SHARKFEST '12

Wireshark Developer and User Conference

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Tuning Win7 Using Wireshark's TCP Stream Graph

Case Study

- Customer is distributing Software over night to remote office in Asia
- But the process does not finish before local business hours starts
- Customer is paying for a WAN bandwidth of 45 Mbps
- He calculates an available throughput of only around 2 Mbps

- Does the bandwidth provider limit the rate?
- Is the server or the client not performing?

- Analyze the performance of a TCP session using TCP Stream graph

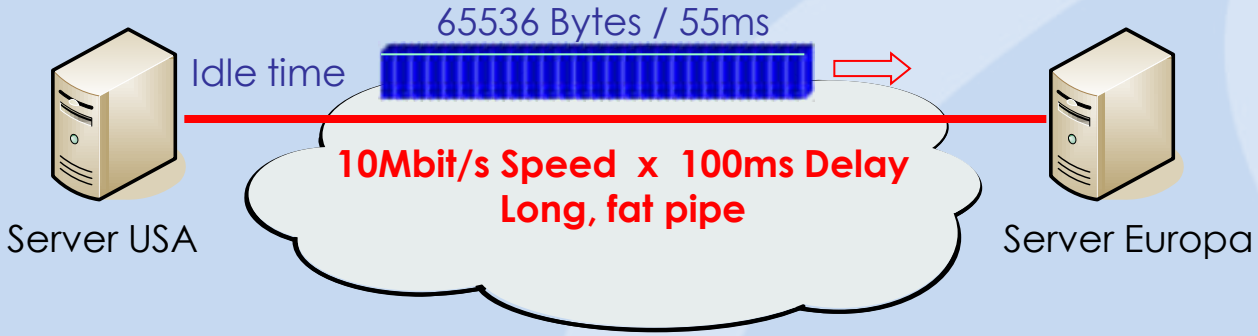
TCP Extension for High performance

- TCP was designed to operate in the range 100bps to 10Mbps and delays of 1ms to 100sec.
- The introduction of fiber optics is resulting in ever higher transmission speeds paths and are moving out of the domain for which TCP was originally engineered.

- TCP performance depends not upon the transfer rate itself, but rather upon the product of the transfer rate and the round-trip delay. If the bandwidth x delay product is large, TCP throughput will be limited.
- Internet path operating in this region are called "long, fat pipe", and a network containing this path as an "LFN" (pronounced "elephan(t)").

‚Long - Fat - Pipe‘ Problems

- Maximum standard TCP window size is 65536 Bytes (=2^{16})



‚Long - Fat - Pipe‘ Problems

- High-capacity packet satellite channels are LFN's. Delay 4 x 35‘800 km = 470ms Round Trip Time
- Terrestrial fiber-optical paths will also fall into the LFN class
- There are three fundamental performance problems with the current TCP over LFN paths:
  - Window Size Limit (max 65k bytes) → Remedy: TCP option „Window scale“
  - Recovery from Segment Losses → Remedy: TCP option „Selective acknowledges“
  - Round-Trip Measurement → Remedy: TCP option „Time stamp“

TCP ‚Window Scaling‘ Option

- TCP Window Size of 65‘535 Bytes is too small.
- A multiplier Skaling Factor resolves this limitation.
- Scaling Factor S is negotiated at TCP setup.
- Each end can offer an individual Scaling Factor.
- The value for the Scaling Factors can vary from 0 to14.
- Calculation for the scaled Window Size is as follows:

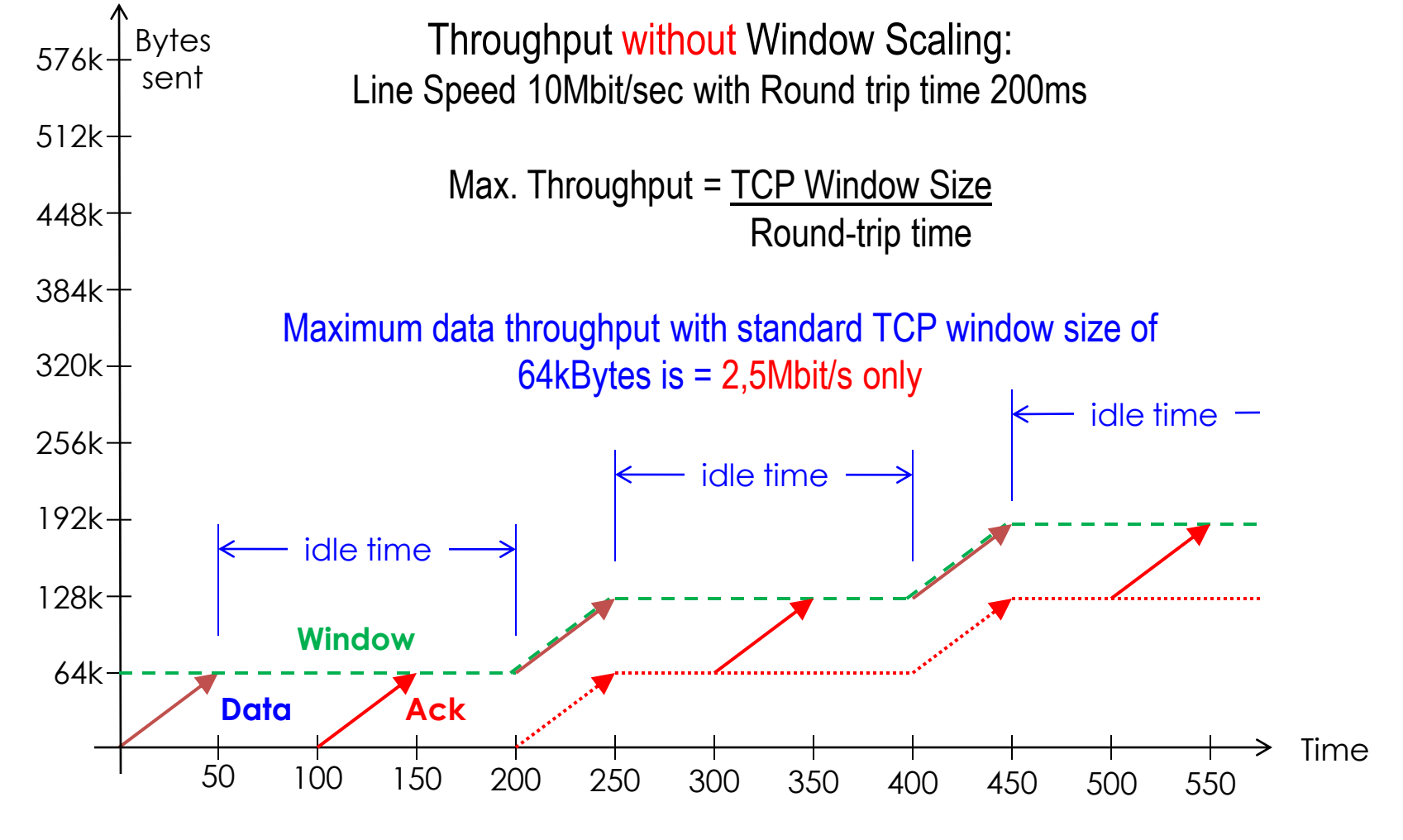
$$\text{Scaled Window Size} = \text{Window Bytes} \times 2^{S}$$

