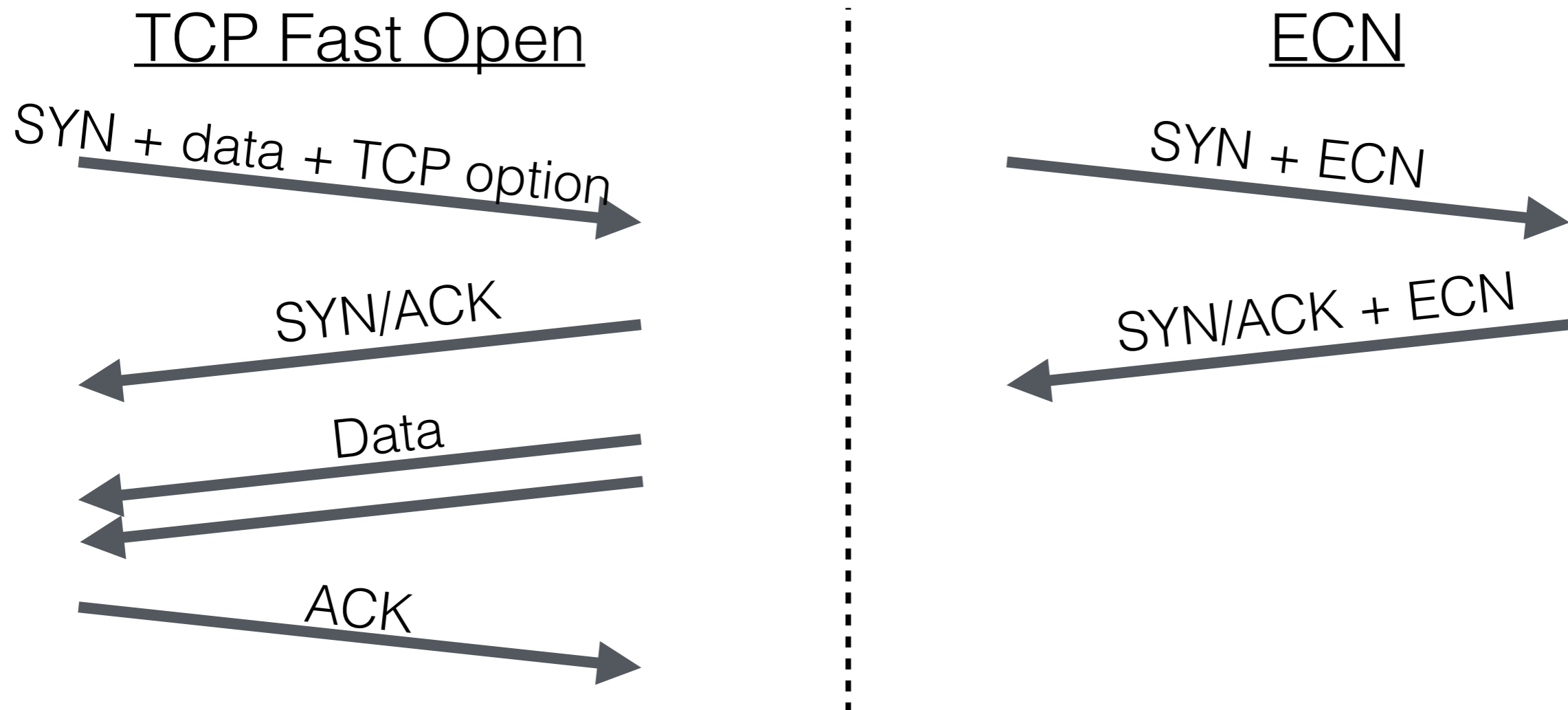


Lessons learned:
TCP Fast Open and ECN
in the Wild Internet

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Middleboxes interfere with TCP extensions

Typical measurement campaigns inspect the handshake-part of TCP extensions (e.g., removing TCP options, dropping SYN+ECN)



Middleboxes “break” the flow after the handshake

TCP Fast Open

SYN + data + TCP option

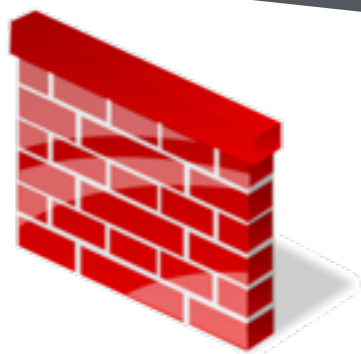


The diagram shows a sequence of packets in a TCP Fast Open flow. It starts with a rightward arrow labeled 'SYN + data + TCP option'. This is followed by a leftward arrow labeled 'SYN/ACK'. Then, two parallel leftward arrows are labeled 'Data'. Finally, a rightward arrow is labeled 'ACK'. Below the 'ACK' arrow is a red brick wall icon.

SYN/ACK

Data

ACK



Flow gets blackhole'd

ECN

SYN + ECN



The diagram shows a sequence of packets in an ECN flow. It starts with a rightward arrow labeled 'SYN + ECN'. This is followed by a leftward arrow labeled 'SYN/ACK + ECN'.

SYN/ACK + ECN

- Mark all packets with CE
- Randomly reorder ECT-marked packets
- ...

Lessons learned

- New TCP extensions might *confuse* middlebox's internal state
- This *confusion* might show its effects only later on, long after the handshake

Measurement campaigns of middlebox interference should consider the *whole flow*