



SHARKFEST '13

Wireshark Developer and User Conference

Multi-tier Trace Correlation

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CTO, Advance7



Agenda

- Context
- Process-to-process communication
- Multi-tier traffic patterns
- Your questions
- **Practical 1** – Timeframe and time accounting
- Your questions
- Correlation strategies
- Final questions
- Closing remarks

The Enemy

Recurring

It keeps happening

Gray

The causing
technology is
unknown

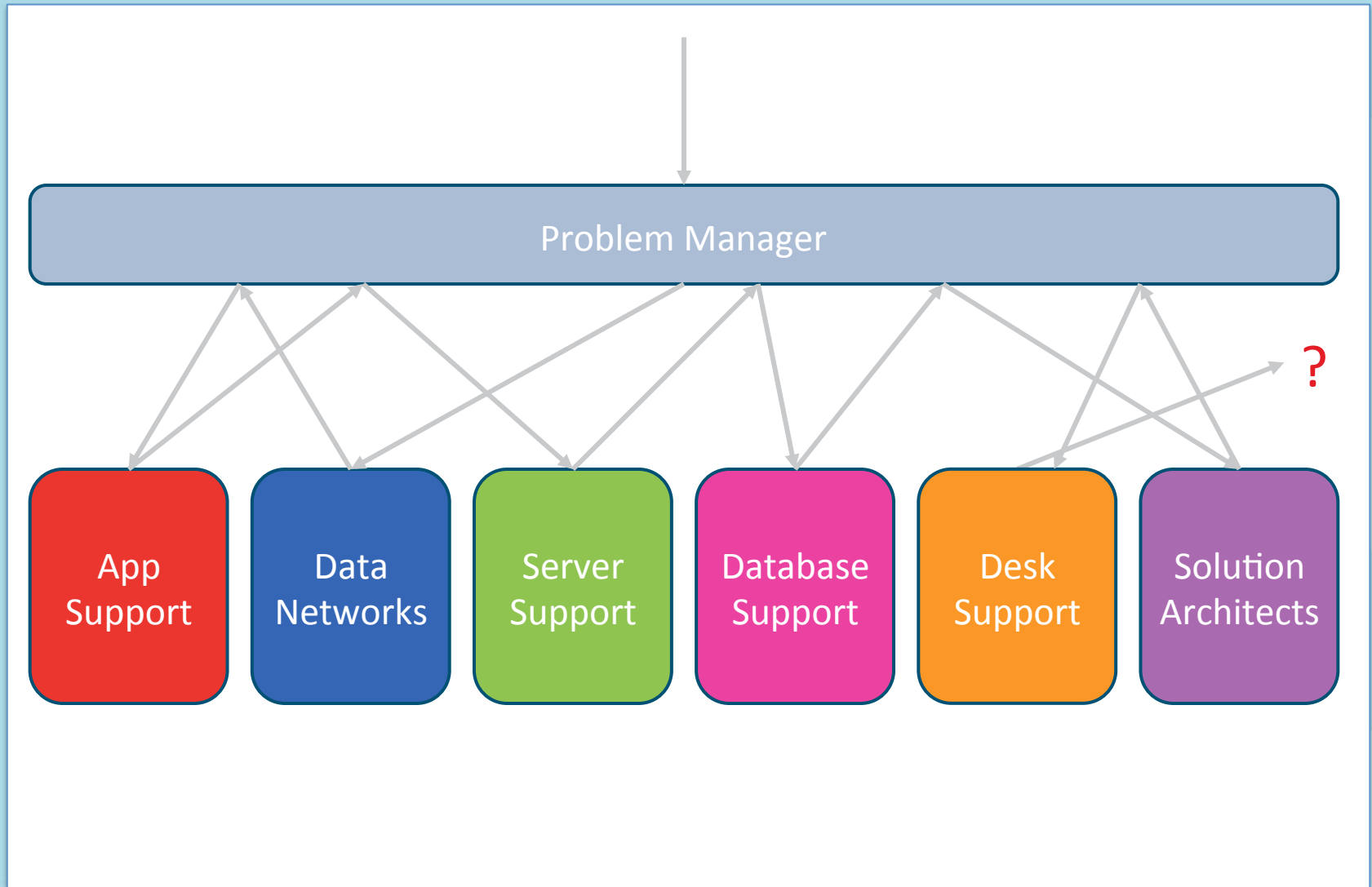
Problem

Performance
Error
Incorrect output



See Wikipedia

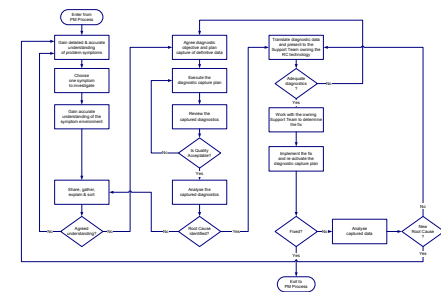
Recurring gray problems



Discovery

Software engineering principles

Standard IT diagnostic tools and techniques



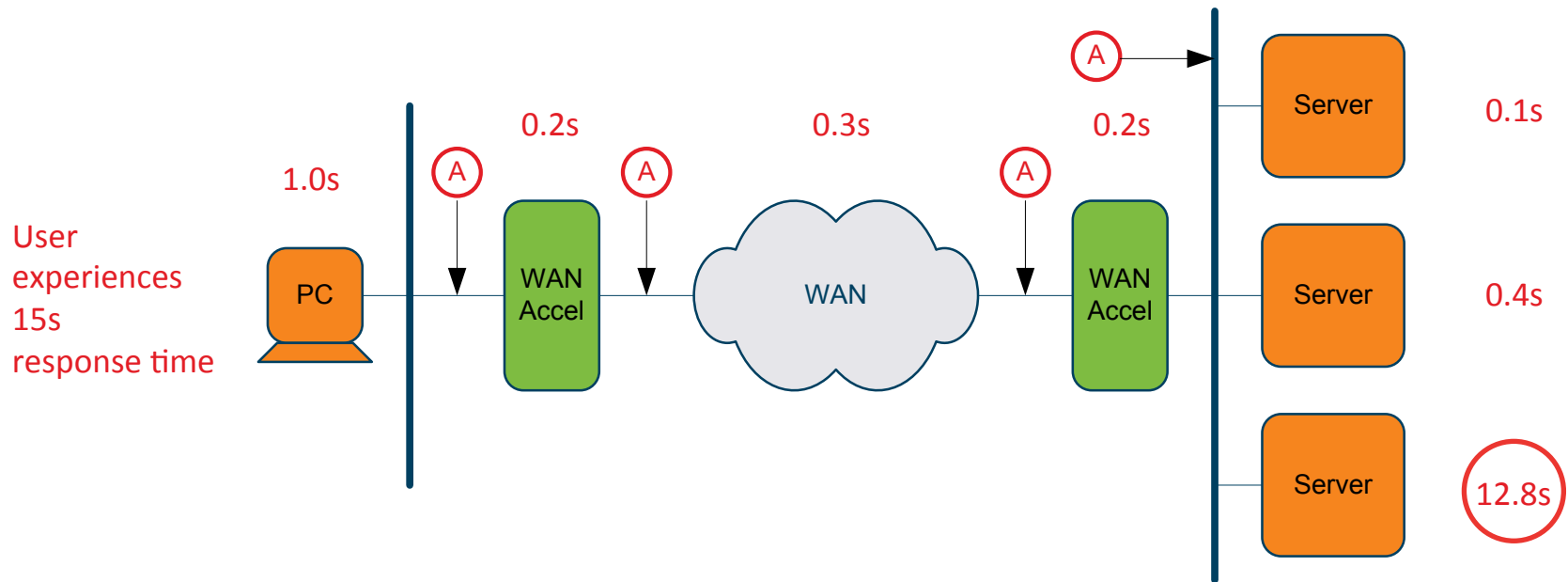
1990

RPR
method

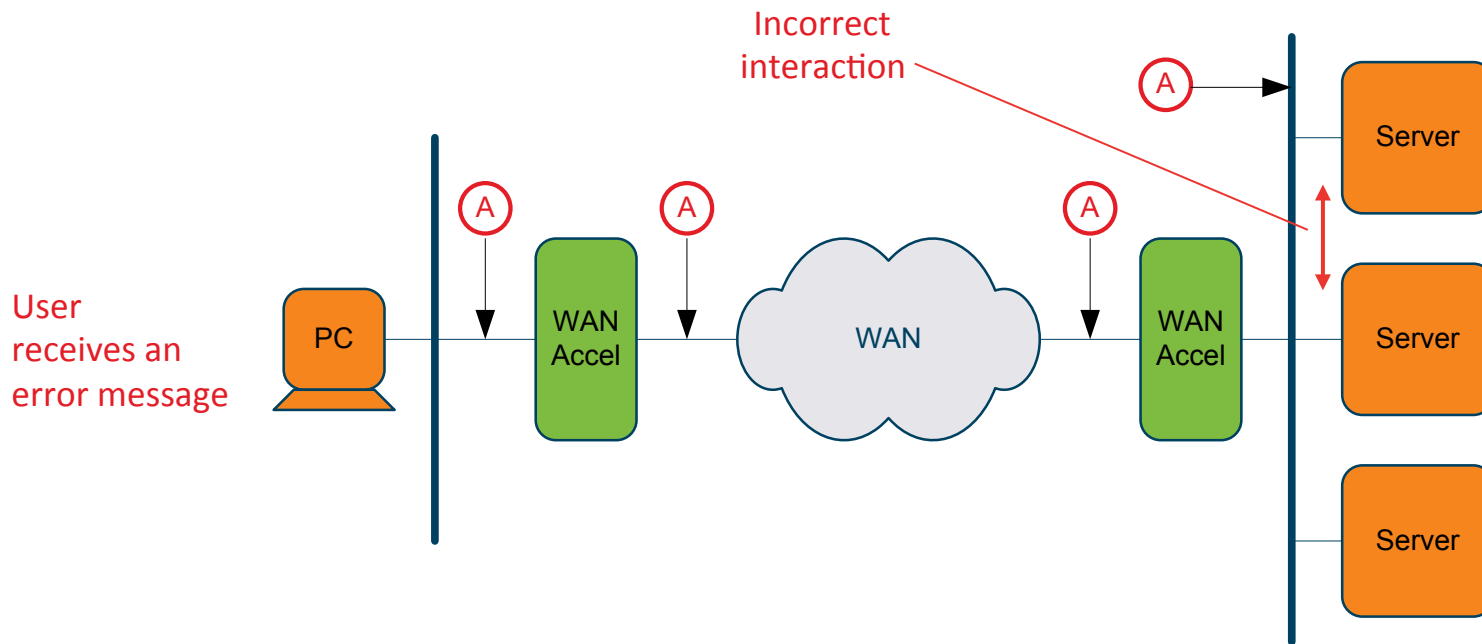
RPR Principles

- Achieve Root Cause Identification (RCI)
- Focus on a single symptom
- Capture individual instances
- Use Definitive Diagnostic Data
- Capture in production

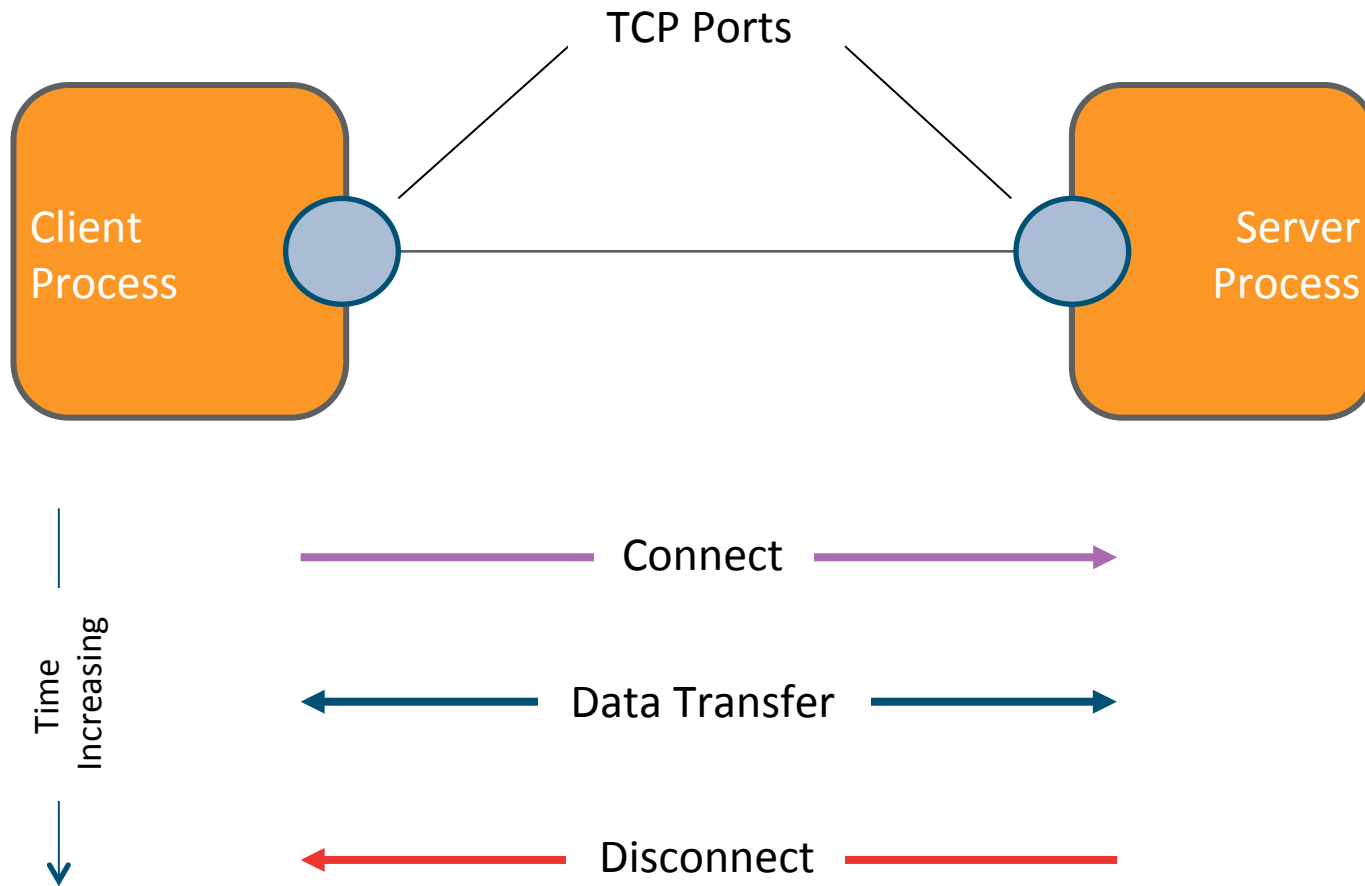
Performance – What happened?