- Example: Window Size 46 Bytes, Scaling Factor S=7→ $2^{7} = 128$

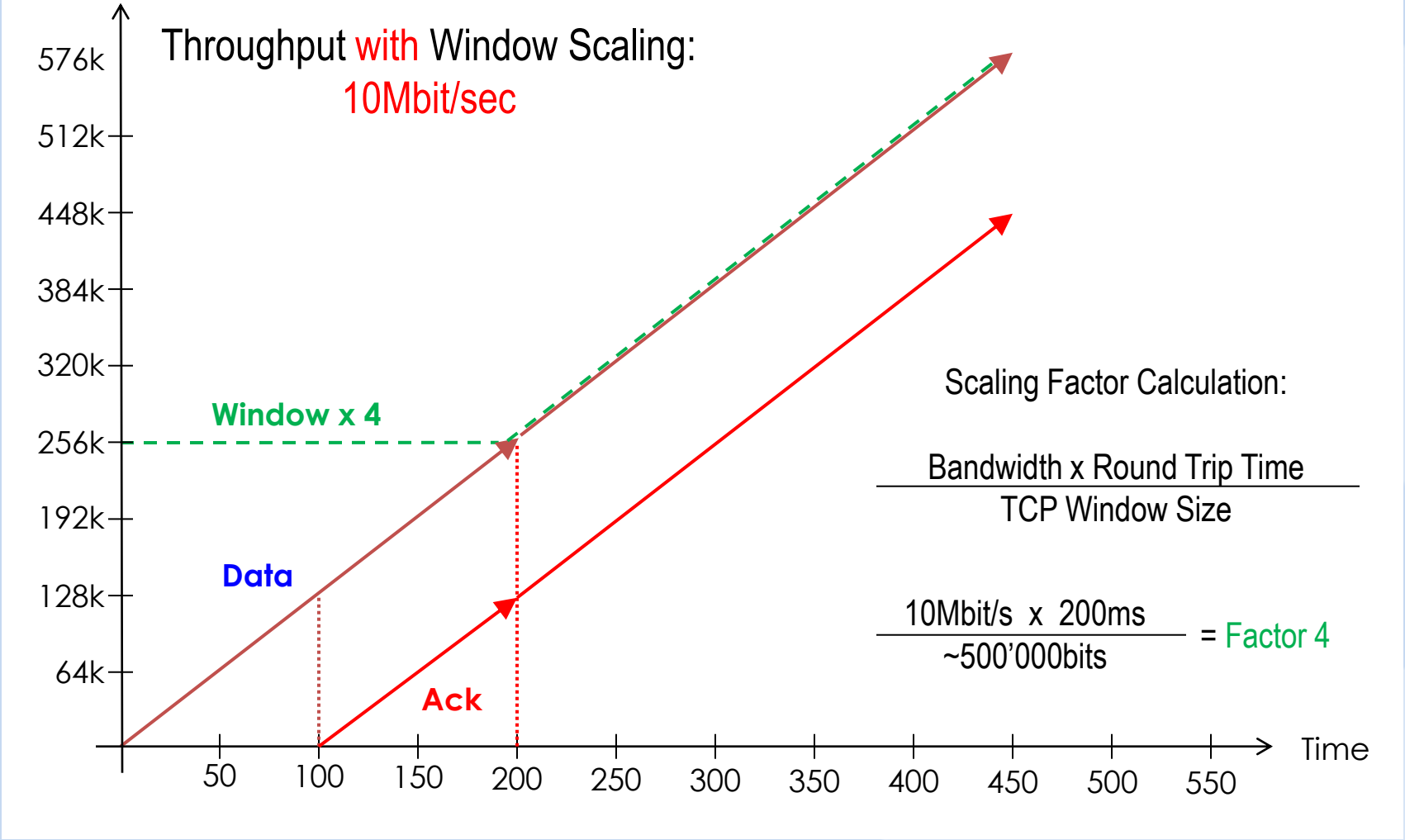
$$46 \text{ Bytes} \times 128 = 5'888 \text{ Bytes}$$

