Is Your Load Generator Launching Web Requests in Bunches?

James F Brady

State Of Nevada, Carson City, NV 89701

jfbrady@admin.nv.gov

CMG IMPACT 2019

February 21, 2019

Ballroom A @ 10:15 AM

Subject: Performance Tuning

The Problem

- Sometimes a Load Generator's User Thread Pool Will Sync Up and Dispatch Queries In Bunches Rather Than Independently From Each Other Like Real Users Initiate Their Requests.
- A Spiky Launch Pattern Mischaracterizes Workload Flow As Well As Yields Erroneous Application Response Time Statistics.
- Few Practitioners Think About User Thread Synchronization, And Those That Do Find The Problem Difficult to Quantify.

A Traffic Generator Vs Real Users

A Traffic Generator:

Is One Computer Initiating Web Requests With A Large Number Of User Threads Operating In Closed Loops.

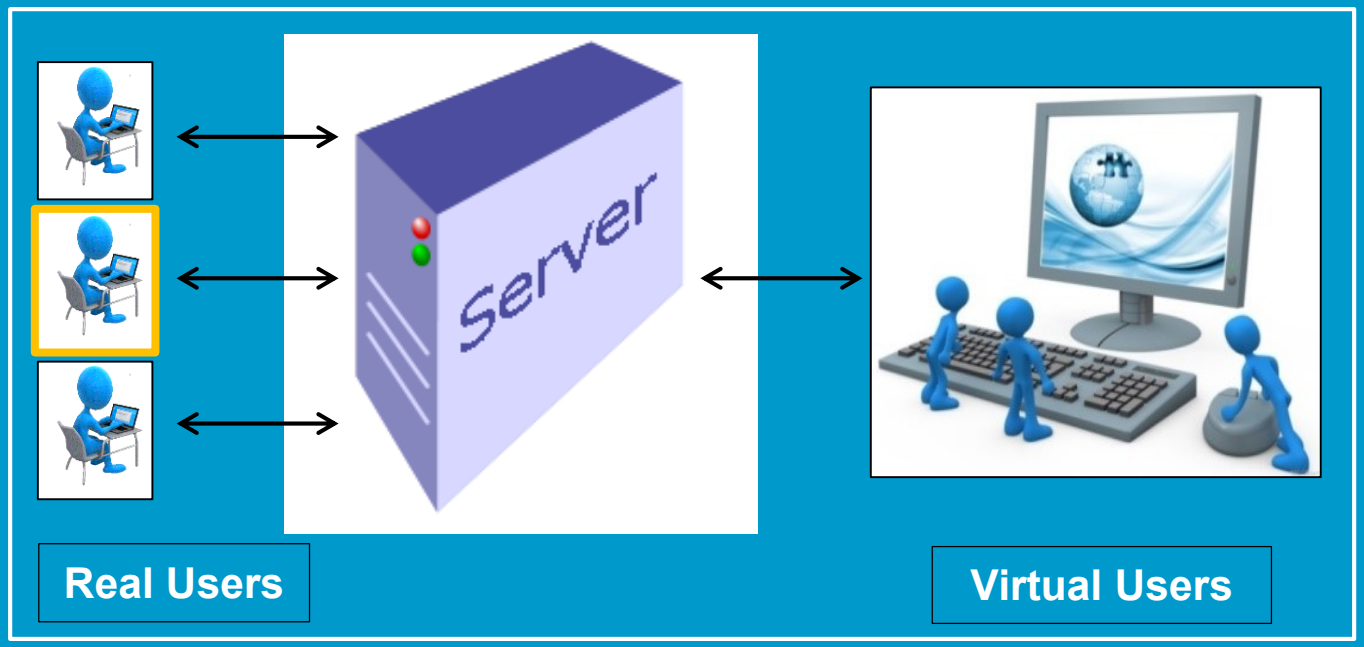
Real Users:

Have Separate Computing Devices And Make Queries Independently From Each Other As A Dynamically Changing Subset Of A Larger Population.