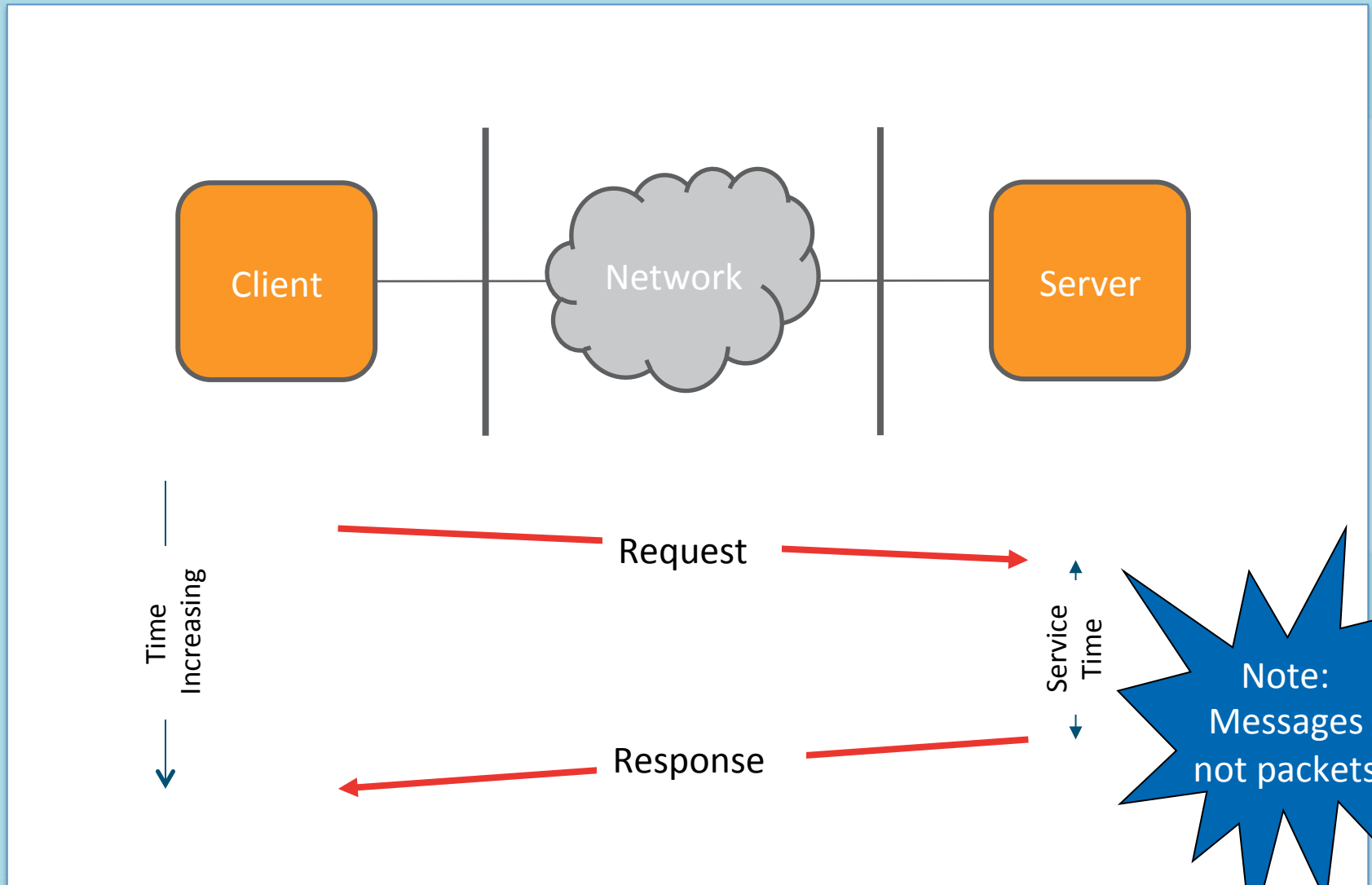
Error – What happened?



