Off-Path TCP Exploit: How Wireless Routers Can Jeopardize Your Secrets

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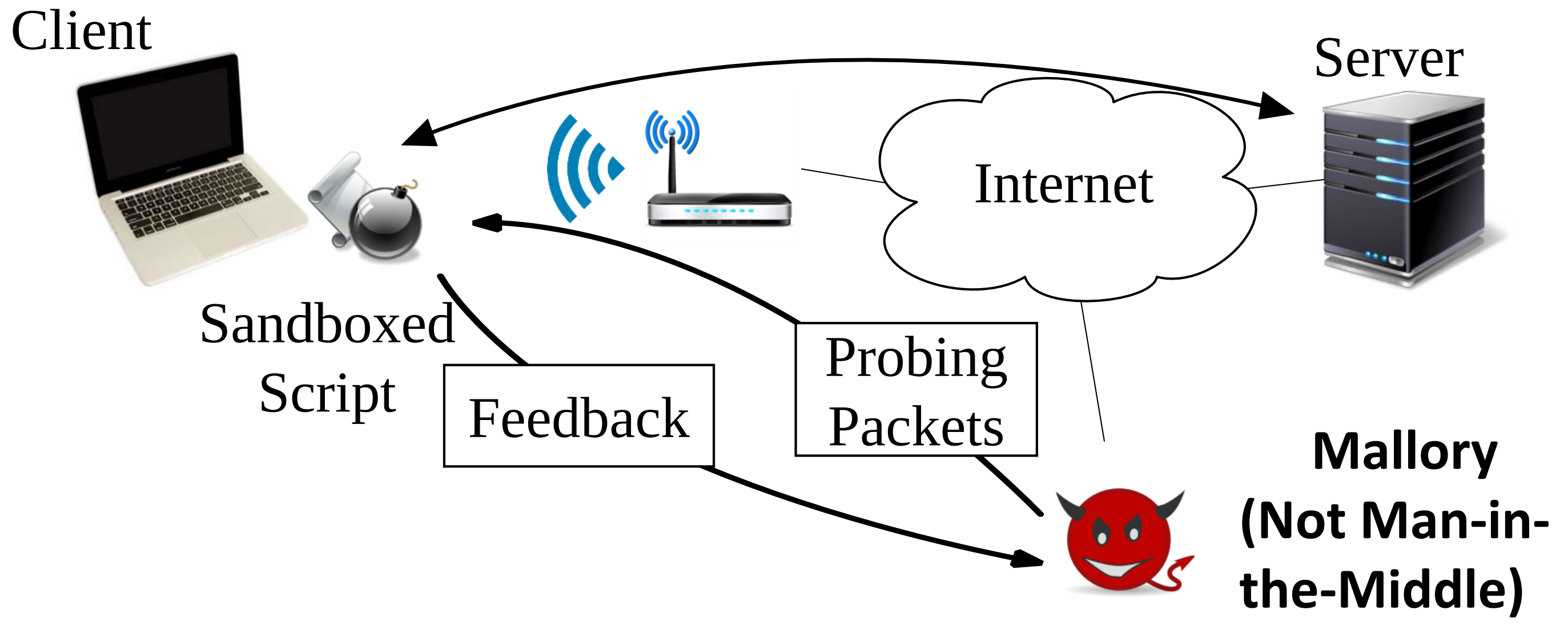
Vulnerability Overview