Introduction

- Real User Vs Virtual User Request Timing
- Load Generator Launch Time Distortions
- Example Load Test
- Summary

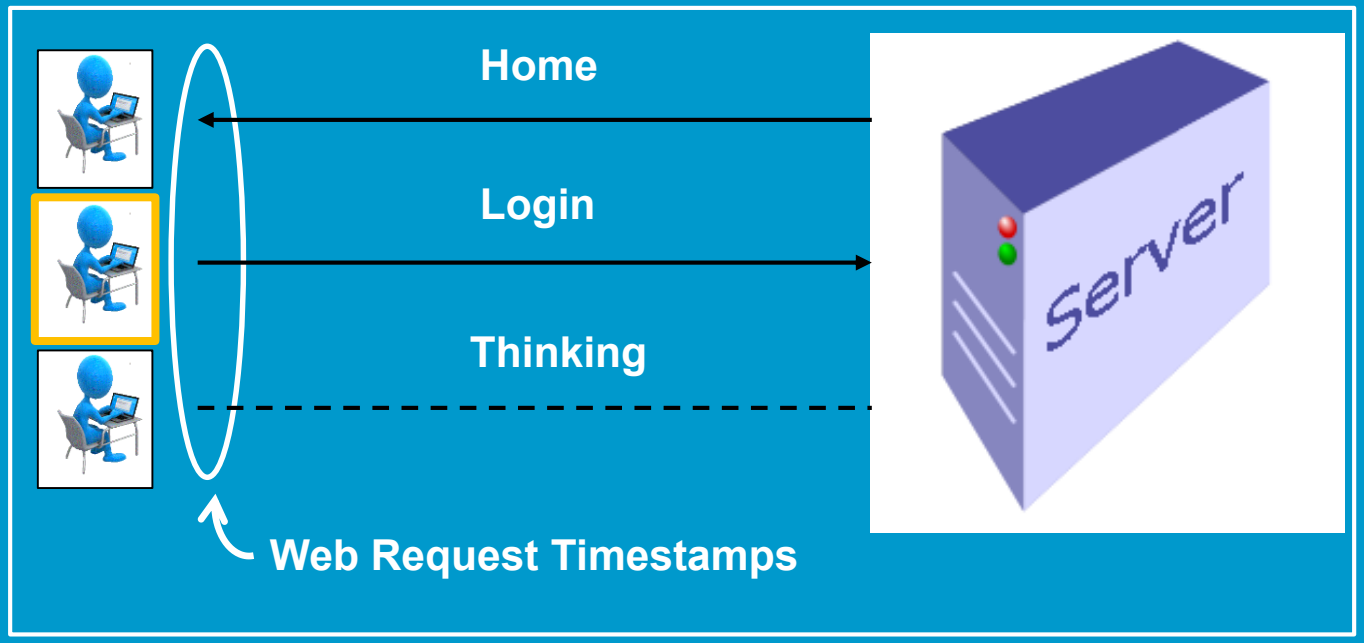
Real Users Vs Virtual Users



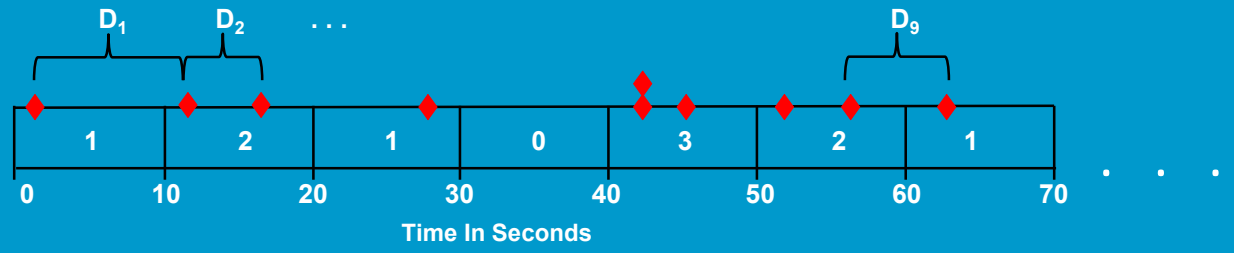
Separate Computing Devices
Individual Boxes Of Activity
Middle User Just Arrived