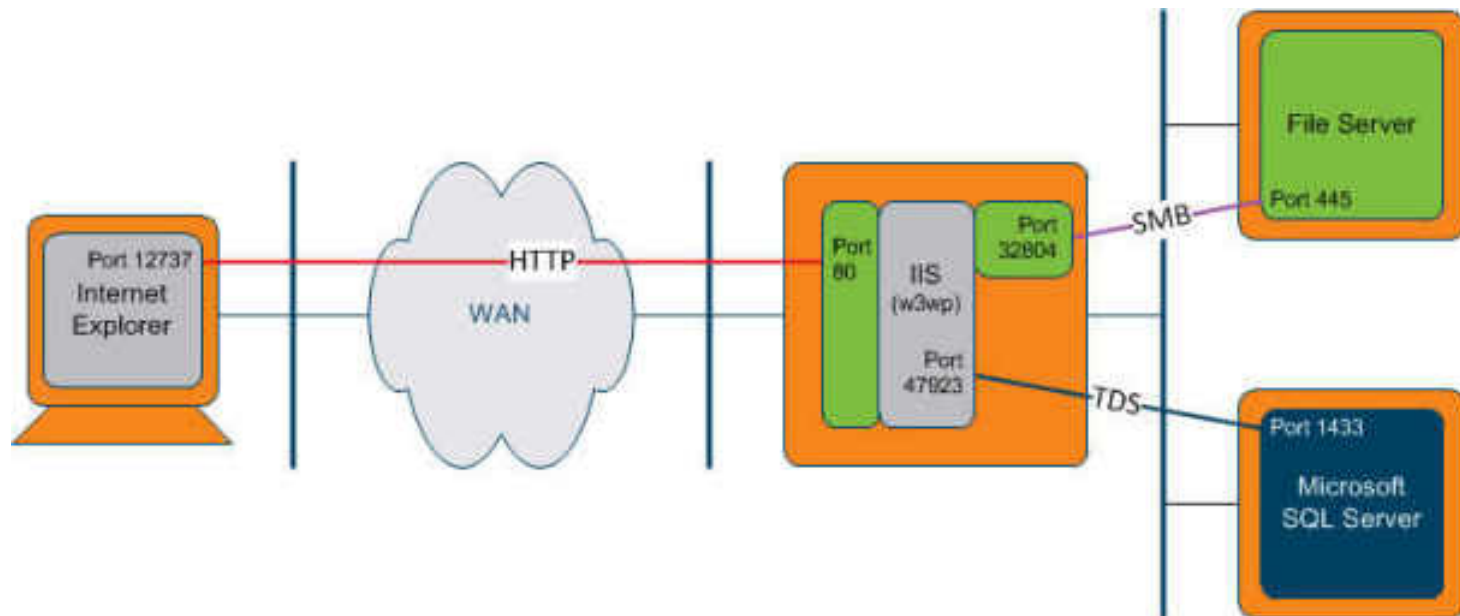
Process-to-process communication



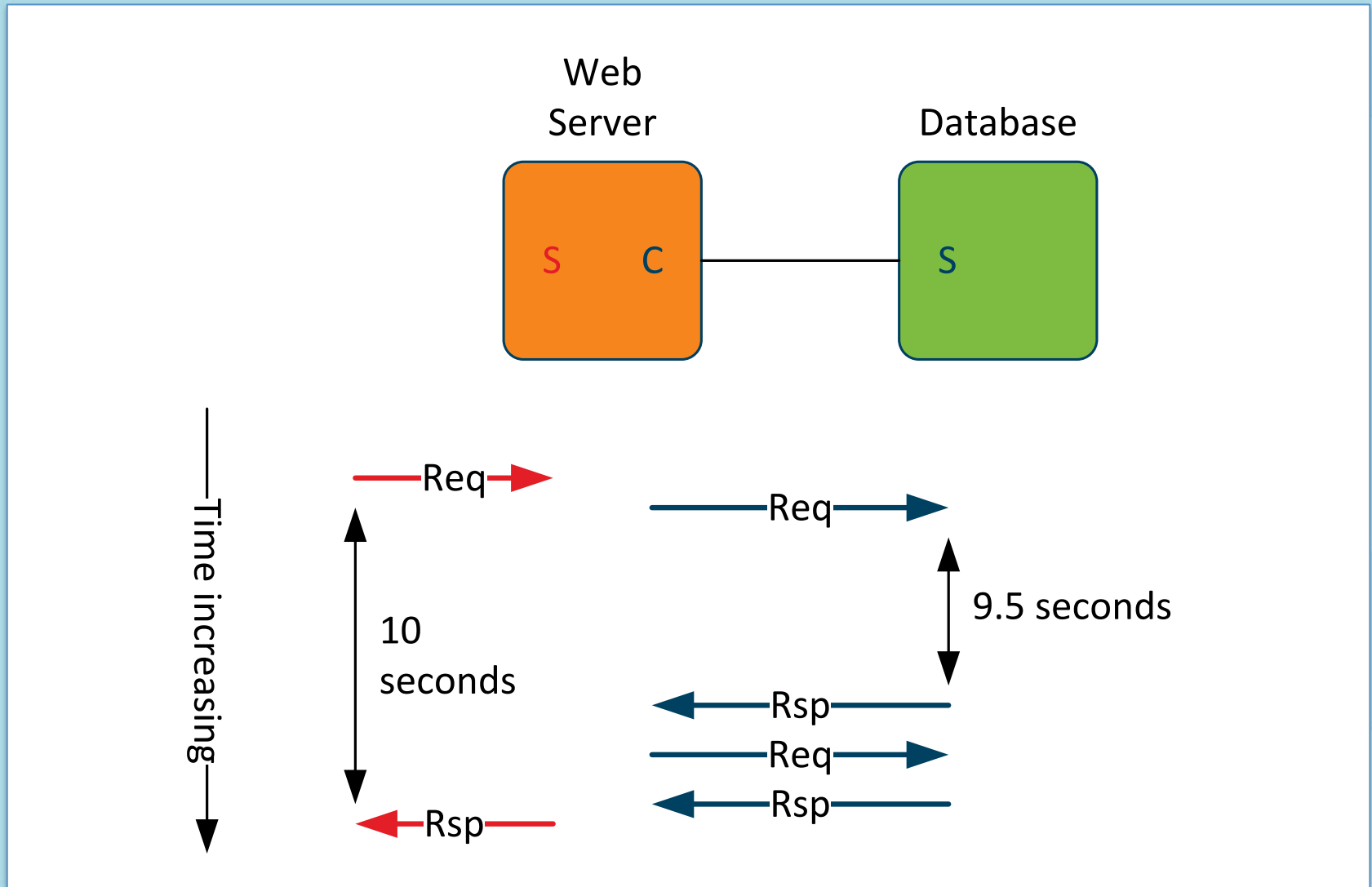
Request-response Pairs



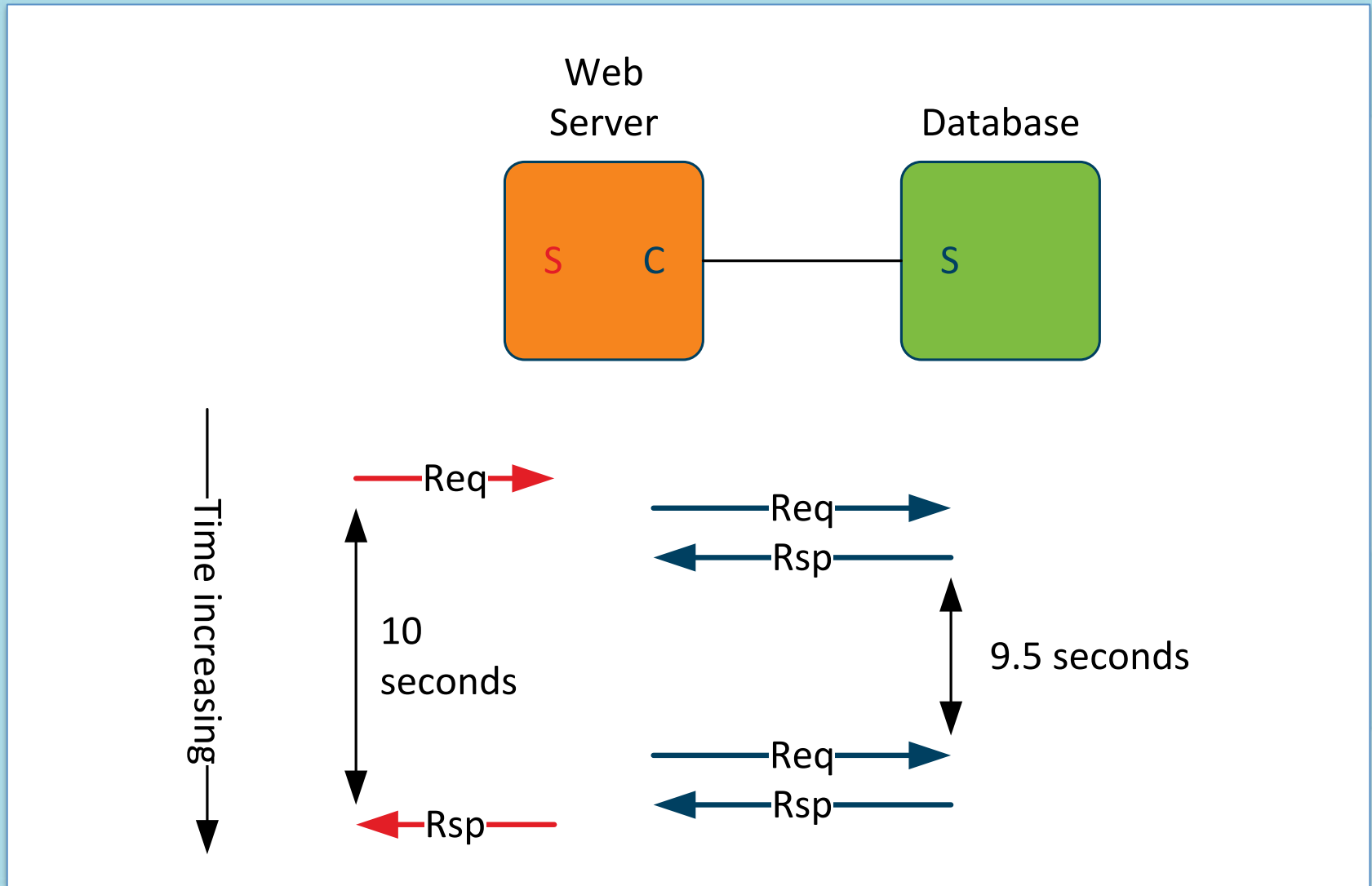
Client-Server Chains



Slow Response – Scenario 1



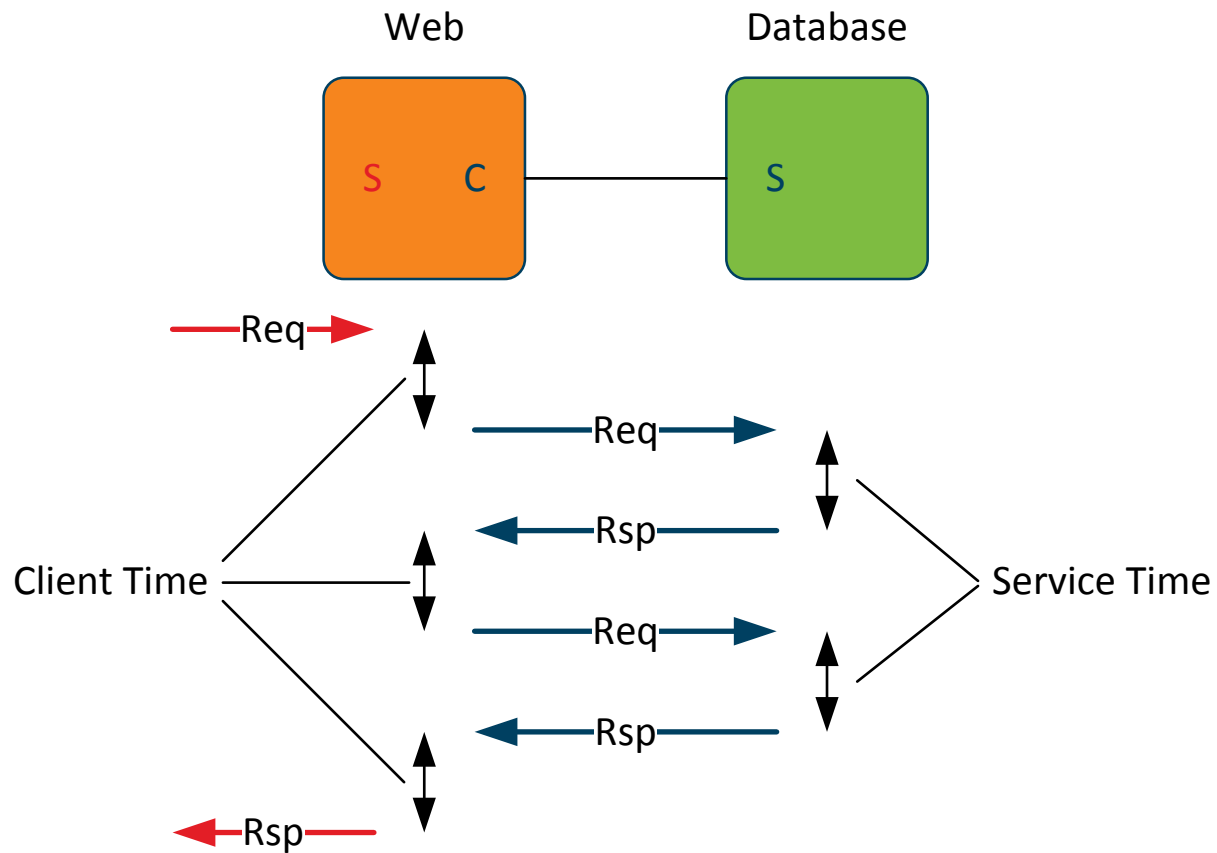
Slow Response – Scenario 2



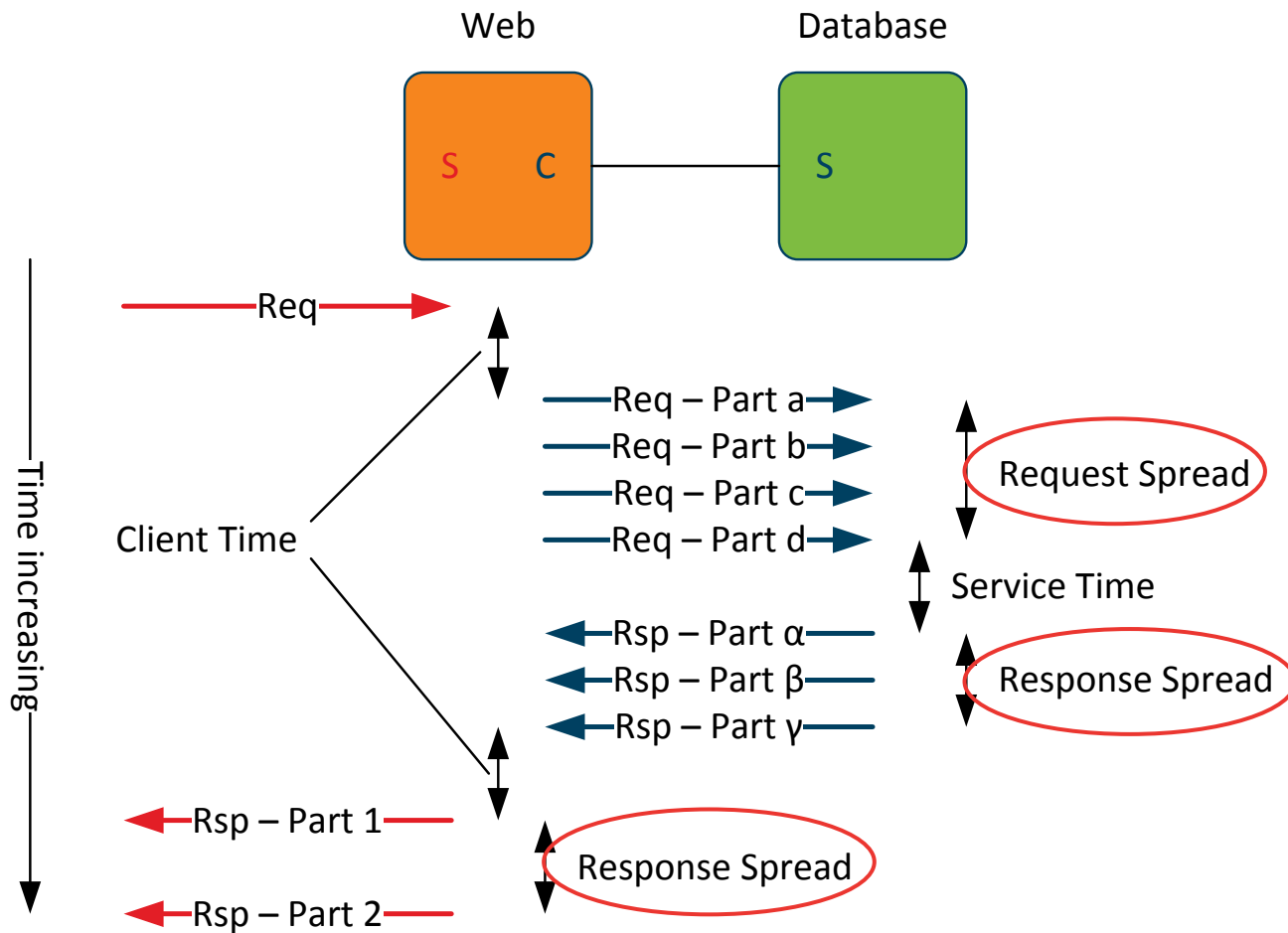
Response Time Elements

- Client time
- Service time
- Request spread
- Response spread

Client and Service Time



Spread



Break for...

Questions?

Protocol Message vs. Packets

No.	Time	Source	Destination	Src Port	Dst Port	Info
470	13:29:58.124513	192.168.1.70	192.168.1.77	64006	80	GET /TicketView.php?TicketNo=511127 HTTP/1.1
472	13:29:58.260861	192.168.1.77	192.168.1.70	80	64006	[TCP segment of a reassembled PDU]
473	13:29:58.264216	192.168.1.77	192.168.1.70	80	64006	[TCP segment of a reassembled PDU]
474	13:29:58.264883	192.168.1.77	192.168.1.70	80	64006	[TCP segment of a reassembled PDU]
475	13:29:58.265179	192.168.1.77	192.168.1.70	80	64006	HTTP/1.1 200 OK (text/html)
487	13:30:02.286050	192.168.1.70	192.168.1.77	64007	80	GET /TicketView.php?TicketNo=510760 HTTP/1.1
489	13:30:02.430607	192.168.1.77	192.168.1.70	80	64007	[TCP segment of a reassembled PDU]
490	13:30:02.430783	192.168.1.77	192.168.1.70	80	64007	[TCP segment of a reassembled PDU]
491	13:30:02.430922	192.168.1.77	192.168.1.70	80	64007	[TCP segment of a reassembled PDU]
493	13:30:02.434839	192.168.1.77	192.168.1.70	80	64007	[TCP segment of a reassembled PDU]
494	13:30:02.434950	192.168.1.77	192.168.1.70	80	64007	[TCP segment of a reassembled PDU]
495	13:30:02.435059	192.168.1.77	192.168.1.70	80	64007	HTTP/1.1 200 OK (text/html)
540	13:30:05.376517	192.168.1.70	192.168.1.77	64008	80	GET /TicketView.php?TicketNo=510005 HTTP/1.1
542	13:30:05.523119	192.168.1.77	192.168.1.70	80	64008	[TCP segment of a reassembled PDU]

Better filter expression

Messages
to service

Remove
ACKs

Detect
connect delays

Ignore retransmissions

`tcp.port==80 && (tcp.len>0 || tcp.flags.syn==1) && !tcp.analysis.retransmission`

Or

Eliminates TCP Keep-alive packets

`tcp.port==80 && (tcp.len>1 || tcp.flags.syn==1) && !tcp.analysis.retransmission`

What about interleaved streams?

No.	Time	Source	Destination	Src Port	Dst Port	Info
268	15:28:02.440482	192.168.1.87	217.41.223.48	62072	80	GET /programmeimages/episode/b01sksvk_86_48.jpg HTTP/1.1
269	15:28:02.440557	192.168.1.87	217.41.223.48	62071	80	GET /programmeimages/episode/b021sj82_86_48.jpg HTTP/1.1
270	15:28:02.440647	217.41.223.48	192.168.1.87	80	62074	HTTP/1.1 304 Not Modified
271	15:28:02.440887	192.168.1.87	217.41.223.48	62073	80	GET /programmeimages/episode/b020vjyy_86_48.jpg HTTP/1.1
272	15:28:02.441086	192.168.1.87	217.41.223.48	62074	80	GET /programmeimages/episode/b0211g4r_86_48.jpg HTTP/1.1
273	15:28:02.443883	217.41.223.48	192.168.1.87	80	62069	HTTP/1.1 200 OK (JPEG JFIF image)
274	15:28:02.444233	192.168.1.87	217.41.223.48	62069	80	GET /programmeimages/episode/b020z0d9_86_48.jpg HTTP/1.1
275	15:28:02.460247	217.41.223.48	192.168.1.87	80	62070	HTTP/1.1 304 Not Modified
276	15:28:02.460584	192.168.1.87	217.41.223.48	62070	80	GET /programmeimages/episode/b021v4cg_86_48.jpg HTTP/1.1
277	15:28:02.470889	217.41.223.48	192.168.1.87	80	62072	HTTP/1.1 304 Not Modified
278	15:28:02.471218	192.168.1.87	217.41.223.48	62072	80	GET /programmeimages/episode/b0078vmr_86_48.jpg HTTP/1.1
279	15:28:02.474968	217.41.223.48	192.168.1.87	80	62071	HTTP/1.1 304 Not Modified
280	15:28:02.475256	192.168.1.87	217.41.223.48	62071	80	GET /programmeimages/episode/b020vg5z_86_48.jpg HTTP/1.1
281	15:28:02.479060	217.41.223.48	192.168.1.87	80	62073	HTTP/1.1 304 Not Modified
282	15:28:02.479343	192.168.1.87	217.41.223.48	62073	80	GET /programmeimages/episode/b020yqsf_172_96.jpg HTTP/1.1
283	15:28:02.488320	217.41.223.48	192.168.1.87	80	62074	[TCP segment of a reassembled PDU]
284	15:28:02.491145	217.41.223.48	192.168.1.87	80	62074	[TCP segment of a reassembled PDU]
286	15:28:02.492307	192.168.1.87	217.41.223.48	62074	80	HTTP/1.1 200 OK (JPEG JFIF image)
287	15:28:02.492307	217.41.223.48	192.168.1.87	62069	80	HTTP/1.1 304 Not Modified

We'll deal with this later

TMS Problem

- Simple workflow system
- Web browser, web server and database
- List of work items called tickets
- Click on ticket to display detail
 - Response time < 1 second
- Intermittent response time of 5+ seconds



TMS Slow Response Time

Firefox

TMS - A7GPJO Queue Summary

192.168.1.77/QueueSummary.php?Qid=A7GPJO

Home Orgs Schemes Drawdowns Users Qs Monitors Autos My Q GreenBook Summary Reports Time Forecast Hols Equip

A7GPJO Queue Summary

Date/Time Q'd	Ticket#	Customer	Description	Pri	Status	Sel
2012-10-16 10:17	511161	INVSTMGT	PSG Create - Discovery	2	Alarm	<input type="radio"/>
2008-12-03 18:27	510005	A7	RPR Project Management	3	Alarm	<input type="radio"/>
2011-08-17 14:52	510760	A7	Development of REACT Operations Manual	3	Alarm	<input type="radio"/>
2012-08-03 07:38	511127	LOCALGOV	PSG Create - Planning	3	Alarm	<input type="radio"/>
2012-08-03 07:39	511128	LOCALGOV	PSG Create - Preparation	3	Alarm	<input type="radio"/>
2012-08-03 07:40	511129	LOCALGOV	PSG Create - Communications	3	Alarm	<input type="radio"/>
2012-08-03 07:40	511130	LOCALGOV	PSG Create - Mentoring	3	Alarm	<input type="radio"/>
2012-09-24 09:14	511152	A7	Network Trace Analysis Guide	3	Alarm	<input type="radio"/>
2013-01-10 10:06	511188	INVSTMGT	RMS Baseline Study	3	Alarm	<input type="radio"/>

Command:

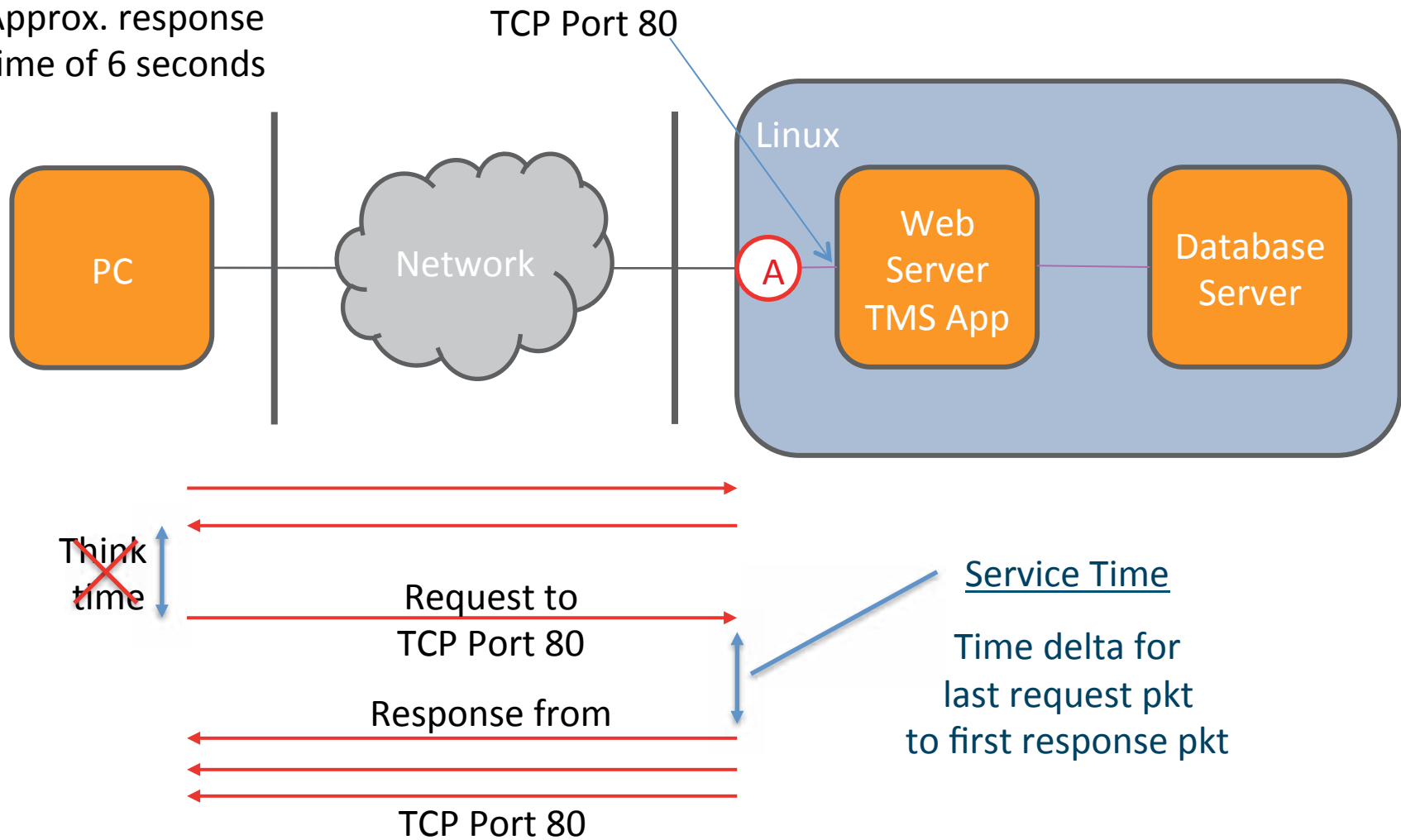
Reset Cancel OK

Selected queue: A7GPJO

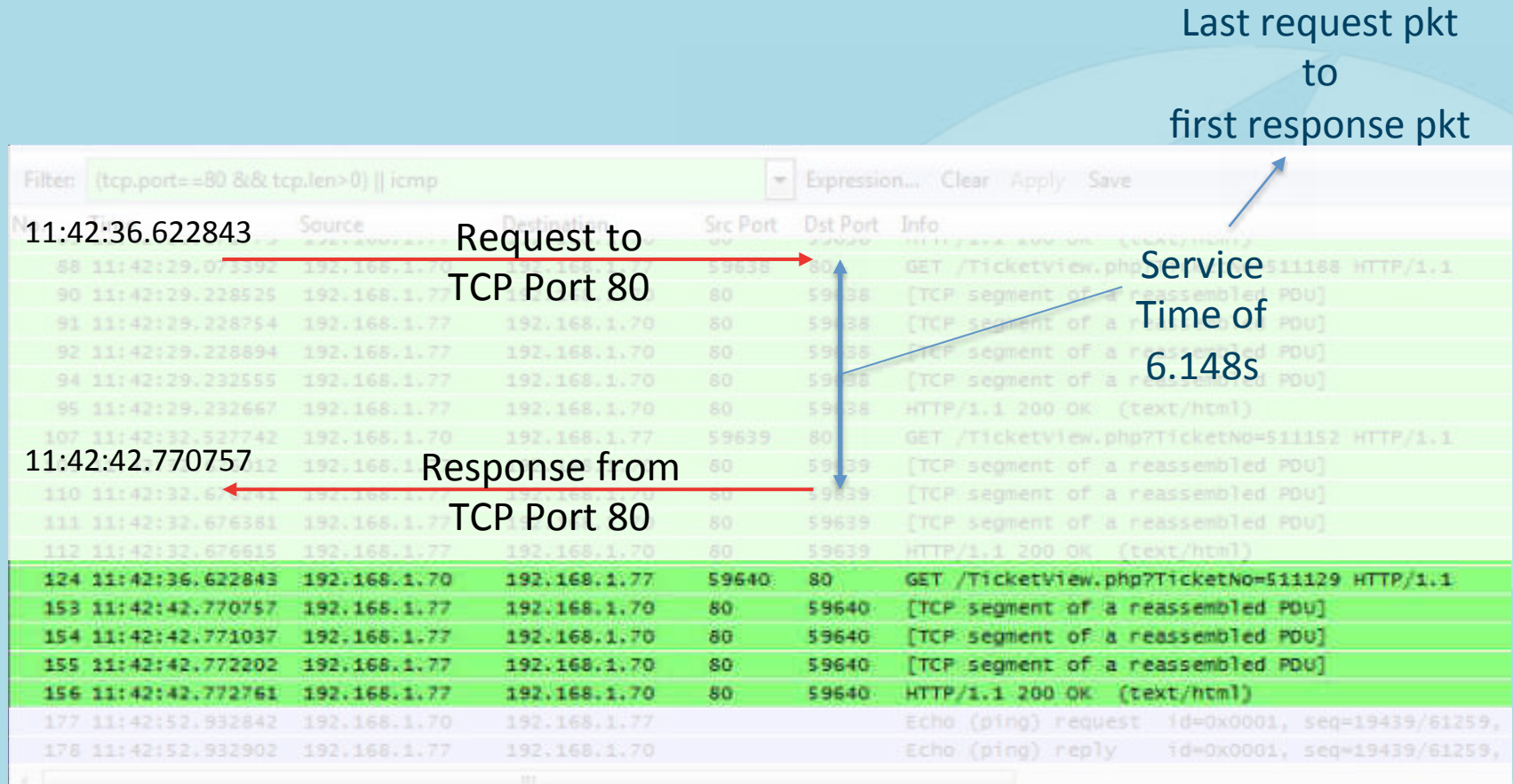
TMS v2.01 r77

TMS HTTP Trace

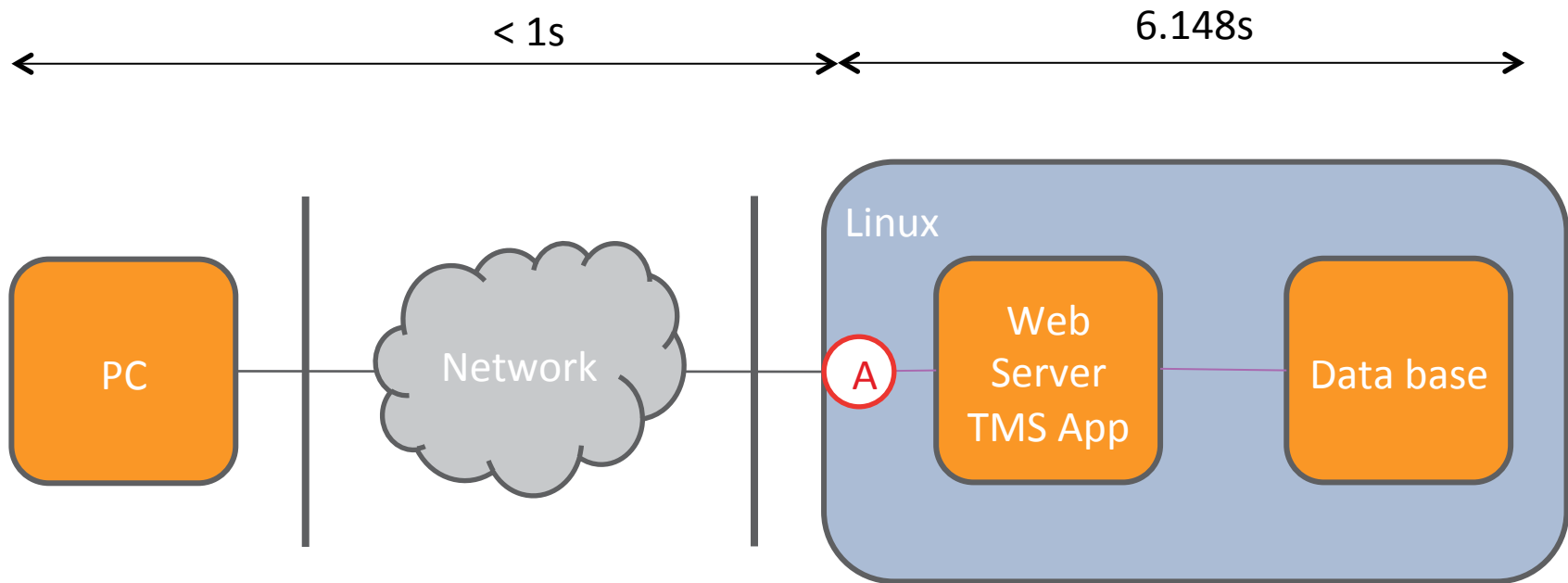
Approx. response time of 6 seconds



HTTP Response Time



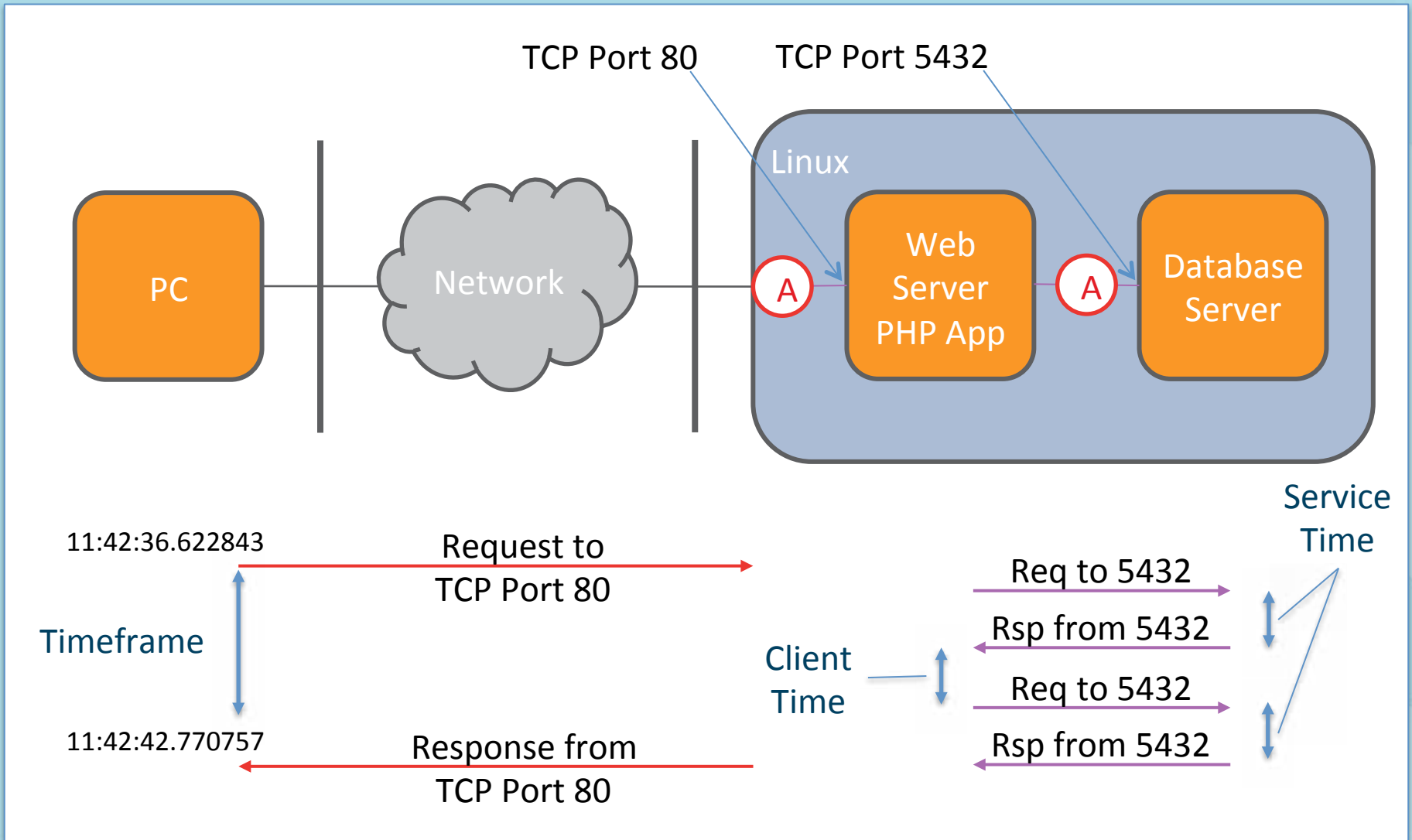
Time Accounting



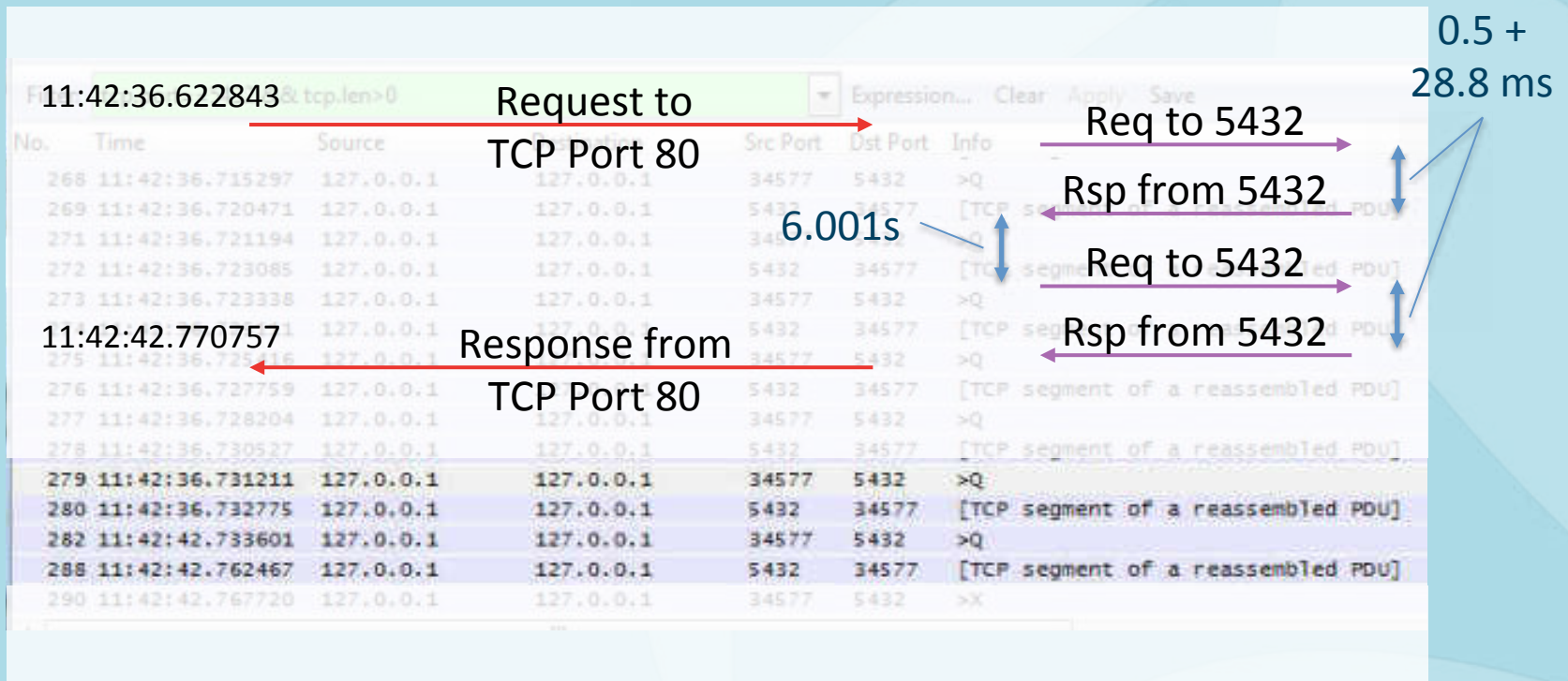
Break for...