- The maximum Window Size can be 1’073’741’824 Bytes = 1 Gigabyte

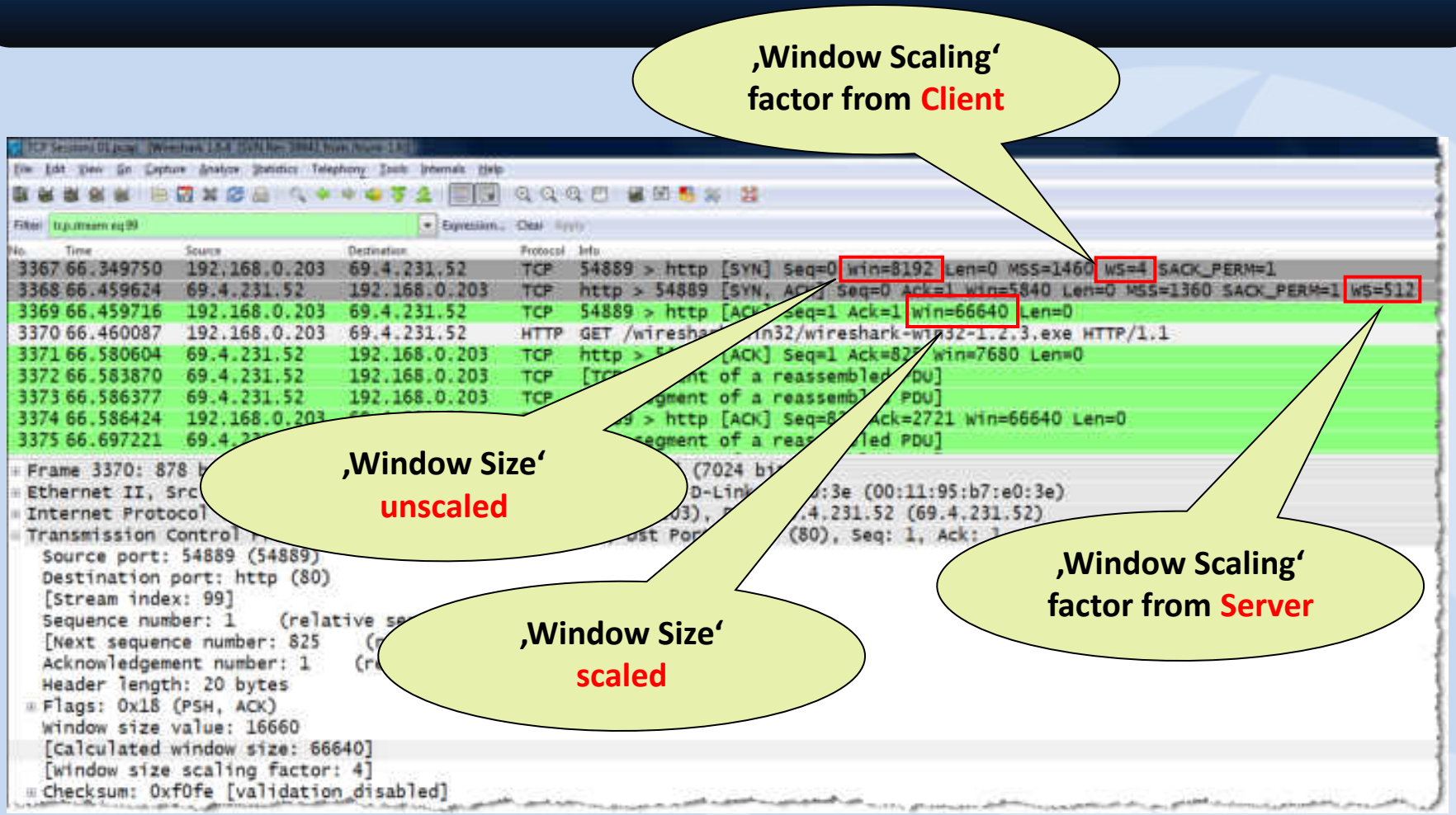
TCP ‚Window Scaling' Option



TCP ‚Window Scaling' Option



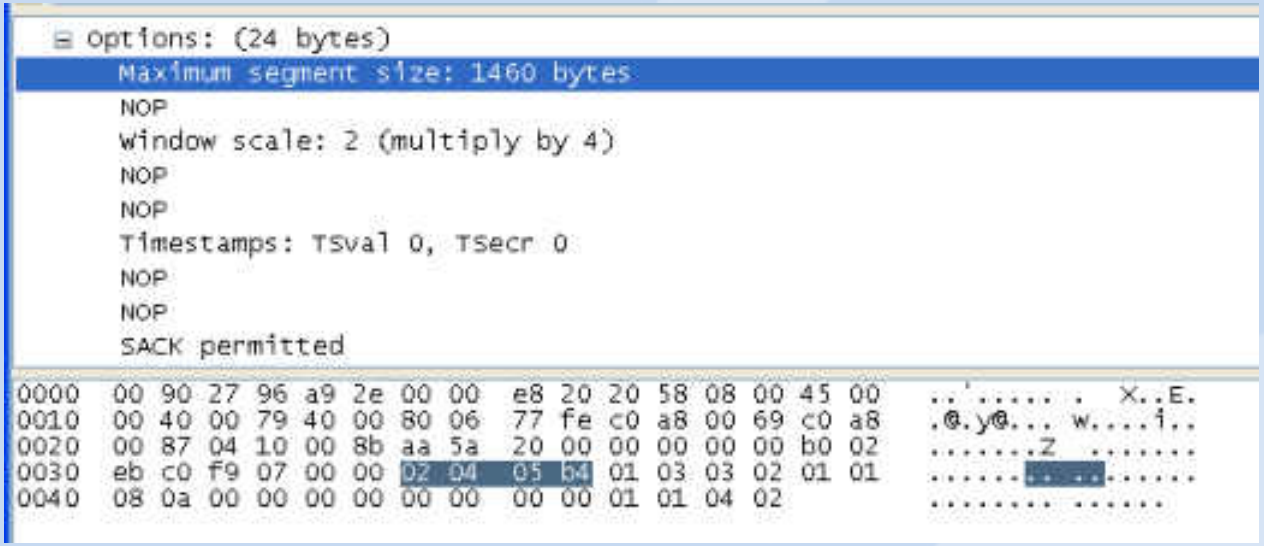
TCP ‚Window Scaling' Option



After the two TCP SYN frames, the window size is announced in the scaled format and Wireshark displays the scaled value.

TCP Extensions for High Performance

- The following TCP options are defined in RFC1323:
  - 01 No operation (for padding)
  - 02 Max. Window size (SYN)
  - 03 Window scale (SYN)
  - 04 SACK permitted (SYN)
  - 05 SACK option (Acknowledges)
  - 08 Time stamp (SYN and Acknowledges)

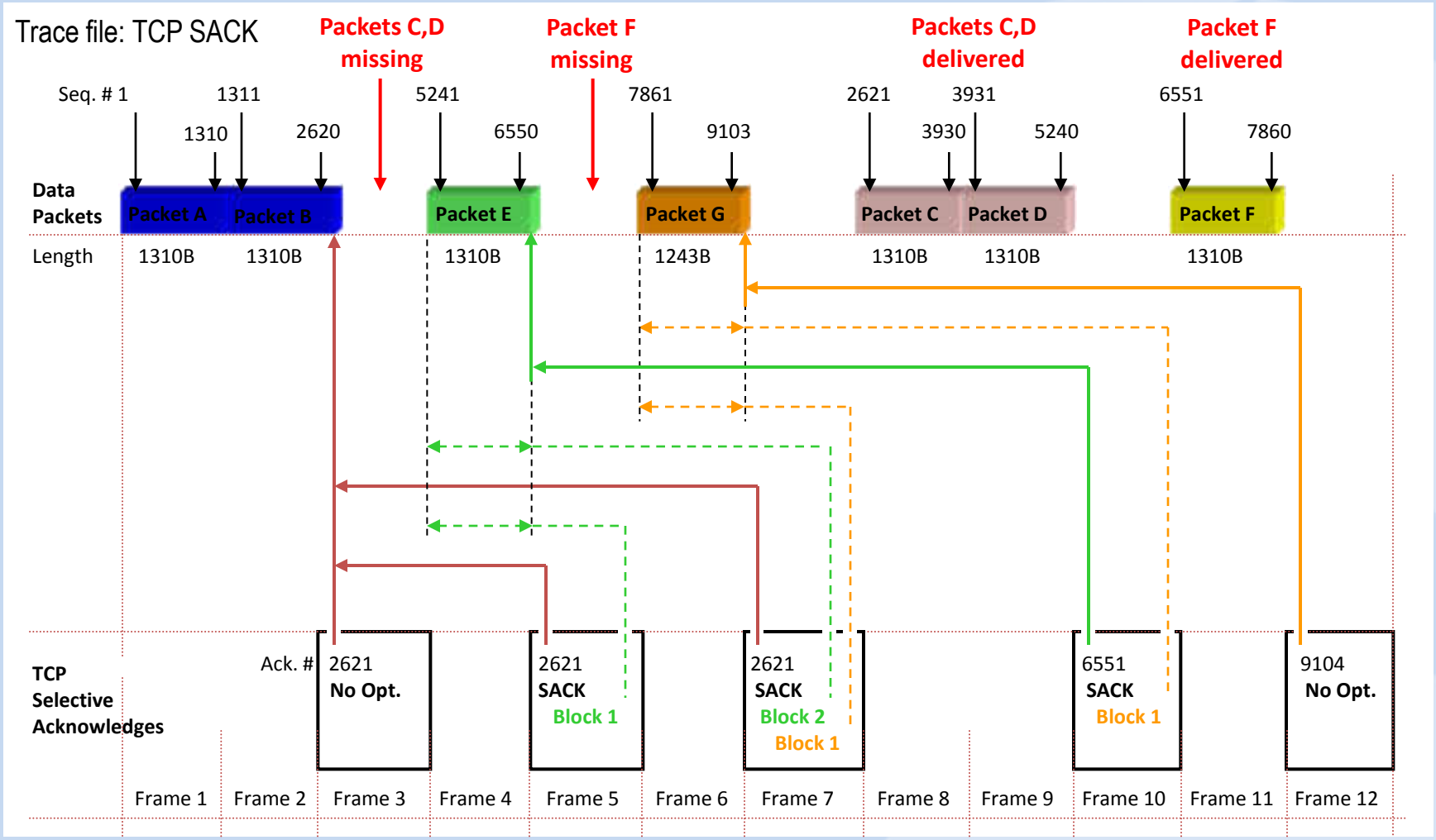


TCP 'Selective Acknowledge' Option

- The usage of the TCP SACK option is negotiated during the 3-Way hand shake.
- The SACK option can be activated from one or both sides.
- Without SACK option, only the last received segment of a contiguous series can be acknowledged.