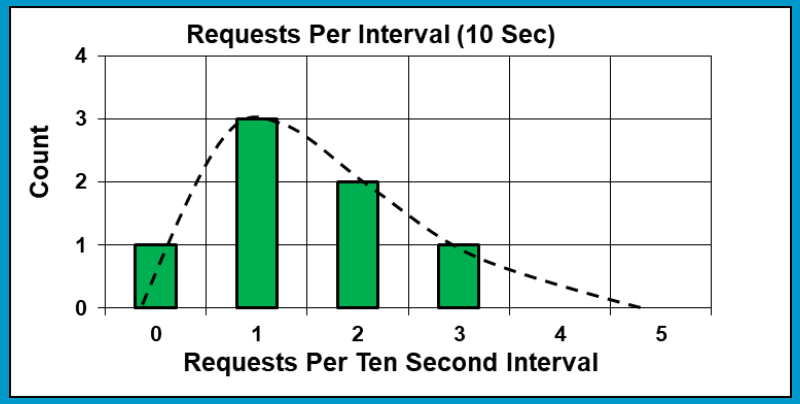
Share Computing Device
One Box Of Activity
Users Are Fixed Position

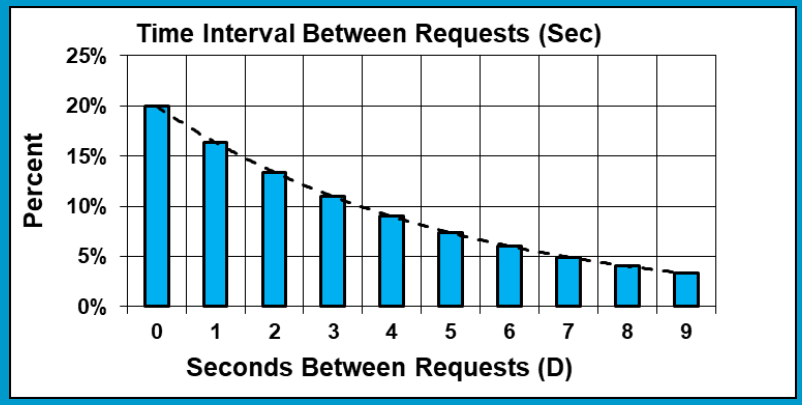
Real User Web Requests



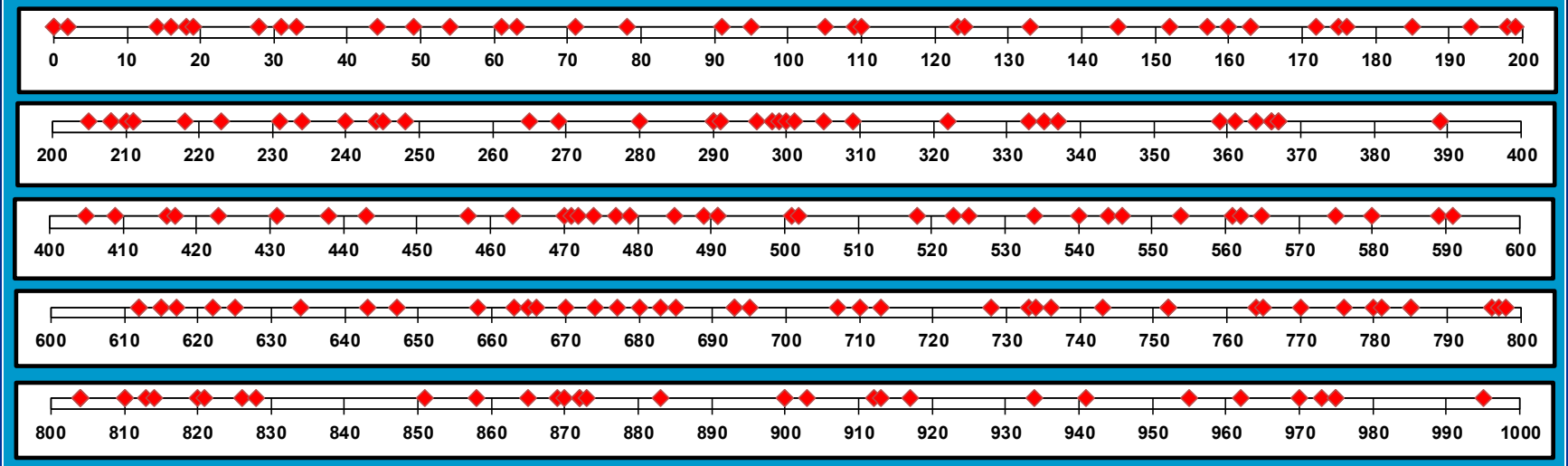
Real User Request Time Line Fragment





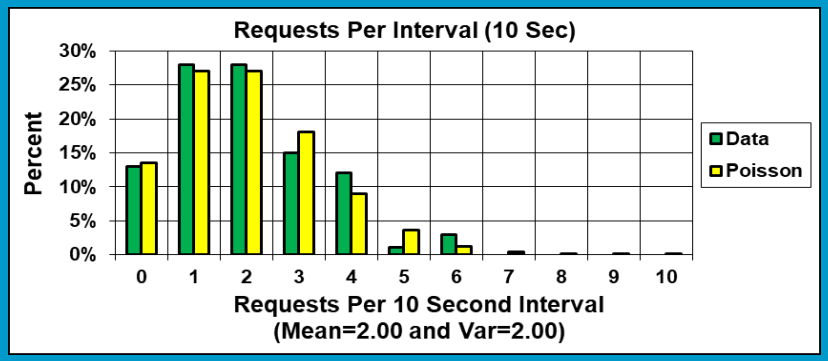


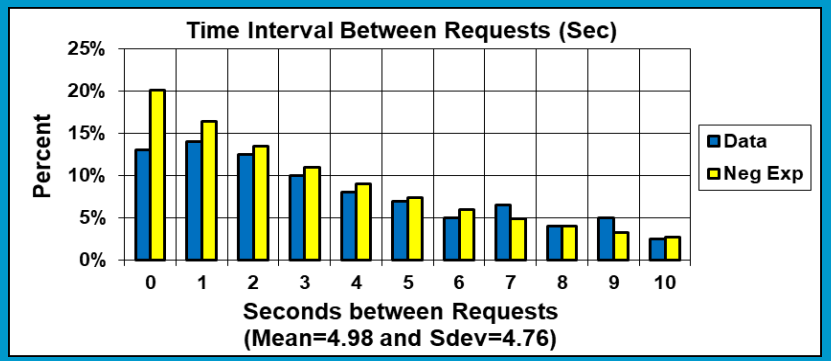
Request Timing Simulation



Intervals Without Diamonds = 13

Diamonds Visible = 174





Real Web User Request Timing

