

TFO(TCP Fast Open)

- TCP Fast Open (TFO) is a real protocol, and it is an extension to the traditional TCP (Transmission Control Protocol). TFO is designed to reduce latency in the establishment of a TCP connection.
- Normally, a TCP connection requires a three-way handshake (SYN, SYN-ACK, ACK) to establish a connection before any data can be exchanged.

Demonstration of TCP:

not udp and not smtp and not icmp								
	Time	Source	Destination	Protocol	Length	Info		
	3659 15.230116	10.81.16.196	180.149.52.217	TCP	66	63365 → 443 [SYN] Seq=0 Win=64240 Len=0 MSS=1460 WS=256 S		
	3660 15.233131	23.217.111.9	10.81.16.196	TCP	66	443 → 63361 [SYN, ACK] Seq=0 Ack=1 Win=64240 Len=0 MSS=12		
	3661 15.233330	10.81.16.196	23.217.111.9	TCP	54	63361 → 443 [ACK] Seq=1 Ack=1 Win=131072 Len=0		
	3662 15.234018	10.81.16.196	23.217.111.9	TLSv1.3	586	Client Hello		
> Frame 3662: 586 bytes on wire (4688 bits), 586 bytes captured (4688 bits) on interface \Device\NPF_{5							0000	00 00 5e 00 01 52 f8
> Ethernet II, Src: CloudNet_c5:24:4d (f8:89:d2:c5:24:4d), Dst: IETF-VRRP-VRID_52 (00:00:5e:00:01:52)							0010	02 3c 5c f1 40 00 80
> Internet Protocol Version 4, Src: 10.81.16.196, Dst: 23.217.111.9							0020	6f 09 f7 81 01 bb 8c
> Transmission Control Protocol, Src Port: 63361, Dst Port: 443, Seq: 1, Ack: 1, Len: 532							0030	02 00 29 46 00 00 16
v Transport Layer Security							0040	03 e3 2d 22 03 a9 ab
v TLSv1.3 Record Layer: Handshake Protocol: Client Hello							0050	80 a5 eb af 2a 54 74
Content Type: Handshake (22)							0060	53 20 32 39 63 ac e3
Version: TLS 1.0 (0x0301)							0070	2a d2 71 26 d8 59 03
Length: 527							0080	ae 46 00 20 3a 3a 13
> Handshake Protocol: Client Hello							0090	c0 2c c0 30 cc a9 cc
							00a0	00 2f 00 35 01 00 01
							00b0	02 00 02 44 69 00 05
							00c0	00 0f 00 00 0c 77 77

- In TCP Fast Open the sender sends data to the receiver along with the initial SYN. This allows for data transfer to begin immediately instead of waiting for the entire handshake process to take place.
- TFO works only for repeat connections because of the requirement of TFO cookie.

Demonstration of TFO:

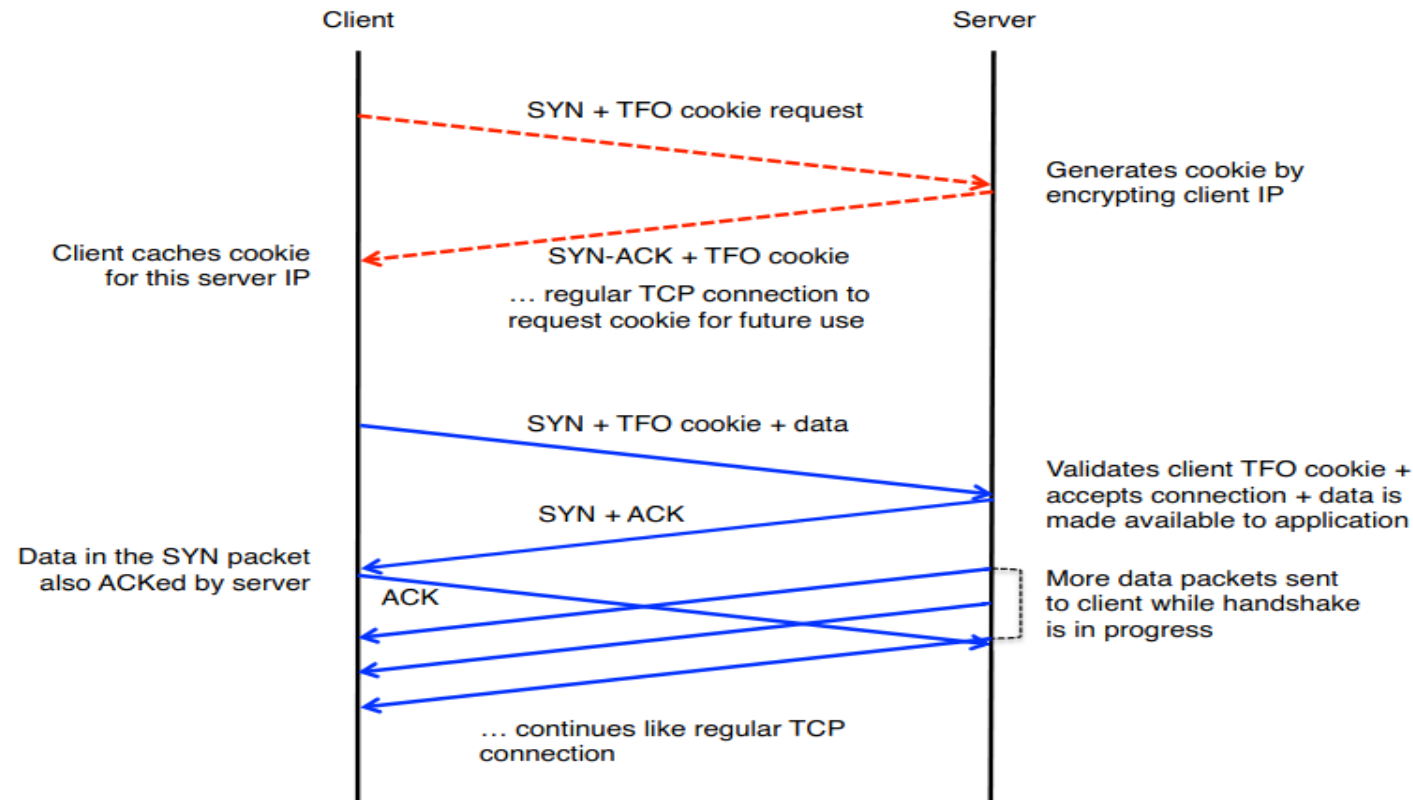
4	0.000209	192.168.1.175	192.168.1.176	TCP	66	50000 → 36702 [ACK] Seq=3950198196
5	10.001508	192.168.1.176	192.168.1.175	TCP	66	36702 → 50000 [FIN, ACK] Seq=369293
6	10.041269	192.168.1.175	192.168.1.176	TCP	66	50000 → 36702 [ACK] Seq=3950198196
7	11.074242	192.168.1.175	192.168.1.176	TCP	66	50000 → 36702 [FIN, ACK] Seq=395019
8	11.074547	192.168.1.176	192.168.1.175	TCP	66	36702 → 50000 [ACK] Seq=3692933010
9	16.788916	192.168.1.176	192.168.1.175	TCP	94	36704 → 50000 [SYN] Seq=2112094440
10	16.788952	192.168.1.175	192.168.1.176	TCP	74	50000 → 36704 [SYN, ACK] Seq=562305
11	16.789649	192.168.1.176	192.168.1.175	TCP	66	36704 → 50000 [ACK] Seq=2112094449
12	27.988306	192.168.1.175	192.168.1.176	TCP	66	36704 → 50000 [ACK] Seq=2112094449


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Flags: 0x002 (SYN)
Window size value: 29200
[Calculated window size: 29200]
Checksum: 0xf0f7 [unverified]
[Checksum Status: Unverified]
Urgent pointer: 0
Options: (32 bytes), Maximum segment size, SACK permitted, Timestamps, No-Operation (NOP), Window scale, TCP
  TCP Option - Maximum segment size: 1460 bytes
  TCP Option - SACK permitted
  TCP Option - Timestamps: TSval 2106150, TSecr 0
  TCP Option - No-Operation (NOP)
  TCP Option - Window scale: 7 (multiply by 128)
  TCP Option - TCP Fast Open
    Kind: TCP Fast Open Cookie (34)
    Length: 10
    Fast Open Cookie: 03e5344d684532f1
  TCP Option - No-Operation (NOP)
  TCP Option - No-Operation (NOP)

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- When a client sends the SYN packet to the server along with TFO cookies and data. And when the server sees the TFO cookies it understands that client supports TFO. The server generates a unique cookie and encrypts it using the IP address of the client so that each client has a unique cookie.



Performance of TFO over TCP

Page	RTT(ms)	PLT : non-TFO (s)	PLT : TFO (s)	Improv.
amazon.com	20	1.54	1.48	4%
	100	2.60	2.34	10%
	200	4.10	3.66	11%
nytimes.com	20	3.70	3.56	4%
	100	4.59	4.30	6%
	200	6.73	5.55	18%
wsj.com	20	5.74	5.48	5%
	100	7.08	6.60	7%
	200	9.46	8.47	11%
TCP wikipedia page	20	2.10	1.95	7%
	100	3.49	2.92	16%
	200	5.15	3.03	41%

Advantages of using TFO:

It generally used in web browsing and HTTP/HTTPS, Mobile networks and Content delivery Networks(CDNs).

It gives faster Page Loading : For web applications, TFO can lead to faster page loading because it allows the client to send an initial cookies along with the SYN packet. This can be especially helpful for loading small resources.

Reduce Latency: In TFO it reduces upto one RTT in compare with TCP.

It is more effective if multiple connections are there.