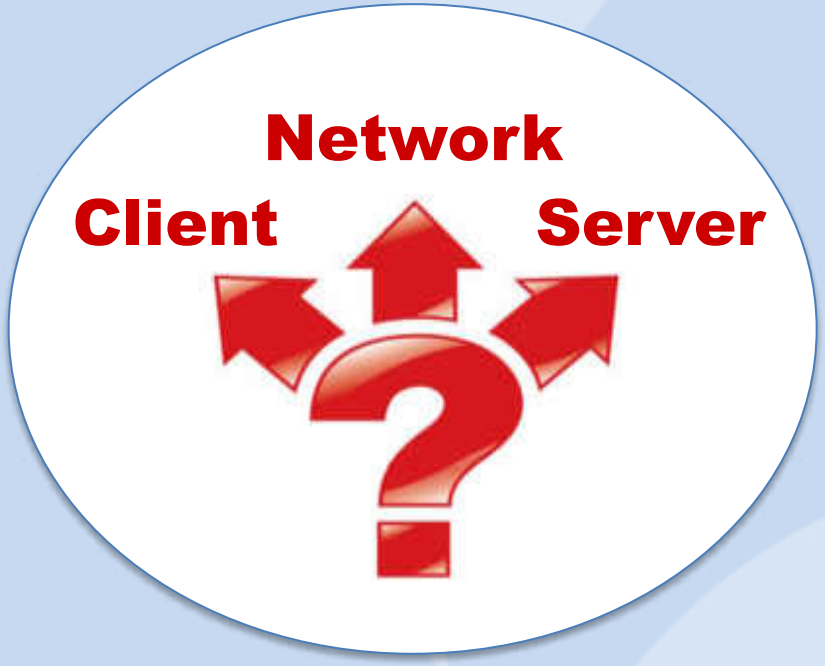
- The SACK Option allows to acknowledge non-contiguous segments of a series and can request for specific segments.
- The SACK Option can improve the throughput of LFN's significantly.

TCP 'Selective Acknowledge' Option



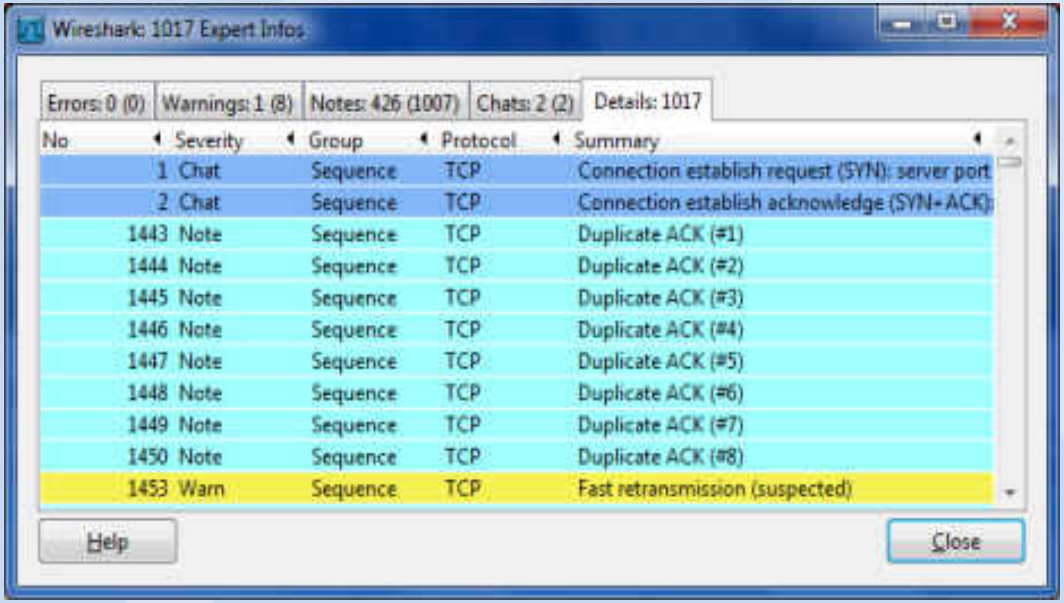
TCP Analysis with Wireshark Expert

- TCP performance can be influenced by these three main components
- The Wireshark Expert is offering great support in analyzing TCP sessions
- Understanding TCP and Expert Messages helps isolating problems



TCP Analysis with Wireshark Expert

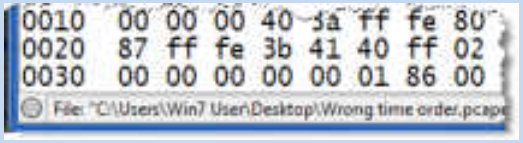
- The Wireshark Expert System recognizes many abnormalities or errors and creates a list sorted by severities:
  - Segment Lost
  - Duplicate ACK
  - Retransmissions
  - Fast Retransmissions
  - Zero Window
  - Window Full
  - and many more…



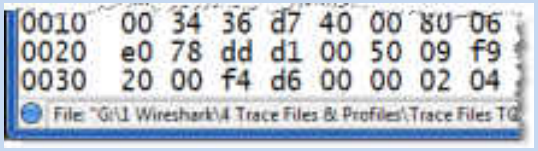
- You still need well-founded TCP knowledge to understand the error messages and to draw the right conclusions.

TCP Analysis with Wireshark Expert

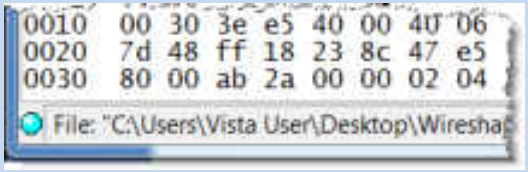
- Click on the colored ‚Expert Button' to open the ‚Expert Infos' window



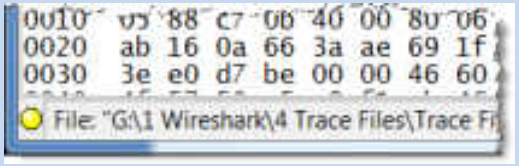
Level 0 = No Expert info available for protocols present in trace file (i.e. for protocols using UDP)



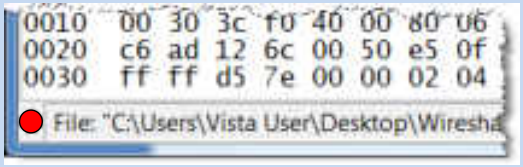
Level 1 = Chats: Information about normal data flow, e.g. TCP session establishment and closing. HTTP Get/OK/404 etc.