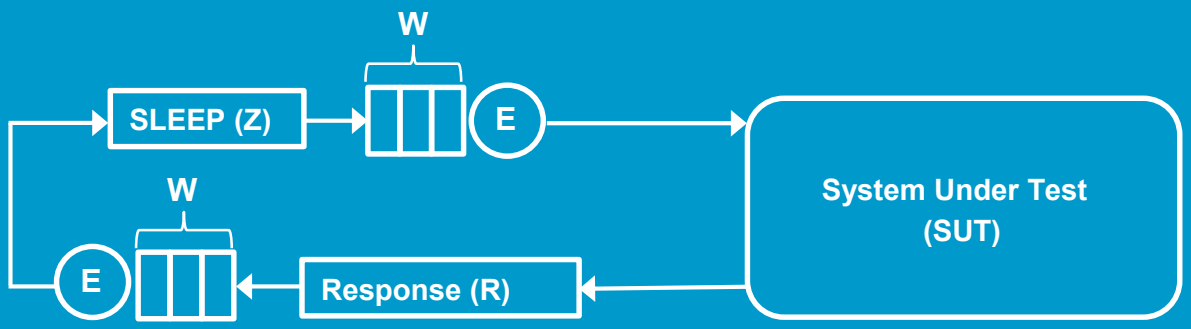
To determine if the load generator is creating web requests independently from each other like real users, sort the launch times is ascending order, calculate their differences, and compute the Coefficient of Variation (CoV) of those differences. If the CoV is approximately equal to one, CoV ~ 1.0, real user request timing is being produced. If the CoV > 1.0 requests are being launched in bunches and if the CoV < 1.0 they are too evenly spaced.