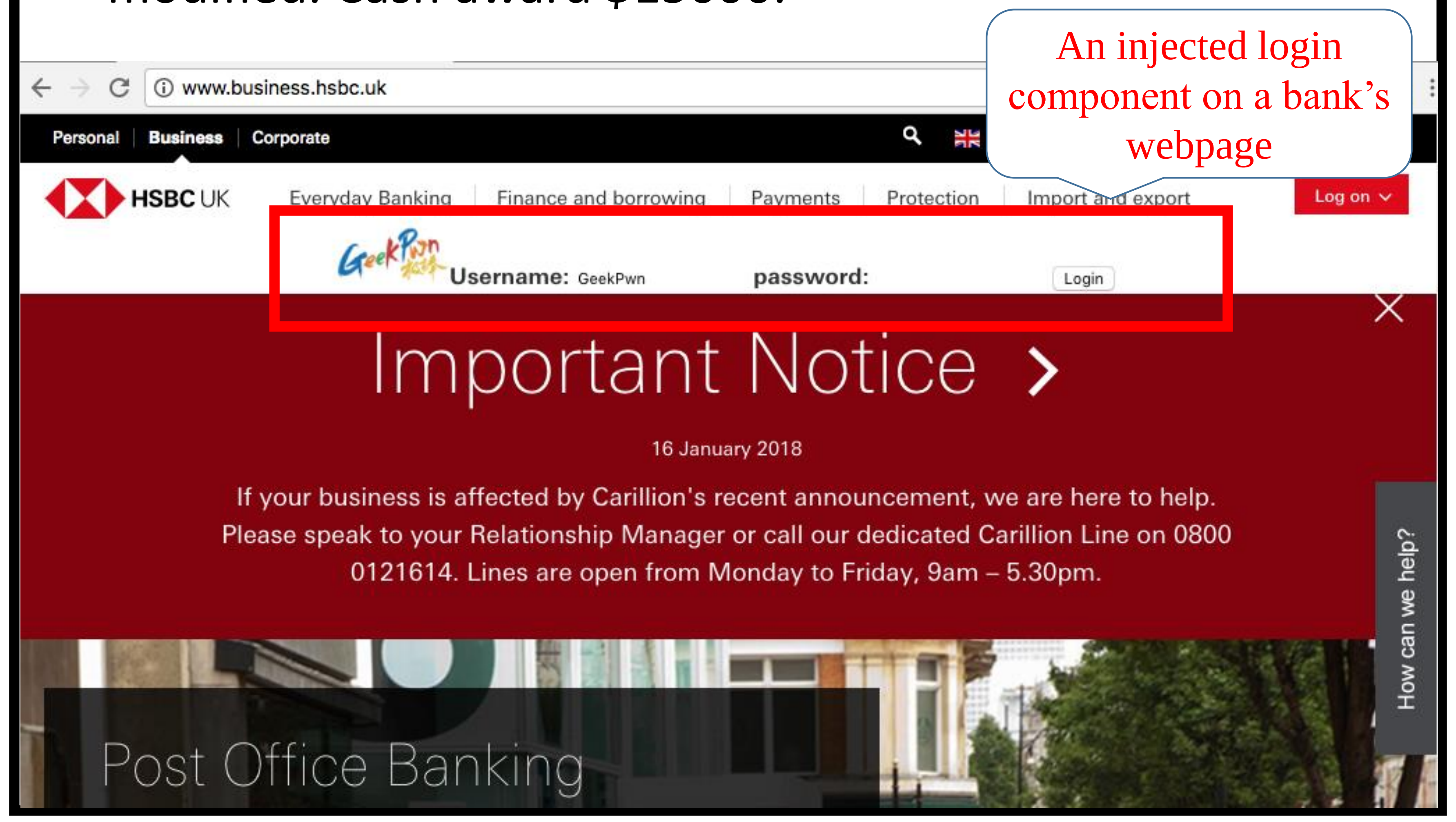
We report a nearly ***impossible-to-fix network side channel vulnerability*** rooted in the "half-duplex" design of all generations of IEEE 802.11 protocols.

It allows a blind off-path attacker to hijack chosen TCP connections, as long as one end-host is connected to the Internet via Wi-Fi.

Threat Model



- Mallory can hijack connections between the client and server by injecting malicious HTTP payload.
- Client browser caches will be permanently poisoned.
- Demoed at Geekpwn 2017 -- a banking homepage is modified. Cash award $15000.