Level 2 = Notes: Reference to slight abnormalities like ‚Duplicate ACK', ‚Retransmissions' etc.



Level 3 = Warnings: Informs about abnormalities like ‚Segment lost', Segments out of order' etc.

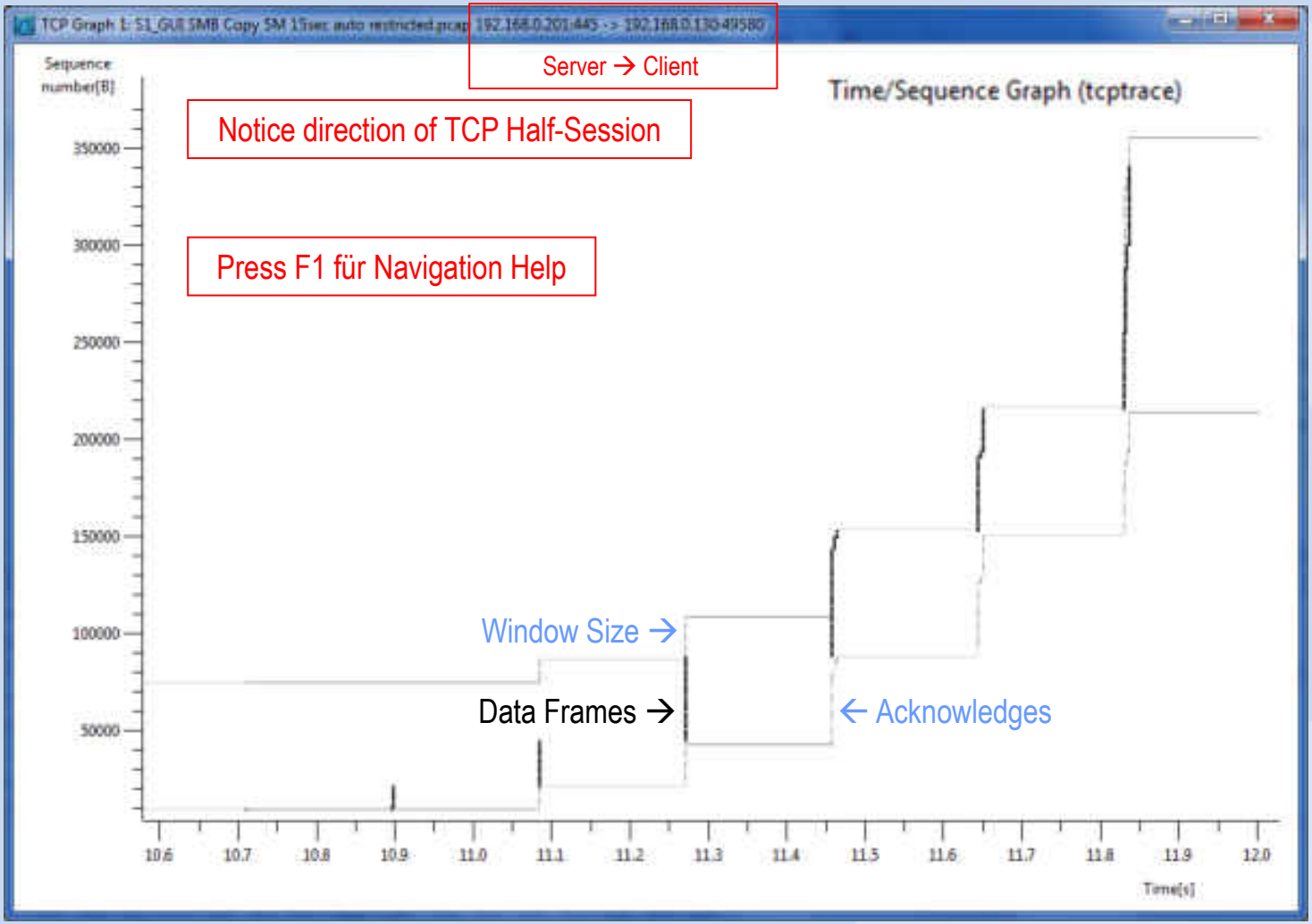


Level 4 = Errors: Messages on serious problems like deformed segments (i.e. missing fields)

TCP Analysis with TCP Stream Graph

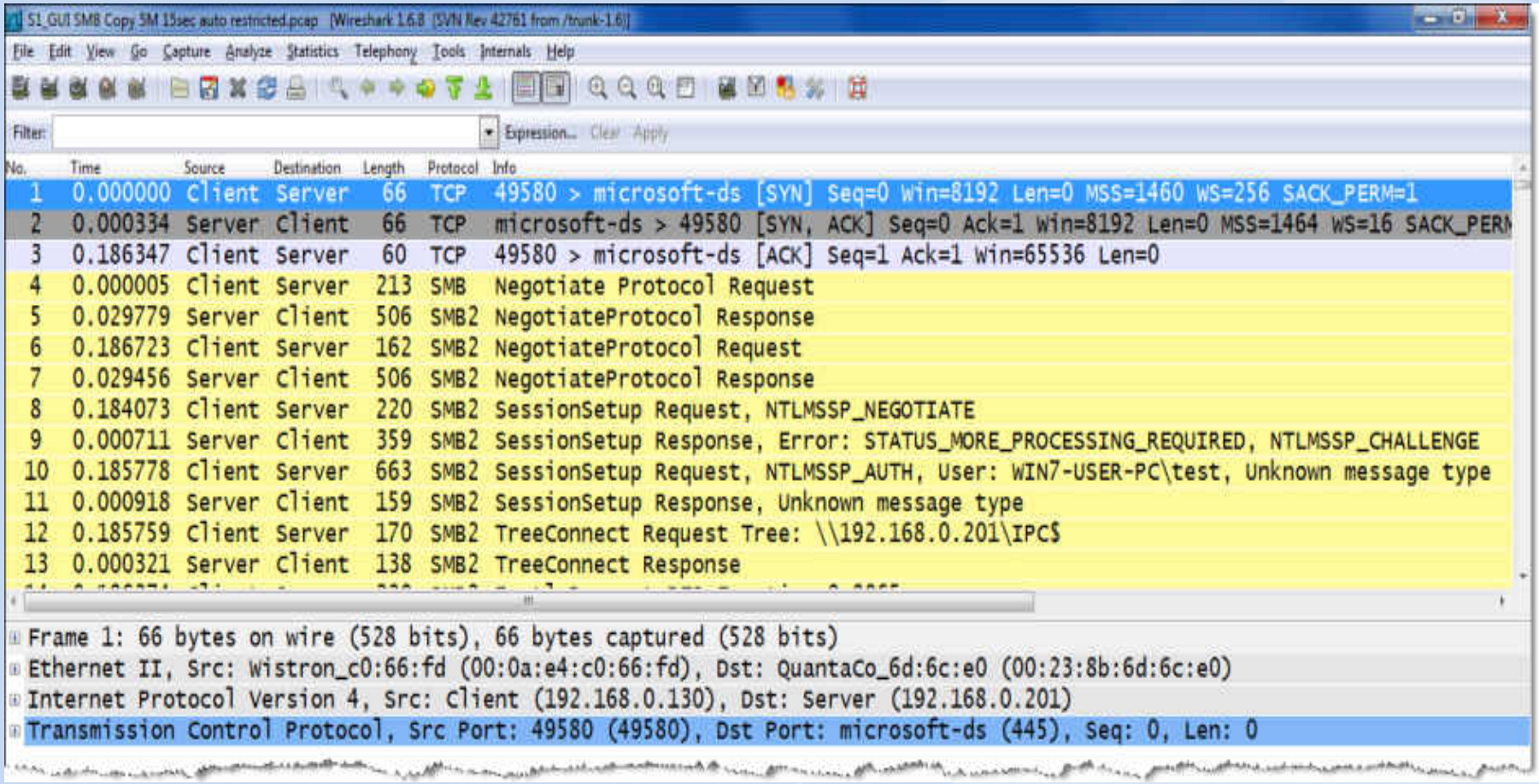
- Sometimes, a graphic tells us more than a thousand frames
- Wireshark offers excellent graphical TCP session presentations
- TCP Stream Graph allows to recognize all the following abnormalities:
  - Lost Frames
  - Duplicate Frames
  - Out of order Frames
  - TCP Sequence number and Segment Sizes
  - Acknowledges, Delayed Acknowledges
  - Duplicate and Selective Acknowledges
  - Retransmissions and Fast Retransmissions
  - Windows Sizes, sliding Window, exceeded und frozen Windows Size
  - Window Scaling, Zero Window and Window Full Situation
  - Slow Start, full Flow rate and Flow throttling