Where:
CoV = Sdev / Mean For Time Intervals Between Requests

Load Generator Launch Time Distortions

1. Heavy Workload
2. Think Time Method Used
3. Closed Loop Feedback

Heavy Workload



Where:

Z = Think Time

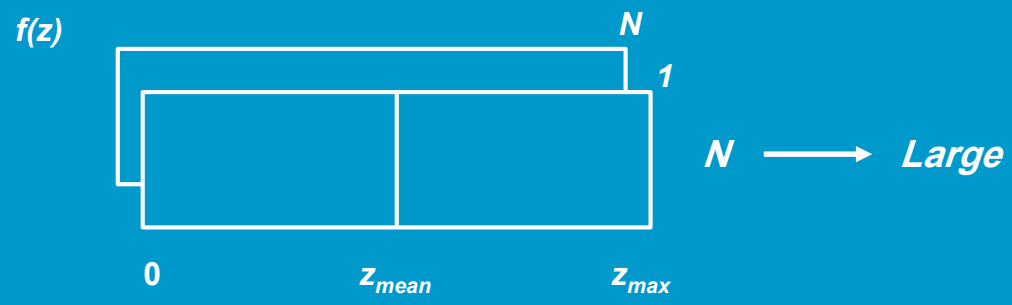
R = Response Time

W = Queueing Time

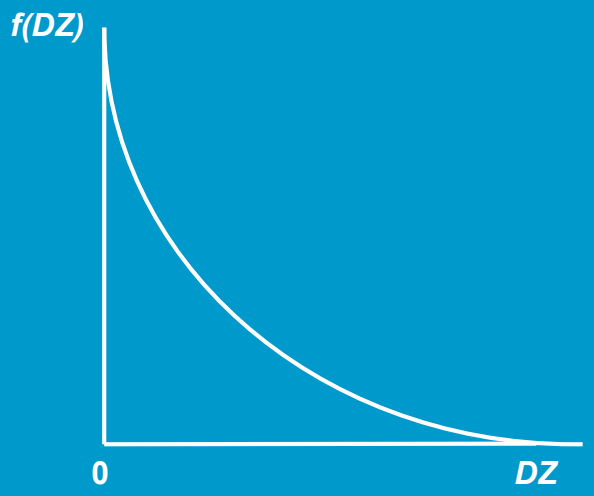
E = Execution Time

SUT = System Under Test

Think Time Method Used



N Uniformly Distributed Z Values



Neg-Exp Distributed DZ Values

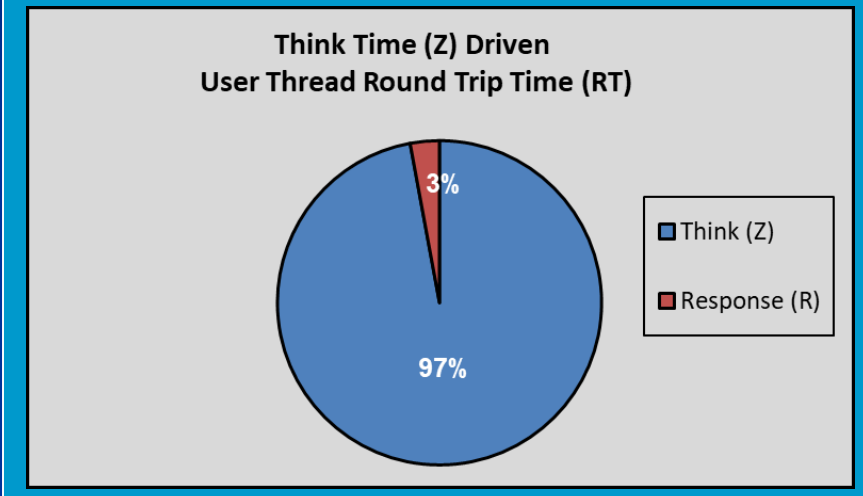
Where:

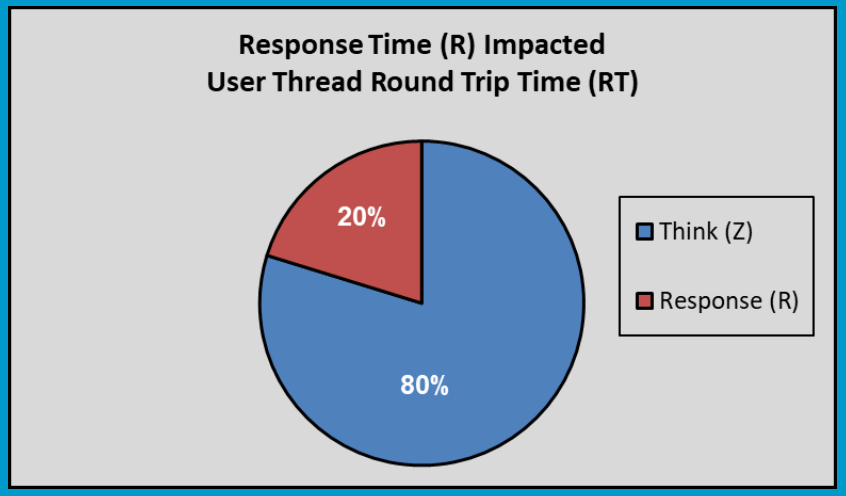
Z = Think Time

N = Number of Load Tool Process Threads

DZ = Time Interval Between Requests Based On Think Time (Z)

