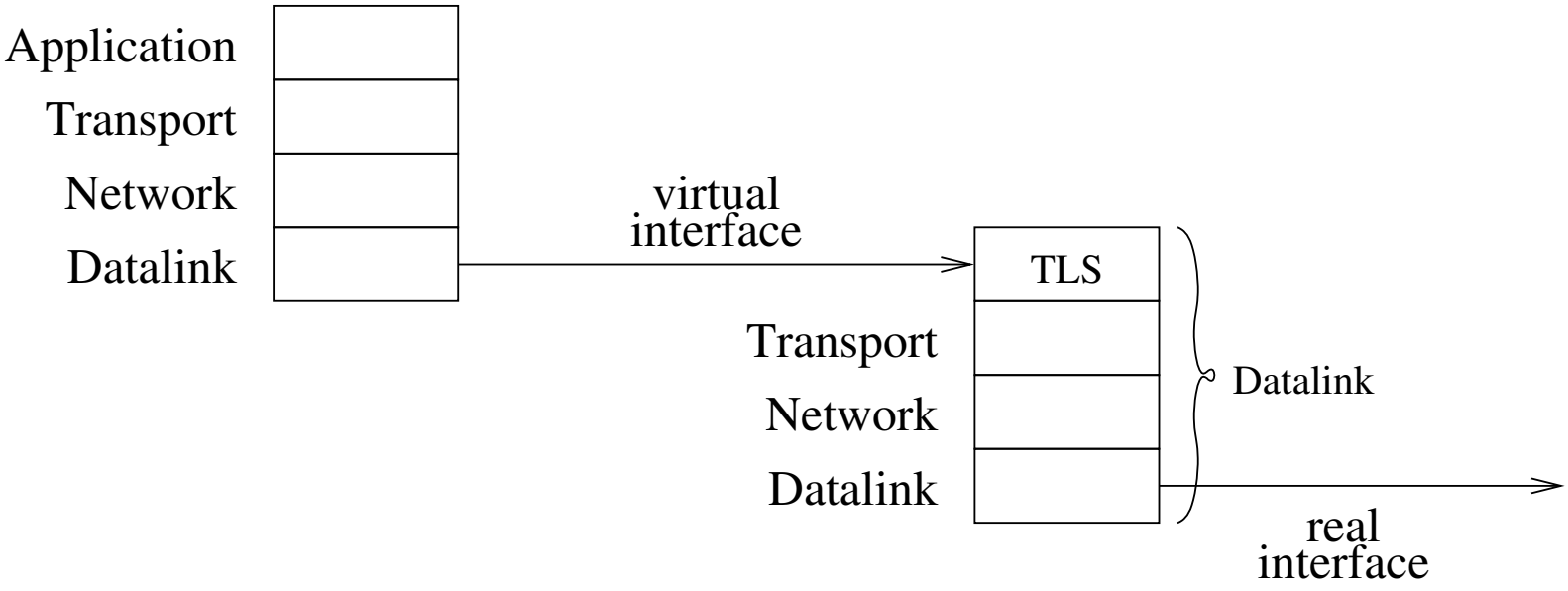
It creates a virtual network interface that the OS can pass IP packets to

The OpenVPN code then encrypts, authenticates and does whatever it needs (using TLS) before handing the result on to a “real” transport layer, usually UDP (as this is a VPN)

Security and Authentication in IP

TLS



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Exercise Compare these costs with using a Network Layer approach to VPNs, such as IPSec or WireGuard

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And now we have the usual benefits of a VPN: user applications can be unsecured (but remember your data is only secure while inside the VPN, not if the final destination is somewhere in the wider Internet)

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Exercise And what about using a secure login on a secure network?

Security and Authentication in IP

TLS

A web browser looking at a page secured by HTTPS on a VPN on a home network might be layering

> Web page in HTML/CSS over HTTP over TLS over TCP over IP over TLS over UDP over IP over PPP over Ethernet over Cat6a