TCP Analysis with TCP Stream Graph



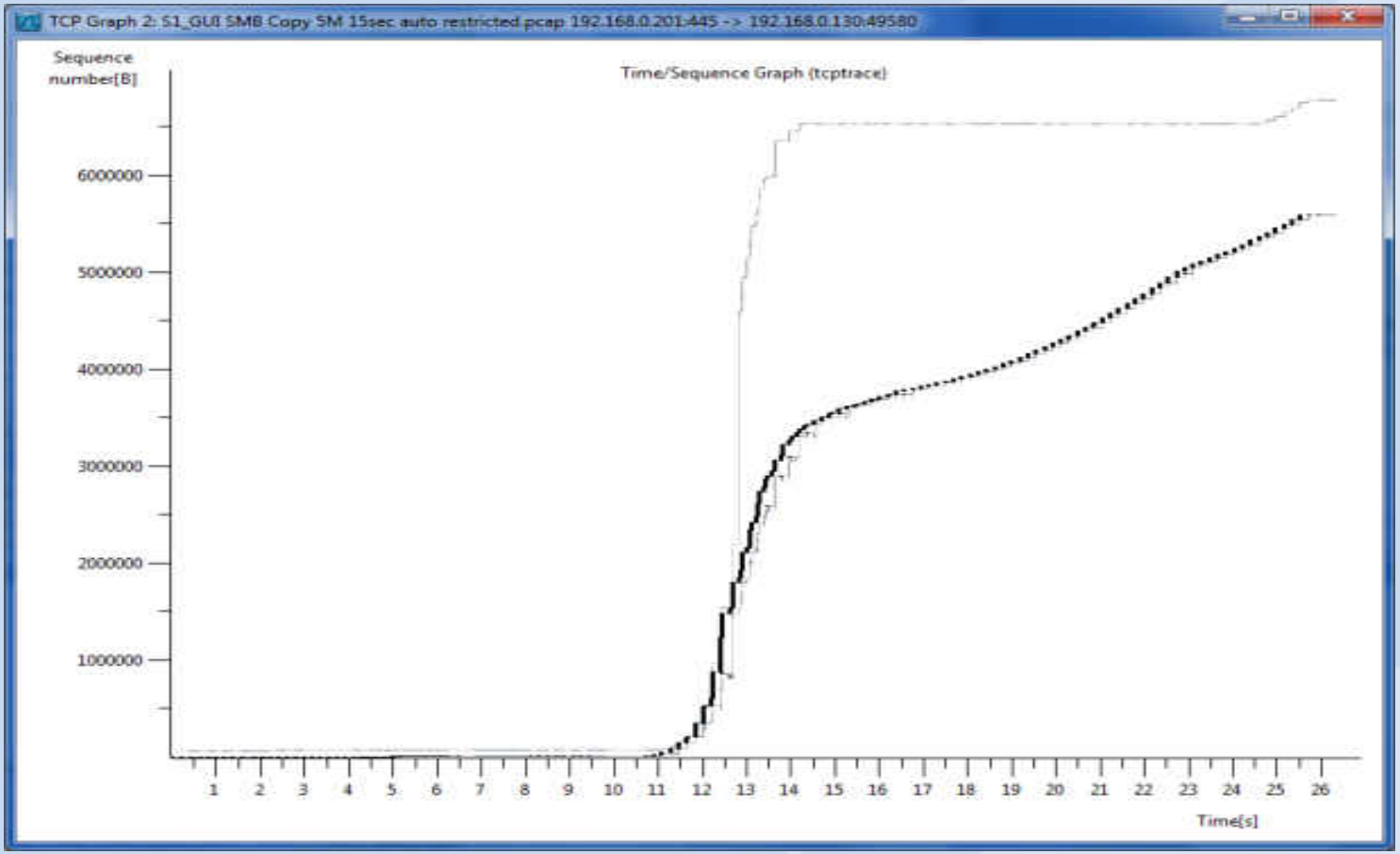
TCP Analysis with TCP Stream Graph

- Now, let us analyze our customer case using Frame Analysis



TCP Analysis with TCP Stream Graph

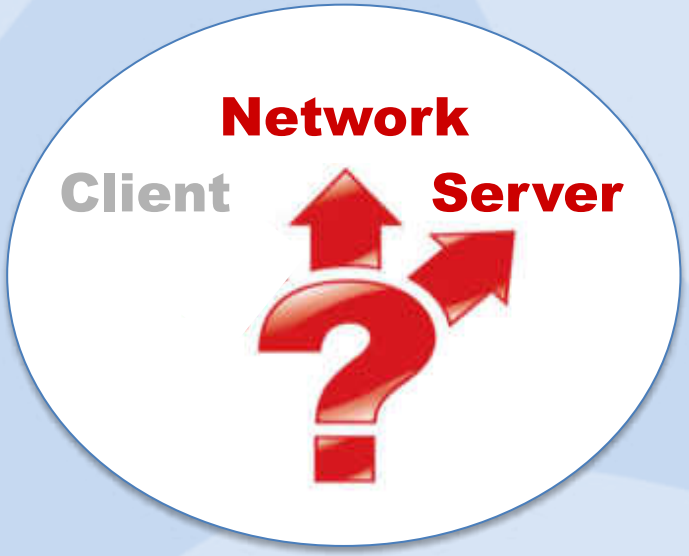
- Now, let us analyze our customer case using TCP Stream Graph



TCP Analysis with TCP Stream Graph

What can be read out of the trace file and the TCP Stream graph:

- Client and Server are both using Window Scaling and Selective ACKs
- The trace file has been captured on the server side
- The Round-Trip-Time is 186ms
- The receiver (Client) window is wide open
- The network is dropping frames
- The server is retransmitting frames



- At this stage, we can exclude the client !