Questions?

TMS Database Trace – Scenario 1



Database Response Time



Break for...

Questions?

Sort by TCP Connection

Use the quadruplet:

ClientIP:ClientPort:ServiceIP:ServicePort

Determining the Client Port

J8 =IF(L8=5432,K8,L8)

	A	B	C	D	E	F	G	H	I	J	K	L	M
1	No.	Time	Client Time (ms)	Req Spread (ms)	Rsp Spread (ms)	Service Time (ms)	Source	Destination	Client IP	Client Port	Src Port	Dst Port	Info
8	248	11:42:36.634	0				127.0.0.1	127.0.0.1	127.0.0.1	34576	34576	5432	>X
9	259	11:42:36.644					127.0.0.1	127.0.0.1	127.0.0.1	34577	34577	5432	>
10	261	11:42:36.644				0	127.0.0.1	127.0.0.1	127.0.0.1	34577	5432	34577	[TCP segment of a reassembled PDU]
11	263	11:42:36.644	0				127.0.0.1	127.0.0.1	127.0.0.1	34577	34577	5432	>
12	266	11:42:36.648				4	127.0.0.1	127.0.0.1	127.0.0.1	34577	5432	34577	[TCP segment of a reassembled PDU]
13	268	11:42:36.715	67				127.0.0.1	127.0.0.1	127.0.0.1	34577	34577	5432	>Q
14	269	11:42:36.720				5	127.0.0.1	127.0.0.1	127.0.0.1	34577	5432	34577	[TCP segment of a reassembled PDU]
15	271	11:42:36.721	1				127.0.0.1	127.0.0.1	127.0.0.1	34577	34577	5432	>Q
16	272	11:42:36.723				2	127.0.0.1	127.0.0.1	127.0.0.1	34577	5432	34577	[TCP segment of a reassembled PDU]
17	273	11:42:36.723	0				127.0.0.1	127.0.0.1	127.0.0.1	34577	34577	5432	>Q
18	274	11:42:36.725				2	127.0.0.1	127.0.0.1	127.0.0.1	34577	5432	34577	[TCP segment of a reassembled PDU]
19	275	11:42:36.725	0				127.0.0.1	127.0.0.1	127.0.0.1	34577	34577	5432	>Q
20	276	11:42:36.728				3	127.0.0.1	127.0.0.1	127.0.0.1	34577	5432	34577	[TCP segment of a reassembled PDU]
21	277	11:42:36.728	0				127.0.0.1	127.0.0.1	127.0.0.1	34577	34577	5432	>Q
22	278	11:42:36.731				3	127.0.0.1	127.0.0.1	127.0.0.1	34577	5432	34577	[TCP segment of a reassembled PDU]
23	279	11:42:36.731	0				127.0.0.1	127.0.0.1	127.0.0.1	34577	34577	5432	>Q
24	280	11:42:36.733				2	127.0.0.1	127.0.0.1	127.0.0.1	34577	5432	34577	[TCP segment of a reassembled PDU]
25	282	11:42:42.734	6,001				127.0.0.1	127.0.0.1	127.0.0.1	34577	34577	5432	>Q
26	288	11:42:42.762				28	127.0.0.1	127.0.0.1	127.0.0.1	34577	5432	34577	[TCP segment of a reassembled PDU]
27	290	11:42:42.768	6				127.0.0.1	127.0.0.1	127.0.0.1	34577	34577	5432	>X
28													
29			6,075	0	0	59							

Calculating Service Time

F12 =IF(AND(L11=5432,K12=5432,J12=J11),(B12-B11)/SNS1,"")

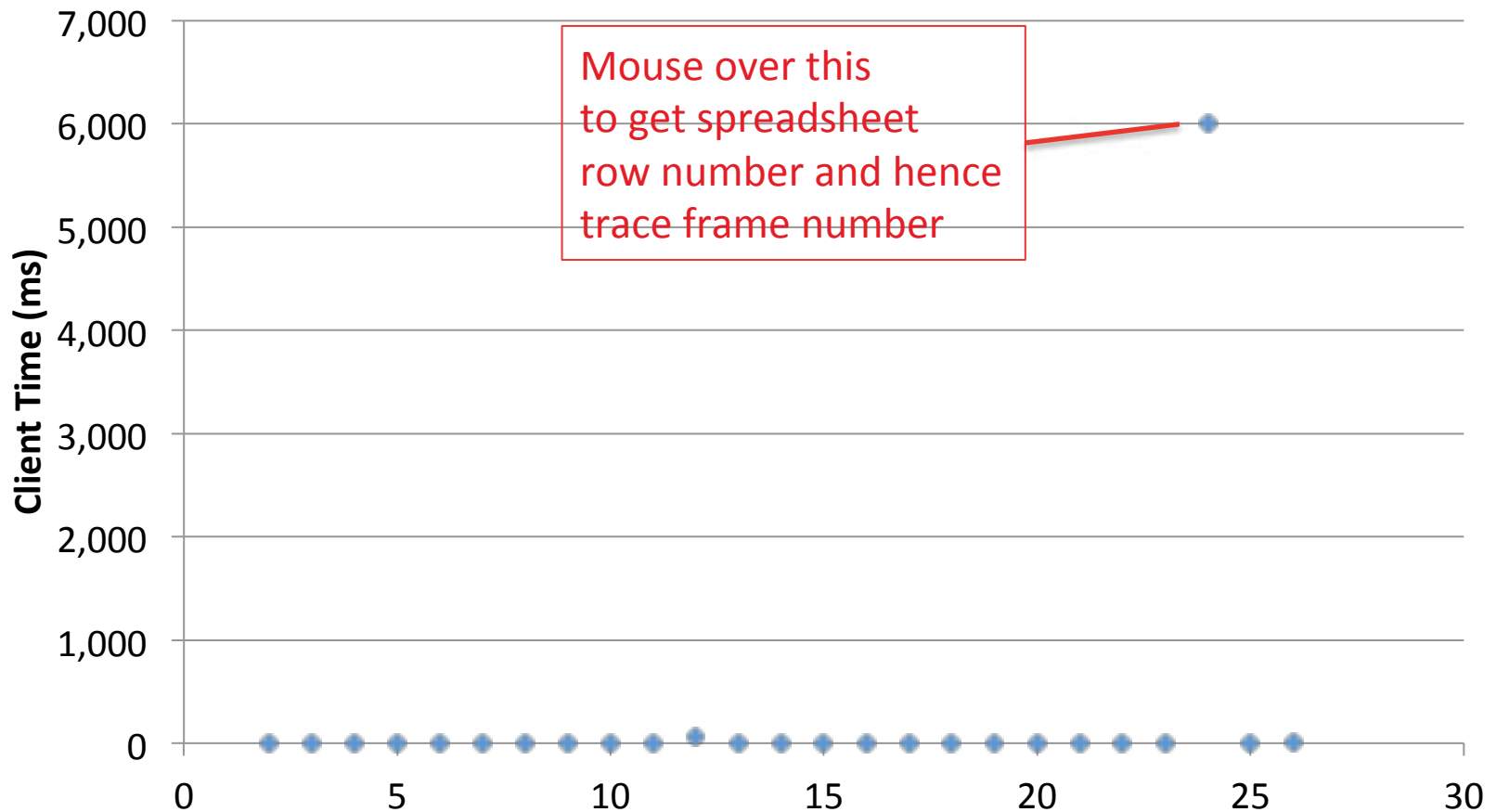
	A	B	C	D	E	F	I	J	K	L	M	N
			Client Time (ms)	Req Spread (ms)	Rsp Spread (ms)	Service Time (ms)	Client IP	Client Port	Src Port	Dst Port	Info	
1	No.	Time										00:00:00.001
8	248	11:42:36.634	0				127.0.0.1	34576	34576	5432	>X	
9	259	11:42:36.644					127.0.0.1	34577	34577	5432	>	
10	261	11:42:36.644				0	127.0.0.1	34577	5432	34577	[TCP segment of a reassembled PDU]	
11	263	11:42:36.644	0				127.0.0.1	34577	34577	5432	>	
12	266	11:42:36.648				4	127.0.0.1	34577	5432	34577	[TCP segment of a reassembled PDU]	
13	268	11:42:36.715	67				127.0.0.1	34577	34577	5432	>Q	
14	269	11:42:36.720				5	127.0.0.1	34577	5432	34577	[TCP segment of a reassembled PDU]	
15	271	11:42:36.721	1				127.0.0.1	34577	34577	5432	>Q	
16	272	11:42:36.723				2	127.0.0.1	34577	5432	34577	[TCP segment of a reassembled PDU]	
17	273	11:42:36.723	0				127.0.0.1	34577	34577	5432	>Q	
18	274	11:42:36.725				2	127.0.0.1	34577	5432	34577	[TCP segment of a reassembled PDU]	
19	275	11:42:36.725	0				127.0.0.1	34577	34577	5432	>Q	
20	276	11:42:36.728				3	127.0.0.1	34577	5432	34577	[TCP segment of a reassembled PDU]	
21	277	11:42:36.728	0				127.0.0.1	34577	34577	5432	>Q	
22	278	11:42:36.731				3	127.0.0.1	34577	5432	34577	[TCP segment of a reassembled PDU]	
23	279	11:42:36.731	0				127.0.0.1	34577	34577	5432	>Q	
24	280	11:42:36.733				2	127.0.0.1	34577	5432	34577	[TCP segment of a reassembled PDU]	
25	282	11:42:42.734	6,001				127.0.0.1	34577	34577	5432	>Q	
26	288	11:42:42.762				28	127.0.0.1	34577	5432	34577	[TCP segment of a reassembled PDU]	
27	290	11:42:42.768	6				127.0.0.1	34577	34577	5432	>X	
28												
29			6,075	0	0	59						

Calculating Client Time

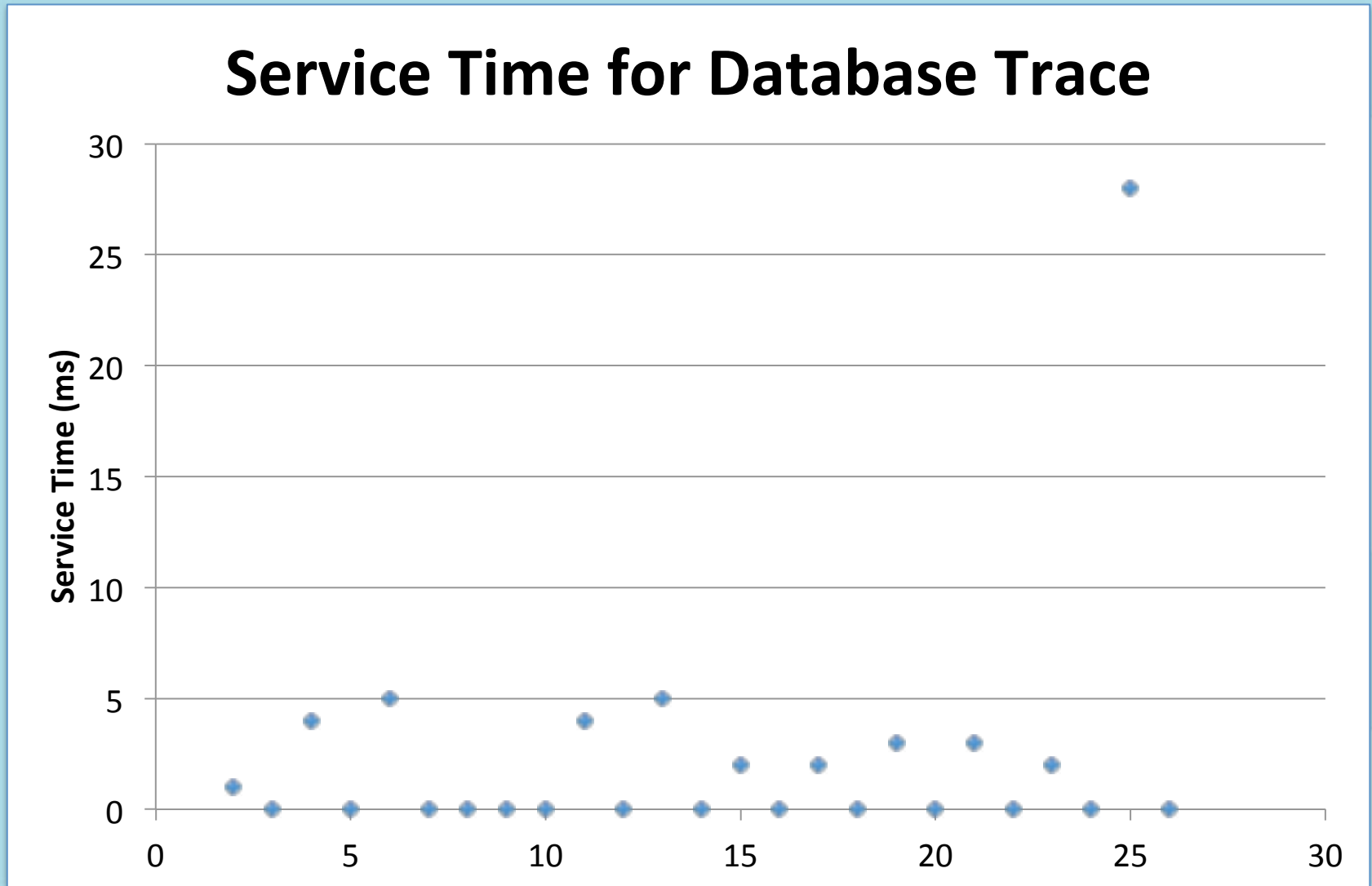
		=IF(AND(K12=5432,L13=5432,J13=J12),(B13-B12)/\$N\$1,"")												
	A	B	C	D	E	F	I	J	K	L	M	N		
	No.	Time	Client Time (ms)	Req Spread (ms)	Rsp Spread (ms)	Service Time (ms)	Client IP	Client Port	Src Port	Dst Port	Info			
8	248	11:42:36.634	0				127.0.0.1	34576	34576	5432	>X			
9	259	11:42:36.644					127.0.0.1	34577	34577	5432	>			
10	261	11:42:36.644				0	127.0.0.1	34577	5432	34577	[TCP segment of a reassembled PDU]			
11	263	11:42:36.644	0				127.0.0.1	34577	34577	5432	>			
12	266	11:42:36.648				4	127.0.0.1	34577	5432	34577	[TCP segment of a reassembled PDU]			
13	268	11:42:36.715	67				127.0.0.1	34577	34577	5432	>Q			
14	269	11:42:36.720				5	127.0.0.1	34577	5432	34577	[TCP segment of a reassembled PDU]			
15	271	11:42:36.721	1				127.0.0.1	34577	34577	5432	>Q			
16	272	11:42:36.723				2	127.0.0.1	34577	5432	34577	[TCP segment of a reassembled PDU]			
17	273	11:42:36.723	0				127.0.0.1	34577	34577	5432	>Q			
18	274	11:42:36.725				2	127.0.0.1	34577	5432	34577	[TCP segment of a reassembled PDU]			
19	275	11:42:36.725	0				127.0.0.1	34577	34577	5432	>Q			
20	276	11:42:36.728				3	127.0.0.1	34577	5432	34577	[TCP segment of a reassembled PDU]			
21	277	11:42:36.728	0				127.0.0.1	34577	34577	5432	>Q			
22	278	11:42:36.731				3	127.0.0.1	34577	5432	34577	[TCP segment of a reassembled PDU]			
23	279	11:42:36.731	0				127.0.0.1	34577	34577	5432	>Q			
24	280	11:42:36.733				2	127.0.0.1	34577	5432	34577	[TCP segment of a reassembled PDU]			
25	282	11:42:42.734	6,001				127.0.0.1	34577	34577	5432	>Q			
26	288	11:42:42.762				28	127.0.0.1	34577	5432	34577	[TCP segment of a reassembled PDU]			
27	290	11:42:42.768	6				127.0.0.1	34577	34577	5432	>X			
28														
29			6,075	0	0	59								