Closed Loop Feedback





Where:

Z = Think Time

R = Response Time

RT = Round Trip Time (Z + R)

Example Load Test

- web-generator-toolkit
- Question

  How Many User Threads Does It Take For The Time Intervals Between Requests To Become Statistically Independent From Each Other, CoV_{DRT} ~ 1.0, When Each Thread Is Drawing Its Think Times From a Uniform Distribution?

Where:

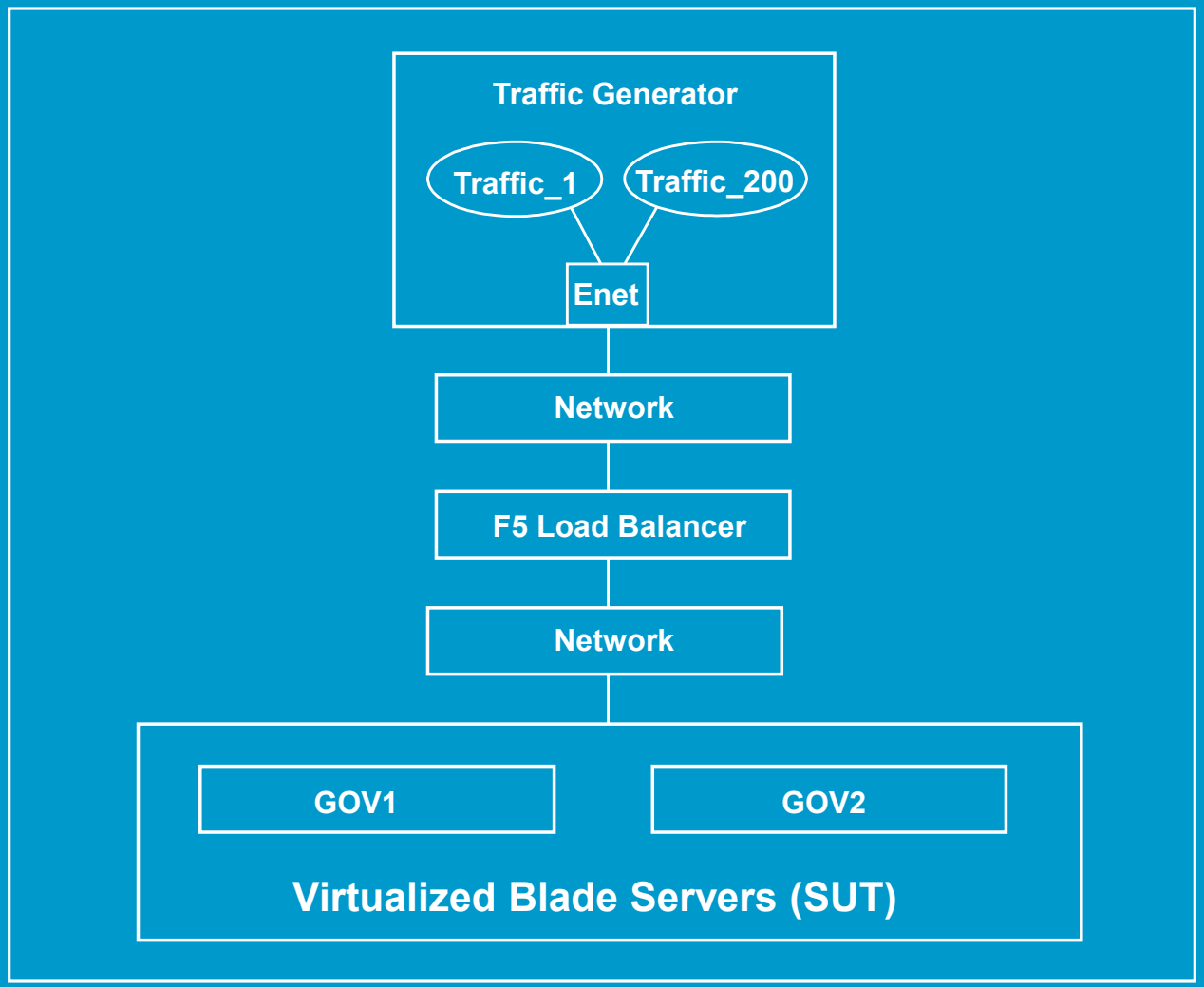
CoV_{DRT} = CoV Of Time Interval Between Requests (D) Based On Round Trip (RT)