An injected login component on a bank's webpage

Important Notice >

16 January 2018

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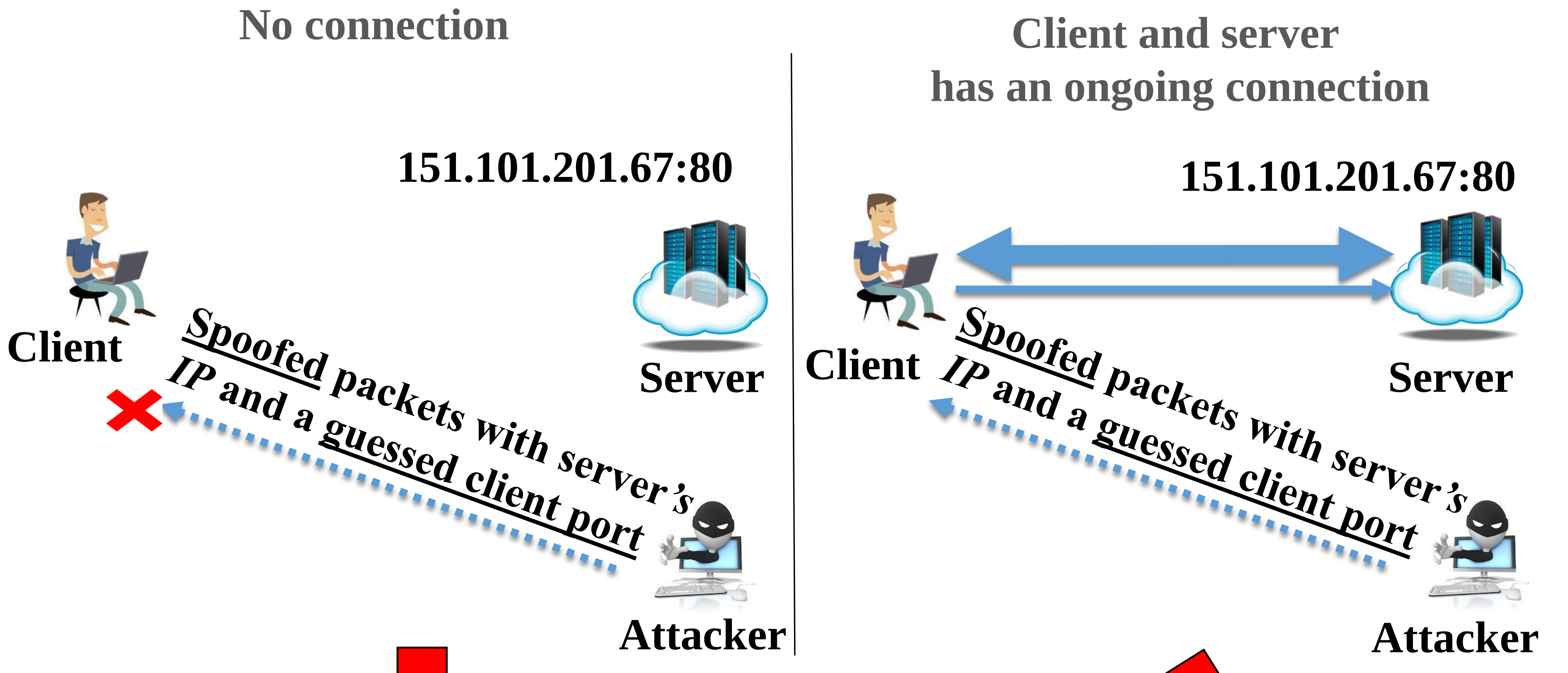
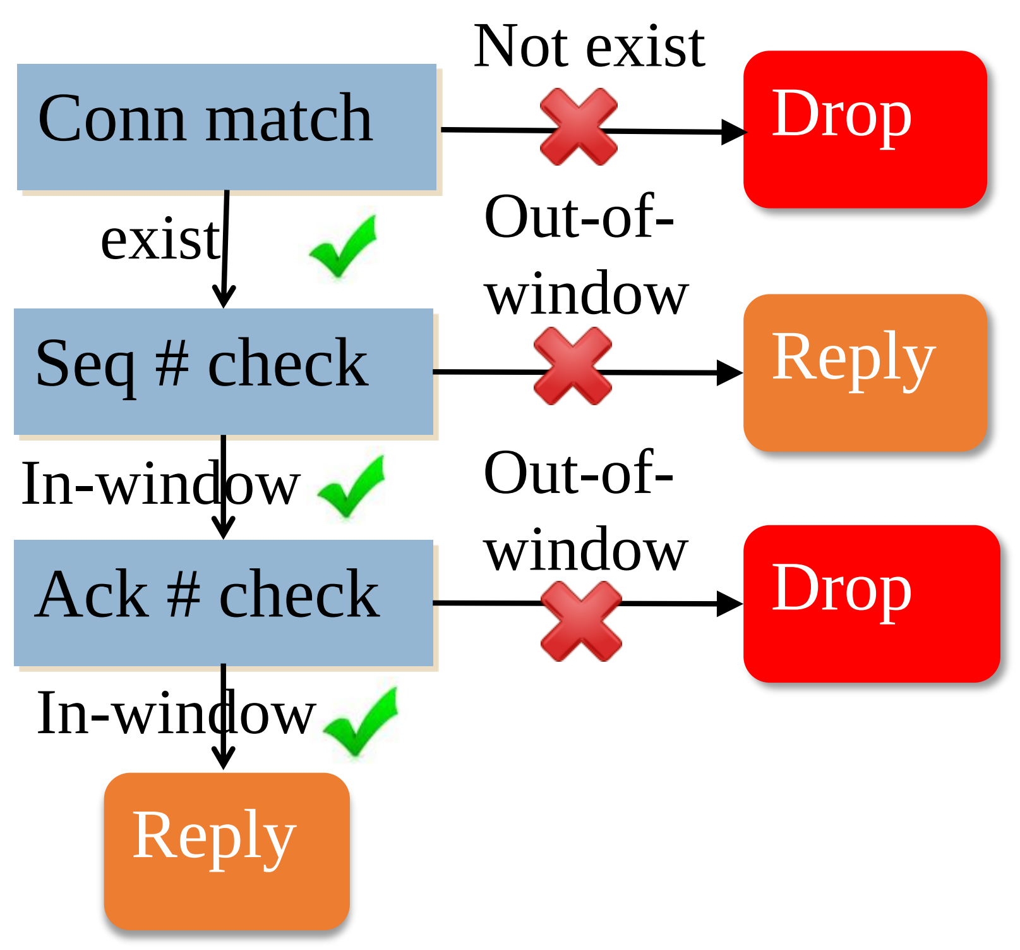
Post Office Banking