Client Time Scatter Plot

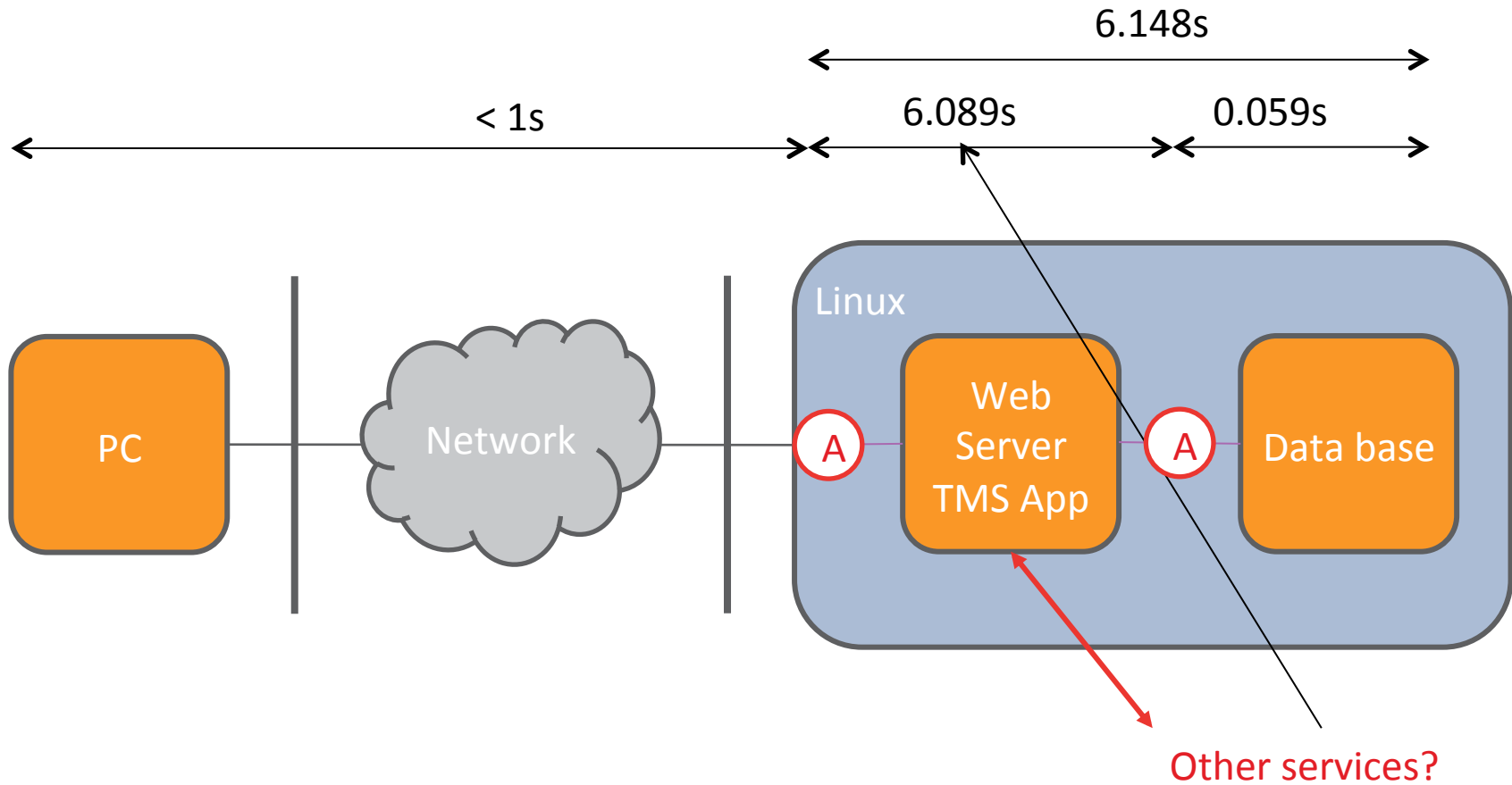
Client Time for Database Trace



Server Time Scatter Plot



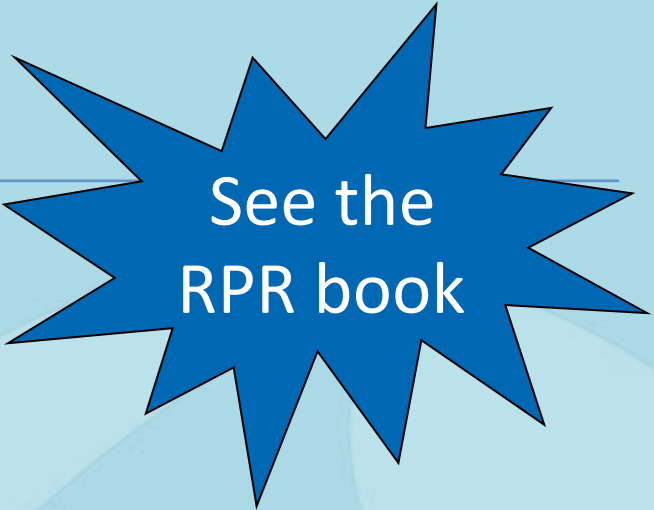
Updated Time Account



Most work but some don't

Protocol	Flip-Flop
Web (HTTP and HTTPS)	Yes
Web Services (e.g. .NET Remoting, WCF)	Yes
Other RPC (e.g. Java RMI, MSRPC)	Yes
Database (e.g. Microsoft ¹ , Sybase, Oracle)	Yes
File Server (SMB ² , SMB2 ³ , NFS)	Yes
Many proprietary protocols	Yes
Citrix ICA	No
Windows Terminal Server RDP	No

1. MARS may have to be considered
2. Further sort criteria need to be considered
3. Further sort criteria need to be considered



See the
RPR book

What about
clock sync?

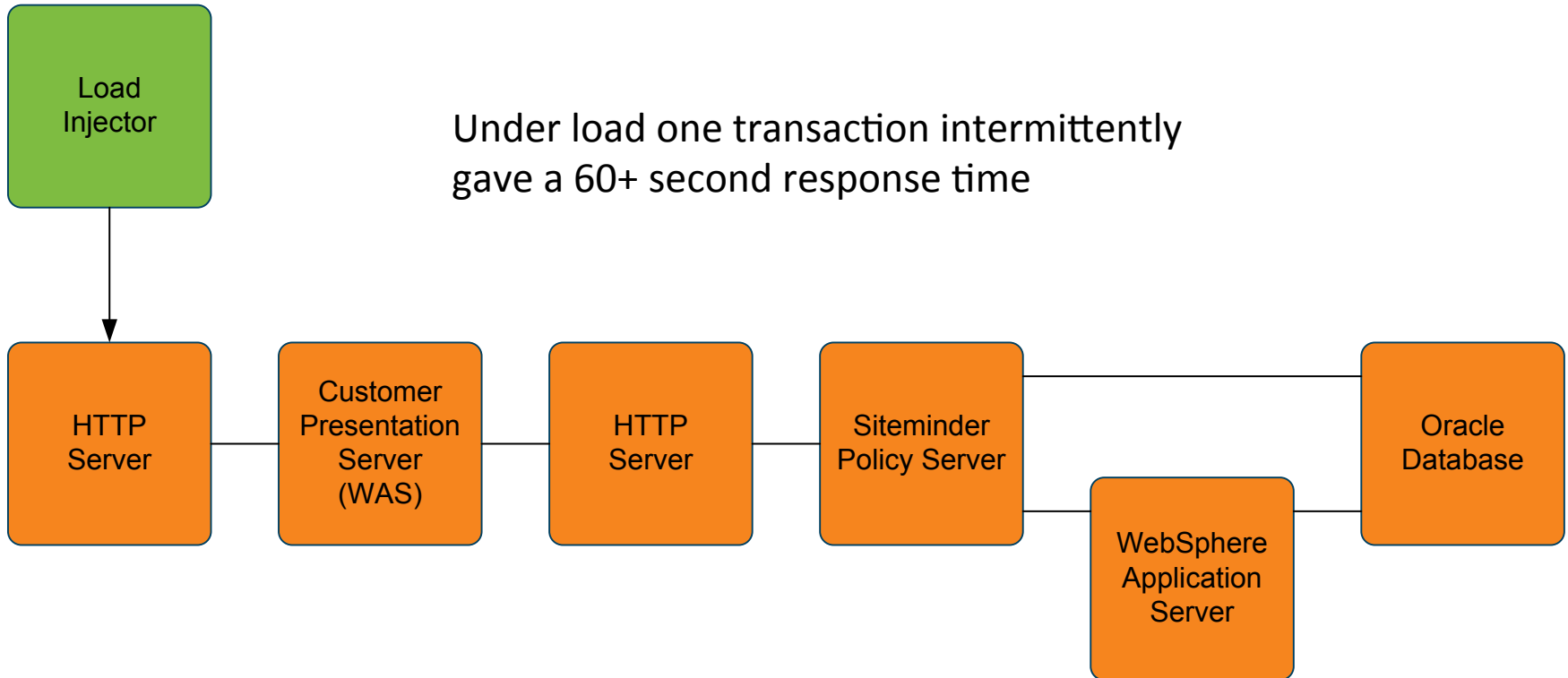
Break for...

Questions?

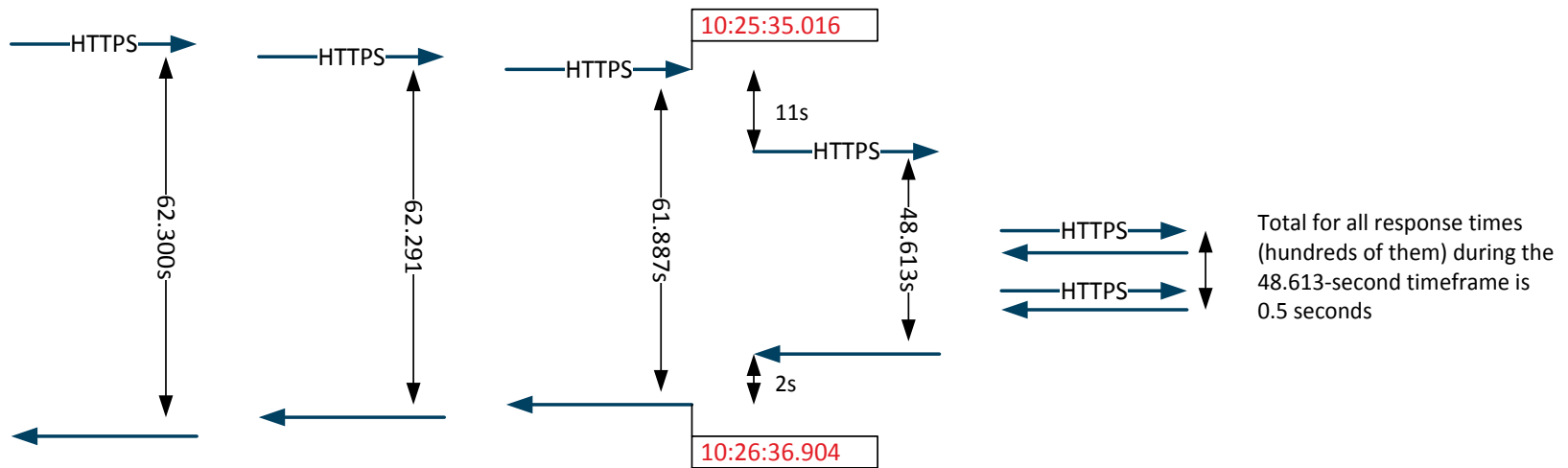
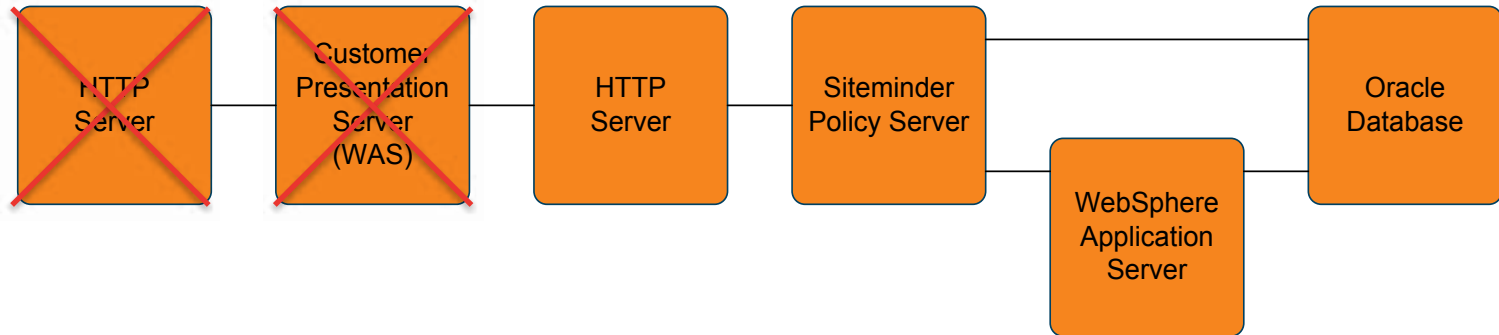
Correlation Strategies

- Don't need to
- Port-to-port mapping
- Based on data content
- Based on characterization