RT = Think Time + Response Time

Load Test GET / POST Events

GOV Web Site – Web Page GET / POST Events	
Object	**Definition**
010_Home	Home page
012_Home_jpg	Background image
020_Dept	Department data
022_Dept_jpg	Department image
030_Demographics	Demographic data
040_Statistics	Government user data

Load Testing Configuration

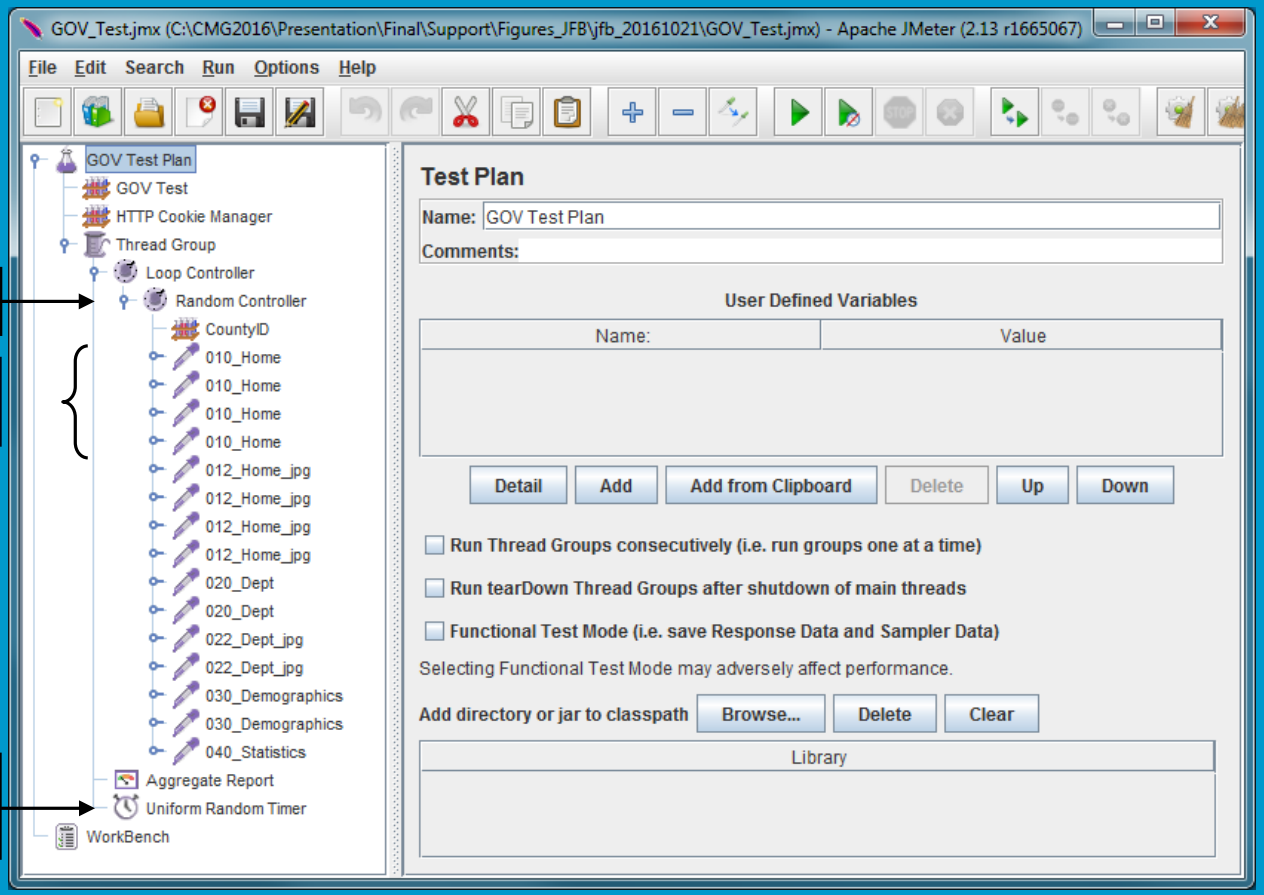


JMeter Load Testing Script

Random Order

Home Page Objects (4)