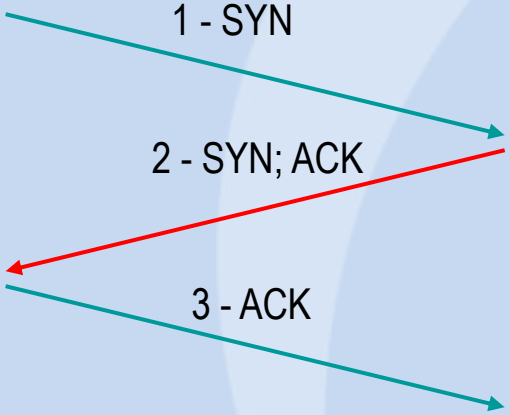
TCP Analysis with TCP Stream Graph

- TCP ‚Three-way Handshake‘

Client SYN
- Start Sequence Number
- Window Size

Options:
- Maximum Segment Size
- Window Scaling
- Selective Acknowledges
- Timestamp
- PAWS (Protection against wrapped sequence #)

Client ACK
- Acknowledge Server Sequence Number

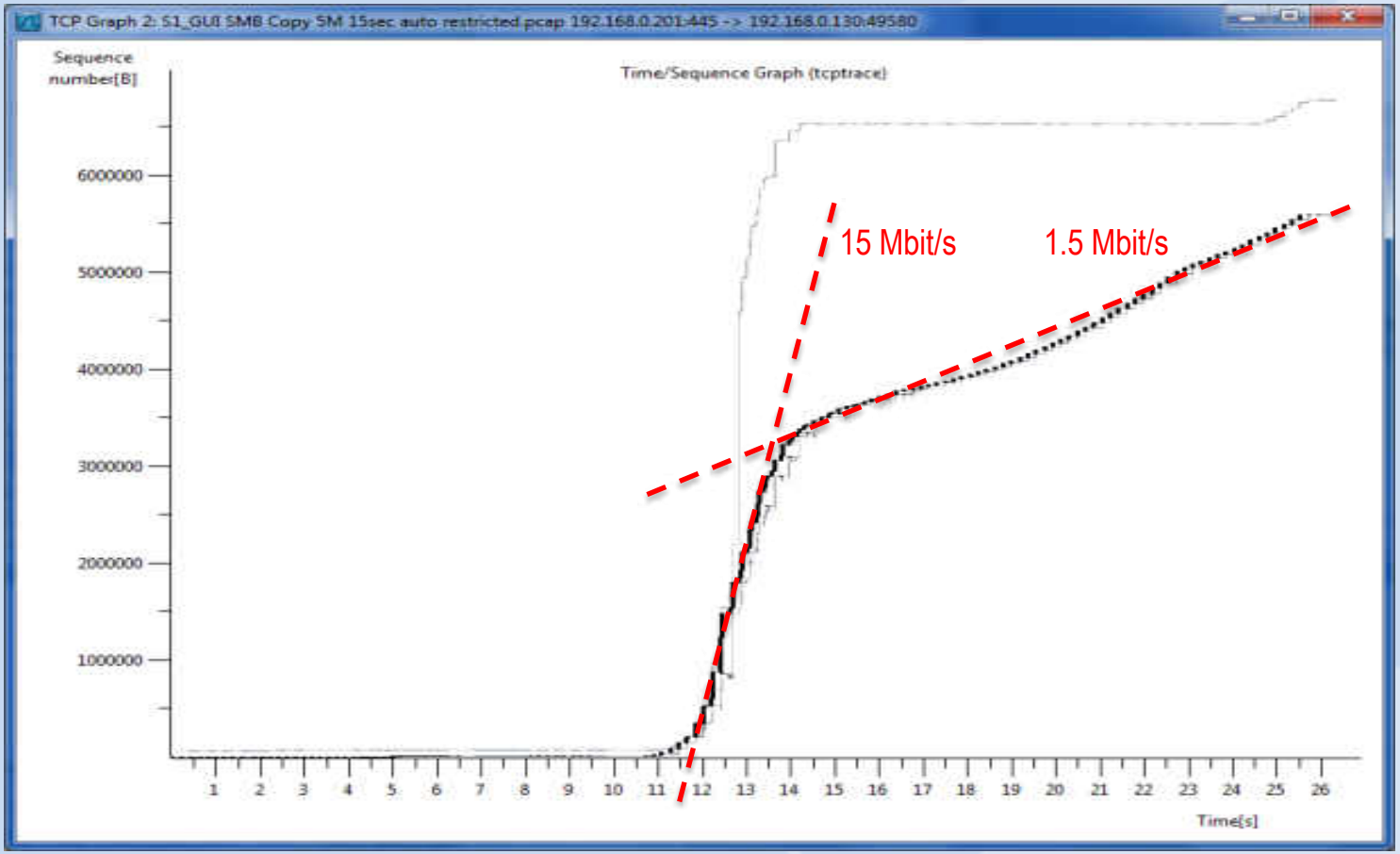


Server SYN; ACK
- Start Sequence Number
- Acknowledge Client Sequence Number
- Window Size

Options:
- Maximum Segment Size
- Window Scaling
- Selective Acknowledges
- Timestamp
- PAWS (Protection against wrapped sequence #)

TCP Analysis with TCP Stream Graph

- Let us have a closer look at the servers behavior!

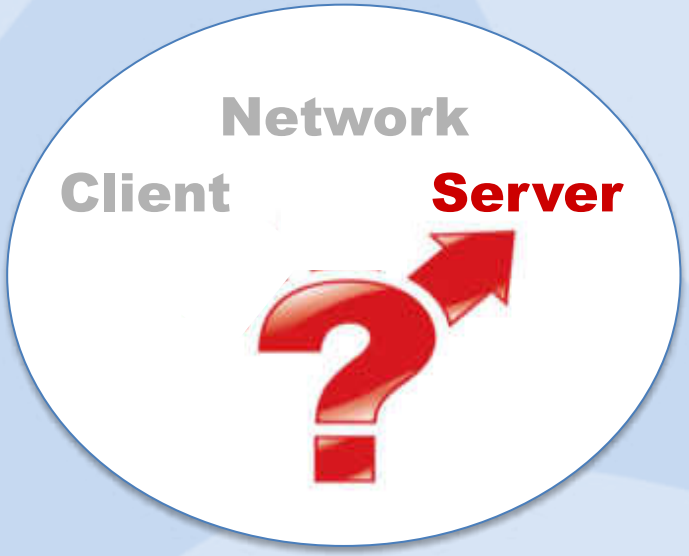


TCP Analysis with TCP Stream Graph

What can be read out of the TCP Stream graph:

- The server is starting with 15Mbit/s transmission rate
- The network is dropping some frames (pretty normal on WAN)
- Server is throttling down to 1.5 Mbit/s
- Server is not trying to speed up again
- But why?