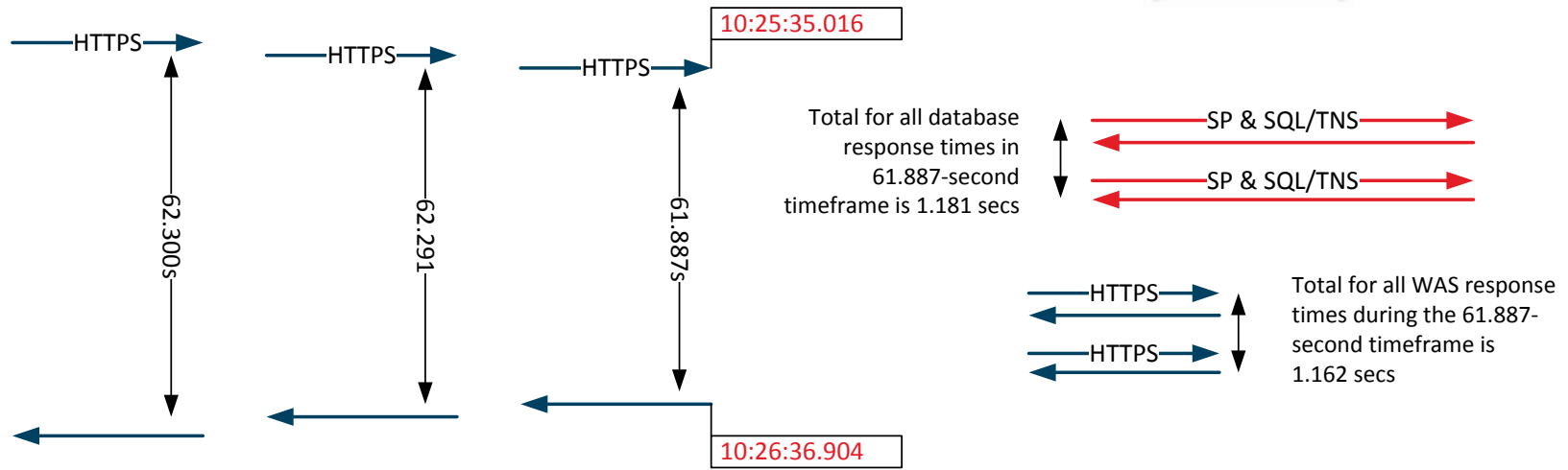
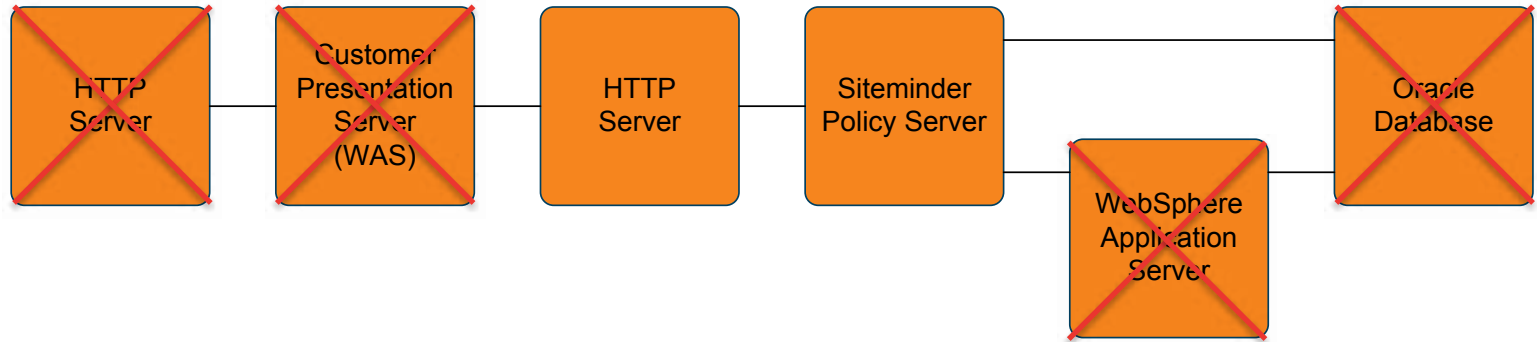
No Need - Scenario



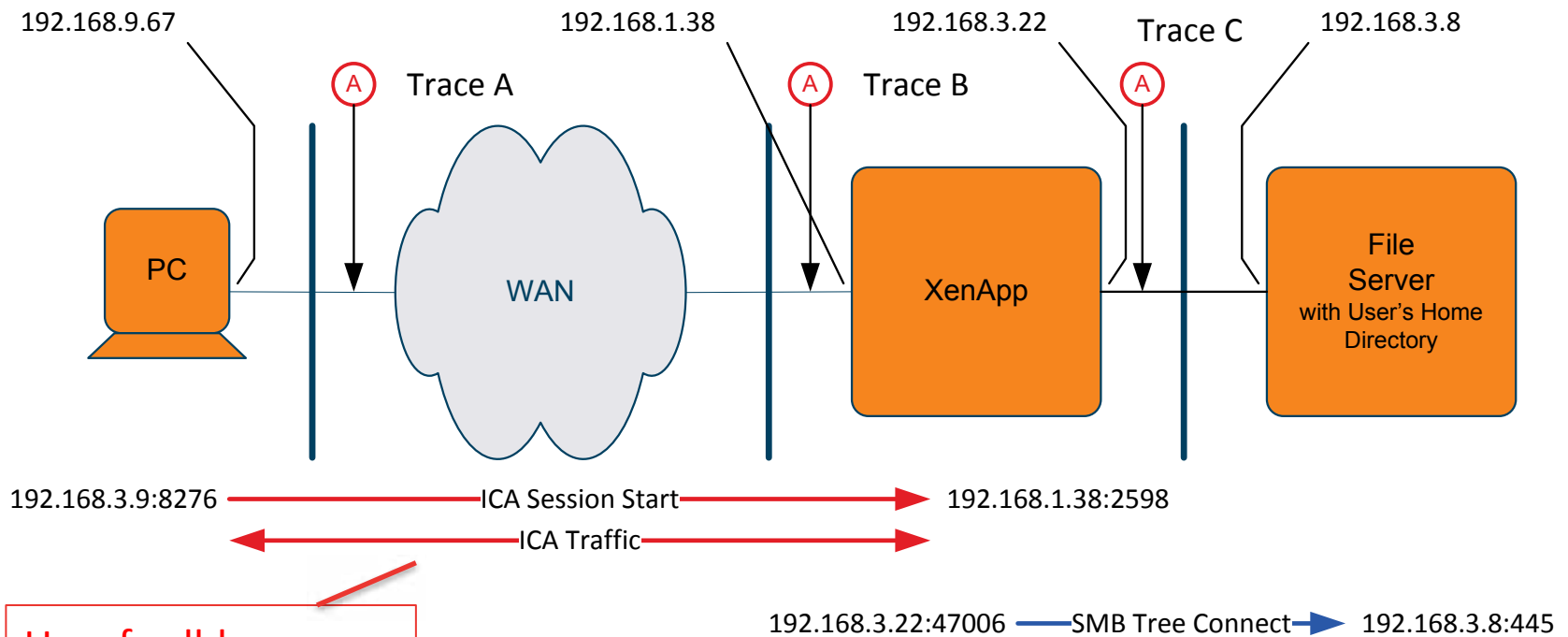
No Need - Analysis



No Need – Further elimination



Port-to-port Mapping

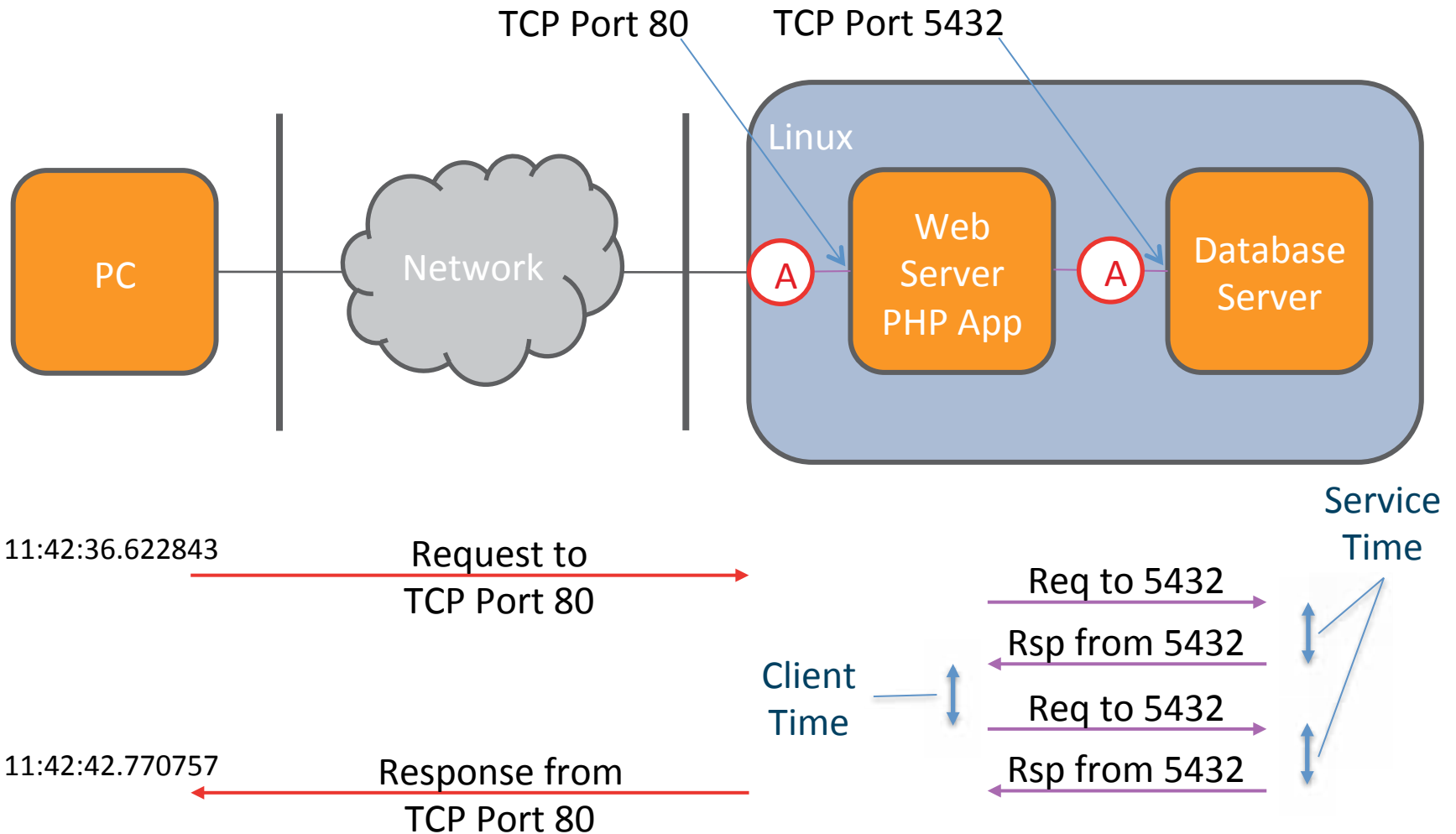


User fredblogs starts the Citrix client

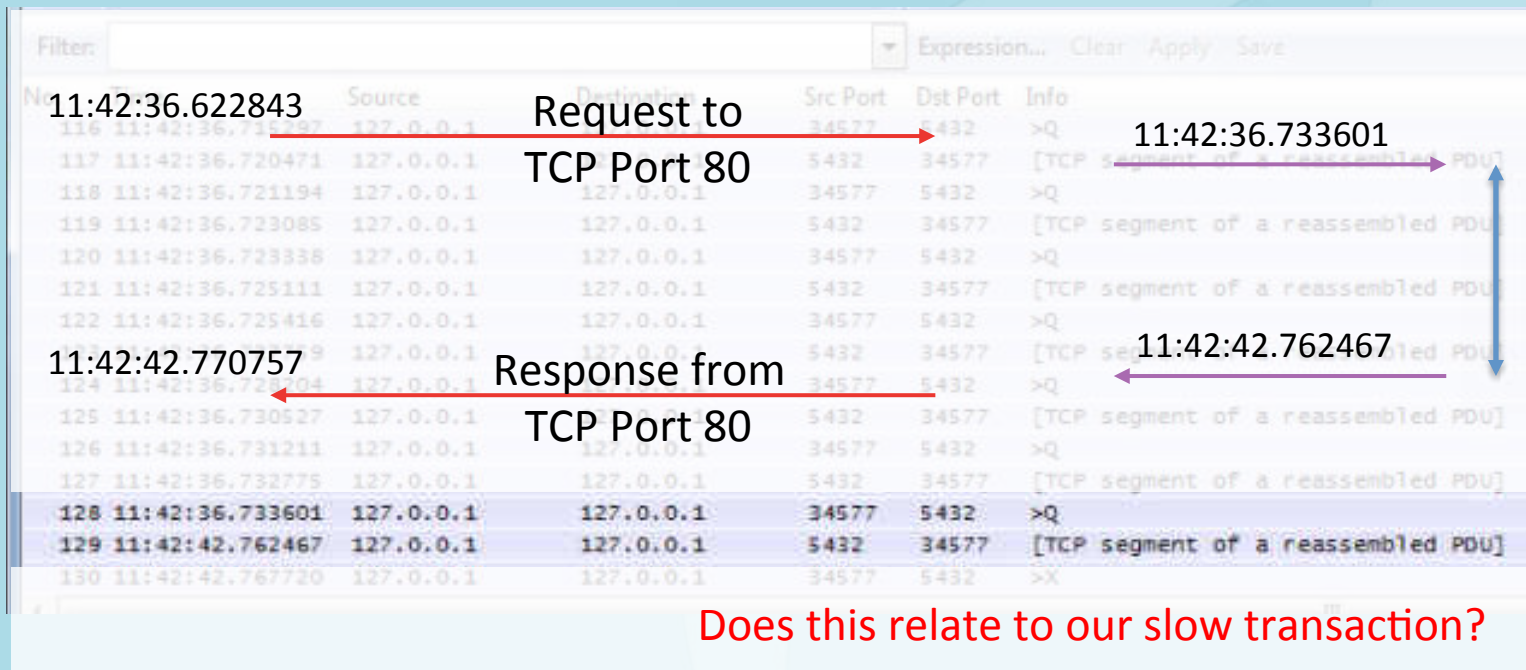
A short time later the XenApp server connects to \\mainfs\home\fredblogs