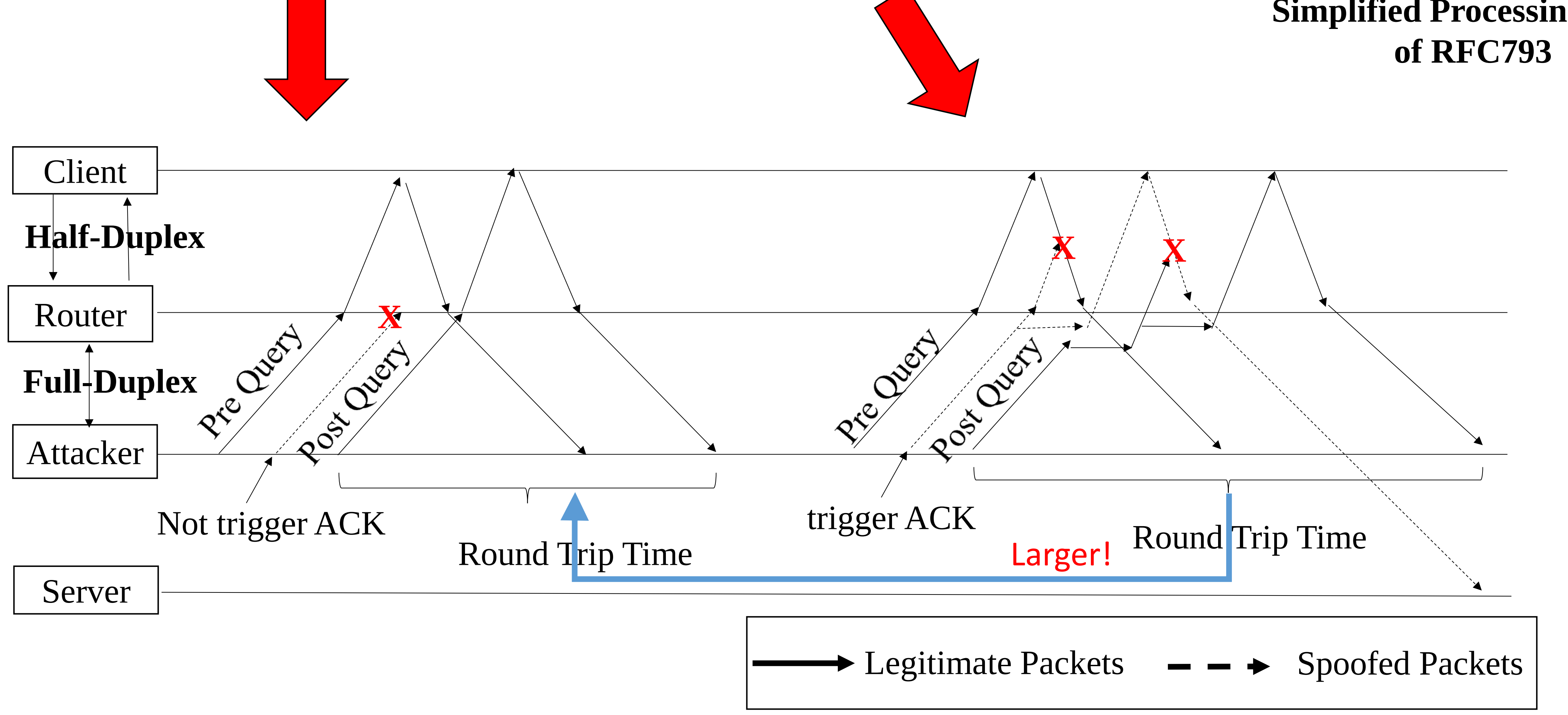
Connection Inference


No connection
151.101.201.67:80
Client
Server
Spoofed packets with server's IP and a guessed client port
Attacker
Client and server has an ongoing connection
151.101.201.67:80
Client
Server
Spoofed packets with server's IP and a guessed client port
Attacker



Simplified Processing Logic of RFC793

- Depending on whether the guessed port number matches an ongoing connection, the client will behave differently i.e., with/without replies.
- By leveraging the side channel we discovered, the attacker can indirectly observe the difference indirectly through timing.
- Sequence and acknowledgement number inference is almost the same as port number inference.



Wireless Timing Side Channel

- The *half-duplex* nature of Wi-Fi creates a "shared resource" among uplink and downlink traffic – only one direction can transmit at the same time.
- Probing strategy: A spoofed probing packet along with a pre-probe query and post-probe query
- Not trigger ACK → little contention → small RTTs
- Trigger ACK → high contention → large RTTs
- The signal is amplifiable: More probing packets → more contention → larger RTTs

Results

- Local experiment

OS	Success Rate	Avg time cost
Linux	10/10	188.80s
MacOS	10/10	48.91s
Windows	10/10	43.42s

- Remote experiment – RTT = 20ms

MacOS	9/10	304.18s

Conclusion

- A timing side channel in Wi-Fi which indirectly affects TCP in all OSes, as long as the host is behind Wi-Fi
- Demo of the threat.
- Reported to IEEE 802.11 working group --- **impossible to fix.**