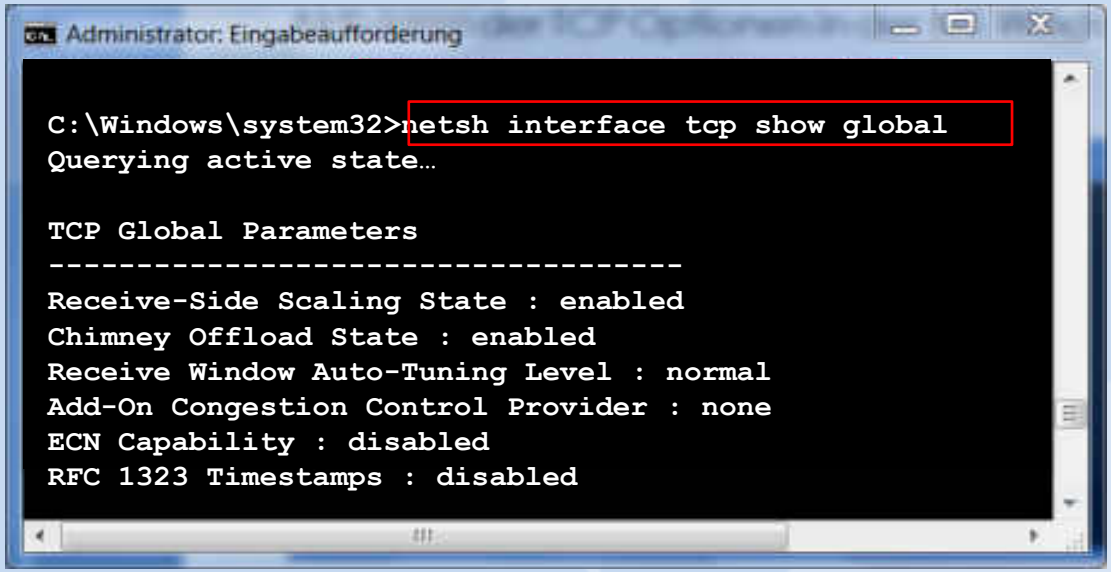
- At this stage we can exclude the network



MS Windows TCP Autotuning Features

Microsoft has implemented new autotuning in Vista, Win7, Server2008

- These features should improve TCP throughput and are ON by default
- However, this is not always the case, and may cause some Internet related issues and problems !



MS Windows TCP Autotuning Features

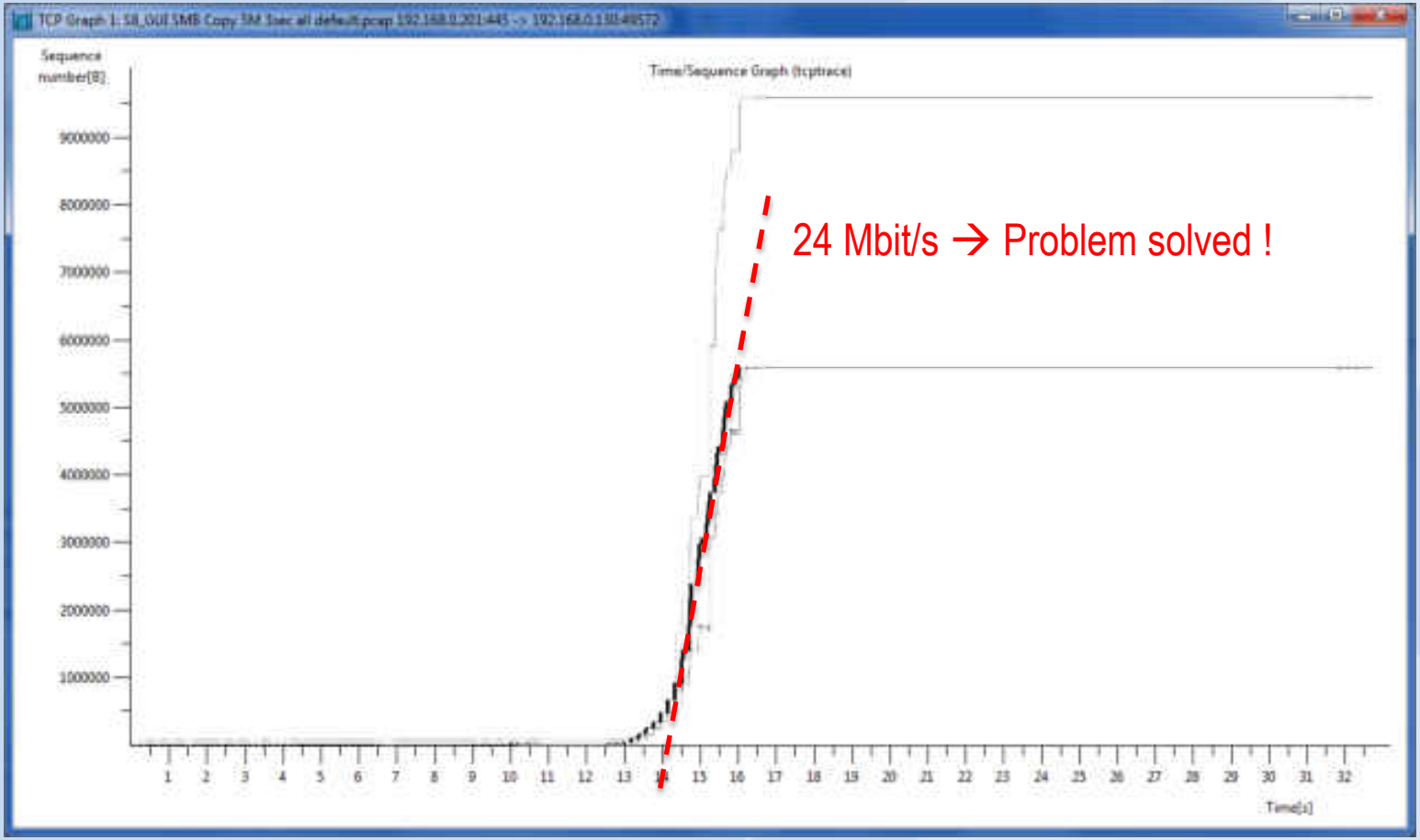
• Autotuning	→ Activate:	netsh interface tcp set global autotuning=normal
	→ Deactivate:	netsh interface tcp set global autotuning=disabled
• Compound TCP	→ Activate:	netsh interface tcp set global congestionprovider=ctcp
	→ Deactivate:	netsh interface tcp set global congestionprovider=none
• ECN Support	→ Activate:	netsh interface tcp set global ecncapability=enabled
	→ Deactivate:	netsh interface tcp set global ecncapability=disabled
• TCP Chimney offloading	→ Activate:	netsh interface tcp set global chimney=enabled
	→ Deactivate:	netsh interface tcp set global chimney=disabled
• Receive-side Scaling (RSS)	→ Activate:	netsh interface tcp set global rss=enabled
	→ Deactivate:	netsh interface tcp set global rss=disabled

This command did solve the issue in our case:

• Windows Scaling heuristics	→ Deactivate:	netsh int tcp set heuristics disabled
	→ Activate:	netsh int tcp set heuristics enabled

TCP Analysis with TCP Stream Graph

- Now let us have a closer look at the servers behavior again!



Thanks for visiting

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