Content Matching

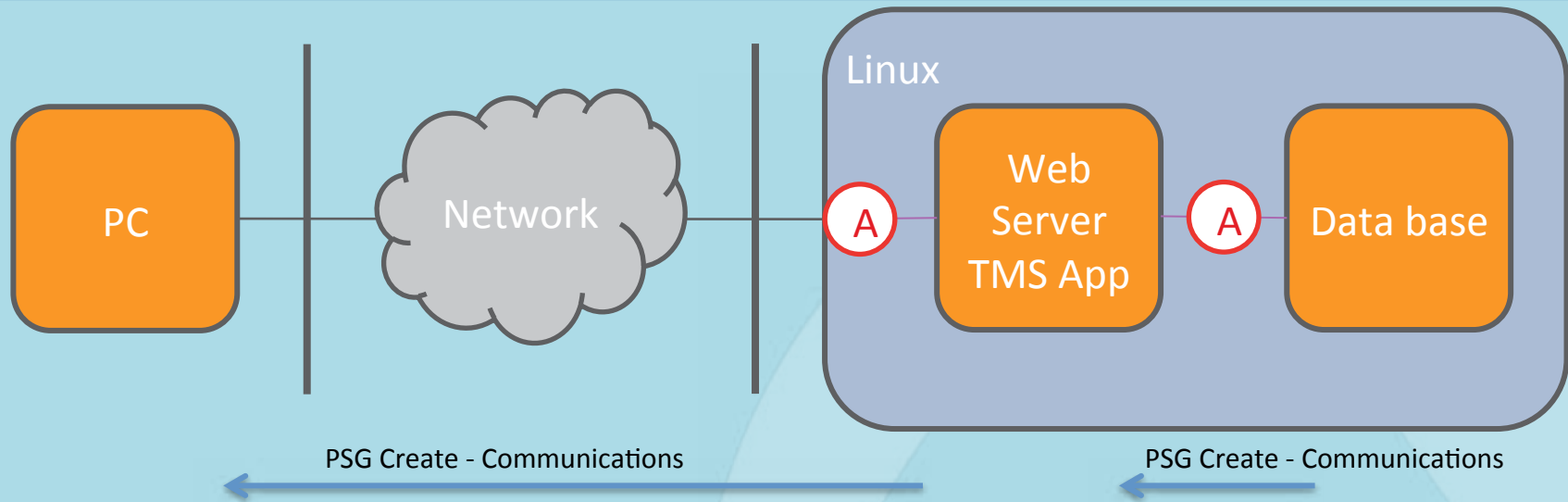
TMS Database Trace – Scenario 2



Database Response Time



Content Matching - Response



Home Orgs Schemes Drawdowns Users Qs Monitors Autos My Q GreenBook Summary Reports Time Forecast Hols Equip				
View Ticket				
Date/Time Queued 2012-08-03 07:40	Ticket# 511129	Description PSG Create - Communications	Pri 3	Status Alarm
Last Dispatch	Last Spec	Customer Name Unitary Council	Project P12702	Queue A7GPJO
Procedure	Proposal	Contact Glen Holmes	Phone	RPR Process Attach ->

Data Content - Response

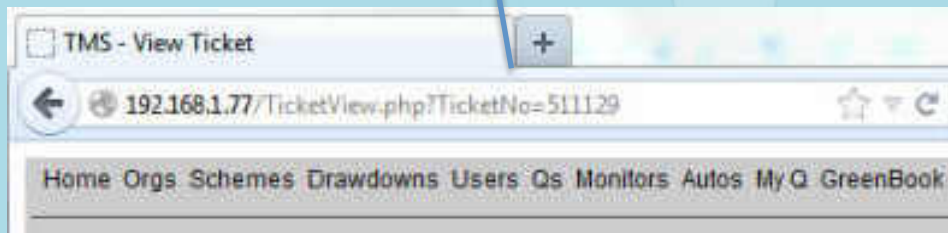
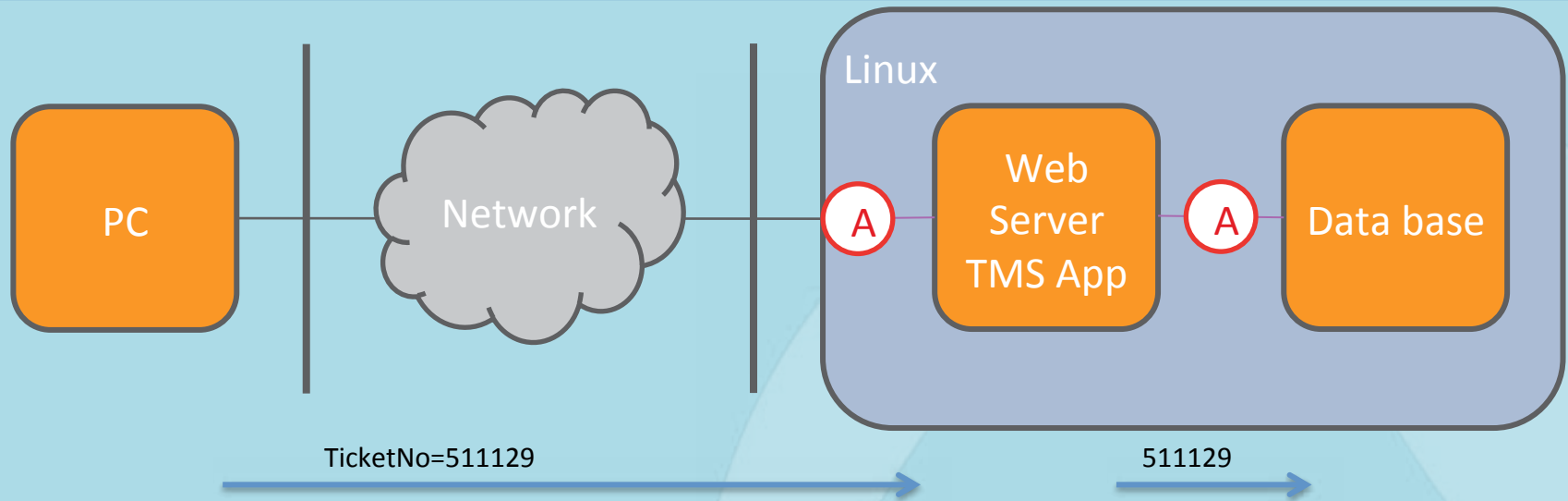
```
156 11:42:42.772761 192.168.1.77 192.168.1.70 80 59640 HTTP/1.1 200 OK

\r\n
<tr> \r\n
  <th width="110">Date/Time Queued</th>\r\n
  <th width="90">Ticket#</th>\r\n
  <th width="240">Description</th>\r\n
  <th width="80">Pri</th>\r\n
  <th width="80">Status</th>\r\n
</tr>\r\n
\r\n
<tr> \r\n
  <td>2012-08-03 07:40</td>\r\n
  <td>511129</td>\r\n
  <td>PSG Create - Communications</td>\r\n
  <td>3</td>\r\n
  <td class="alarm">Alarm</td>\r\n
</tr>\r\n
\r\n
```

Frame 129: 251 bytes on wire (2008 bits), 251 bytes captured (2008 bits)
Ethernet II, Src: 00:00:00_00:00:00 (00:00:00:00:00:00), Dst: 00:00:00_00:00:00
Internet Protocol Version 4, Src: 127.0.0.1 (127.0.0.1), Dst: 127.0.0.1
Transmission Control Protocol, Src Port: postgresql (5432), Dst Port: 34

00	00	00	00	00	00	00	00	00	00	00	00	08	00	45	00E.	
10	00	ed	2e	62	40	00	40	06	0d	a7	7f	00	00	01	7f	00	...ba@.
20	00	01	15	38	87	11	90	85	d5	04	85	55	db	6d	80	18	...8....U.m..
30	02	11	fe	e1	00	00	01	01	08	0a	05	34	b6	40	05	344.@.4
40	b6	23	54	00	00	00	a6	00	06	74	69	63	6b	65	74	5f	..#T.....ticket_
50	6e	6f	00	00	00	a8	81	00	01	00	00	00	17	00	04	ff	no.....
60	ff	ff	ff	00	00	75	73	65	72	69	64	00	00	00	a8	81use fid.....
70	00	02	00	00	04	13	ff	ff	00	00	00	24	00	00	64	74\$.dt
80	5f	75	70	64	61	74	65	00	00	00	a8	81	00	03	00	00	_update.....
90	04	5a	00	08	ff	ff	ff	ff	00	00	74	61	67	5f	6c	69	.Z.....tag_li
a0	6e	65	00	00	00	a8	81	00	04	00	00	04	13	ff	ff	00	ne.....
b0	00	00	34	00	00	69	6e	66	6f	00	00	00	a8	81	00	05	..4..inf 0.....
c0	00	00	04	13	ff	ff	00	00	28	04	00	00	61	63	74	69[...act]
d0	76	69	74	79	69	64	00	00	00	a8	81	00	06	00	00	00	vityid.....
e0	17	00	04	ff	ff	ff	ff	00	00	43	00	00	00	0b	53	45C....SE
f0	4c	45	43	54	00	5a	00	00	00	05	49						LECT,Z...I

Content Matching - Request



Data Content - Request

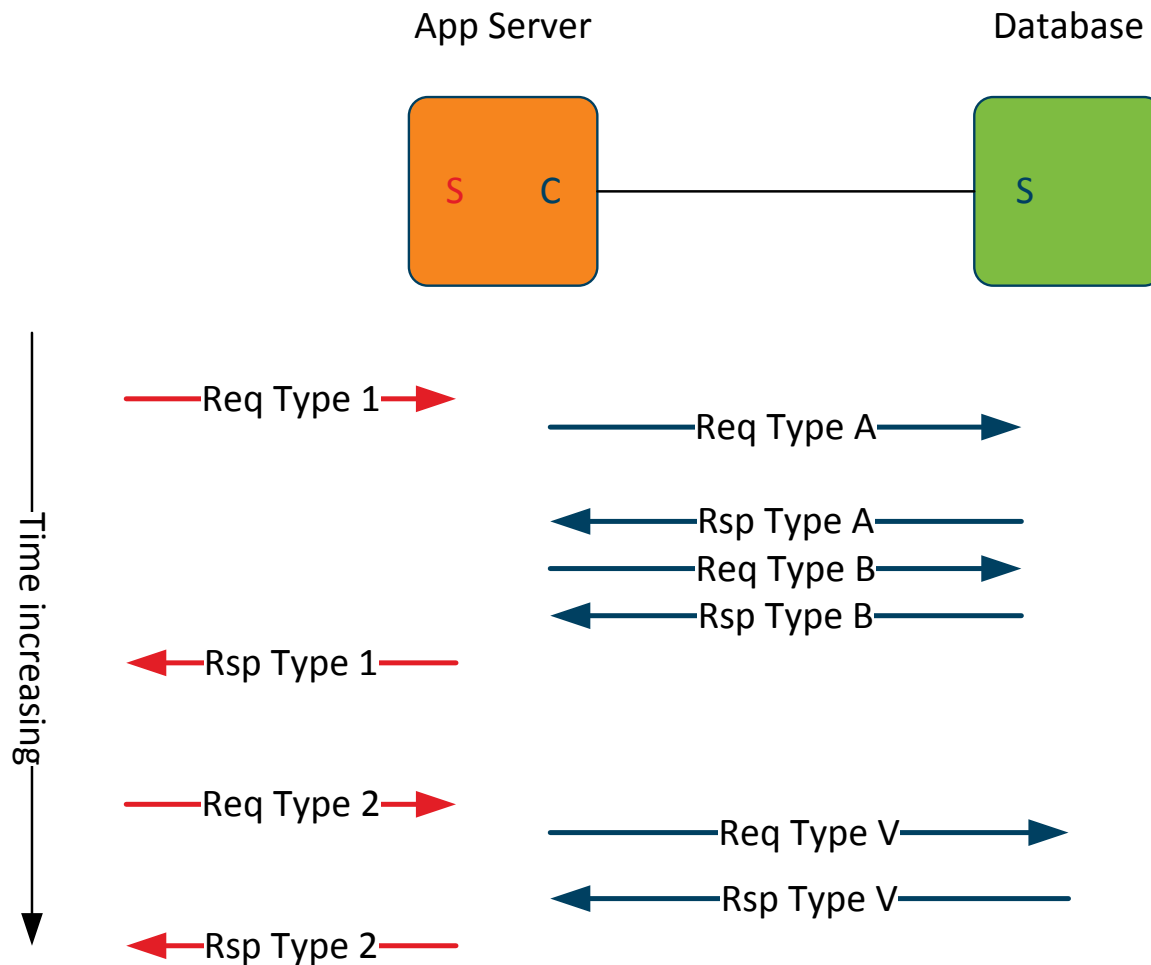
```
Ethernet II, Src: Netgear_a3:5b:a9 (00:09:5b:a3:5b:a9), Dst: IntelCor_73:a5:11 (00:13:ce:73:
Internet Protocol Version 4, Src: 192.168.1.70 (192.168.1.70), Dst: 192.168.1.77 (192.168.1.
Transmission Control Protocol, Src Port: 59640 (59640), Dst Port: http (80), Seq: 3292362848
Hypertext Transfer Protocol
GET /Ticketview.php?TicketNo=511129 HTTP/1.1\r\n
Host: 192.168.1.77\r\n
User-Agent: Mozilla/5.0 (Windows NT 6.1; WOW64; rv:20.0) Gecko/20100101 Firefox/20.0\r\n
Accept: text/html,application/xhtml+xml,application/xml;q=0.9,*/*;q=0.8\r\n
Accept-Language: en-US,en;q=0.5\r\n
Accept-Encoding: gzip, deflate\r\n
Referer: http://192.168.1.77/QueueSummary.php?Qid=A7GPJ0\r\n
Authorization: Basic cGF1bG9mOkExd2lhcDB5\r\n
```

Therefore

This slow database transaction
relates to the web transaction

```
Frame 128: 142 bytes on wire (1136 bits), 142 bytes captured (1136 bits)
Ethernet II, Src: 00:00:00_00:00:00 (00:00:00:00:00:00), Dst: 00:00:00_00:00:00
Internet Protocol Version 4, Src: 127.0.0.1 (127.0.0.1), Dst: 127.0.0.1
Transmission Control Protocol, Src Port: 34577 (34577), Dst Port: postgresql (5432)
00 00 00 00 00 00 00 00 00 00 00 00 00 08 00 45 00 .....E.
10 00 80 47 5d 40 00 40 06 f5 18 7f 00 00 01 7f 00 ..G]@.@. ....
20 00 01 87 11 15 38 85 55 db 21 90 85 d5 04 80 18 .....8.U .l.....
30 03 02 fe 74 00 00 01 01 08 0a 05 34 b6 23 05 34 ...t....4.#.4
40 9e b2 51 00 00 00 4b 53 45 4c 45 43 54 20 20 2a ..Q...KS ELECT =
50 20 46 52 4f 4d 20 20 61 63 74 69 76 69 74 79 20 FROM a ctivity
60 57 48 45 52 45 20 20 74 69 63 6b 65 74 5f 6e 6f WHERE t ticket no
70 20 3d 20 35 31 31 31 32 39 20 4f 52 44 45 52 20 = 51112 9 ORDER
80 42 59 20 64 74 5f 75 70 64 61 74 65 20 00 BY dt_up date .
```

Characterization



Resources



White Paper

Network Trace Analysis Strategies

from www.advance7.com

Book

RPR: A Problem Diagnosis Method for IT Professionals

Gift today or from Amazon or Lulu



Video

RPR NA03: Analysing SQL Server performance using Wireshark and Excel

from YouTube



More Resources



Forum

RPR Practitioners

from www.linkedin.com

Video

RPR NA01: Analysing fileserver performance using Wireshark and Excel

from YouTube



Video

RPR NA02: Analysing SMB2 and fileserver performance

from YouTube

Questions?

Project completion

Operation costs

Revenue

Cloud

Outsource

Recurring Gray Problems

SaaS

IT cap-ex

IT budget

CCaaS

PaaS

BPO

UCaaS

Recurring Gray Problems

The issue will grow

It will slow development of the industry

Only evidence-based methods will help

Only

**You have the skills & techniques
to make the difference**



Lead the way

Thank you



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