Uniform Random Timer



Example Load Test Procedure

1. All Tests Are Run With 200 JMeter Threads
2. Load Increased By Reducing Mean Think Time
3. Seven 25 Minutes Tests Performed
   - First Two And Last Three Minutes Excluded To Ensure Steady State
   - Lowest to Highest Traffic Load Numbers - 1800, 1830,1900, 1930, 2000, 2030, 2100

Load Test Traffic And Response Time

JMeter Load Generator Statistics						
	Threads	Tps	Milliseconds			CoV_R
Test Run	N	Trans / Sec	Z_{mean}	R_{mean}	R_{sdev}	R_{sdev} / R_{mean}
1800	200	15.91	12500	53	155	2.89
1830	200	31.73	6250	53	156	2.95
1900	200	46.79	4200	54	167	3.08
1930	200	60.26	3250	59	179	3.03
2000	200	77.56	2500	75	229	3.06
2030	200	118.03	1563	134	357	2.67
2100	200	159.16	1000	254	536	2.11

CoV_R = CoV Of Response Time (R)

What About The Launch Time Pattern Of The Web Requests?

Inter-arrival Summary Statistics web-generator-tookit CoV$_{DRT}$

Inter-arrival Summary Statistics (ms) - select_1830_AggRpt_120_1200 Thursday 03/15/2012											
label	n	tps	median	mean	sdev	cv	p90	p95	p99	min	max
010_Home	10026	8.36	82	119.7	119.2	1	278	358	555	0	1201
012_Home_jpg	10205	8.51	81	117.6	117	0.99	270	352	527	0	1145
020_Dept	4975	4.15	172	241.2	232.5	0.96	555	710	1038	0	2285
022_Dept_jpg	5068	4.22	166	236.8	235.4	0.99	546	712	1080	0	2143
030_Demographics	5220	4.36	161	229.6	229	1	519	662	1071	0	2208
040_Statistics	2573	2.15	332	465.9	458.2	0.98	1062	1419	2054	0	3660
Total	38072	31.73	22	31.52	31.59	1	73	94	143	0	435

The CoV$_{DRT}$ Column Is Labeled CV

JMeter Aggregate Report Event File web-generator-tookit

JMeter Aggregate Report Event File - 1830_AggRpt_120_1200.csv									
TimeStamp (ms)	R (ms)	Web Event Name	Response Code	Response Message	User Thread	Data Type	Success	Byte Count	R (1st Byte) (ms)
1331861523116	9	010_Home	200	OK	Thread Group 1-97	text	TRUE	17991	7
1331861523145	9	010_Home	200	OK	Thread Group 1-127	text	TRUE	17991	7
1331861523160	5	022_Department_jp	200	OK	Thread Group 1-198	bin	TRUE	31541	3
1331861523166	9	020_Department	200	OK	Thread Group 1-8	text	TRUE	26632	6
1331861523167	25	012_Home_jpg	200	OK	Thread Group 1-179	bin	TRUE	141907	2
1331861523169	26	012_Home_jpg	200	OK	Thread Group 1-87	bin	TRUE	141907	7
1331861523213	5	022_Department_jp	200	OK	Thread Group 1-110	bin	TRUE	31541	3
1331861523283	14	012_Home_jpg	200	OK	Thread Group 1-80	bin	TRUE	141907	3
1331861523306	15	012_Home_jpg	200	OK	Thread Group 1-52	bin	TRUE	141907	3
1331861523330	5	022_Department_jp	200	OK	Thread Group 1-95	bin	TRUE	31541	3
1331861523355	7	020_Department	200	OK	Thread Group 1-168	text	TRUE	26632	5
1331861523466	15	012_Home_jpg	200	OK	Thread Group 1-29	bin	TRUE	141907	3
1331861523595	10	010_Home	200	OK	Thread Group 1-31	text	TRUE	17991	8
1331861523620	637	040_Statistics	200	OK	Thread Group 1-72	text	TRUE	110193	610

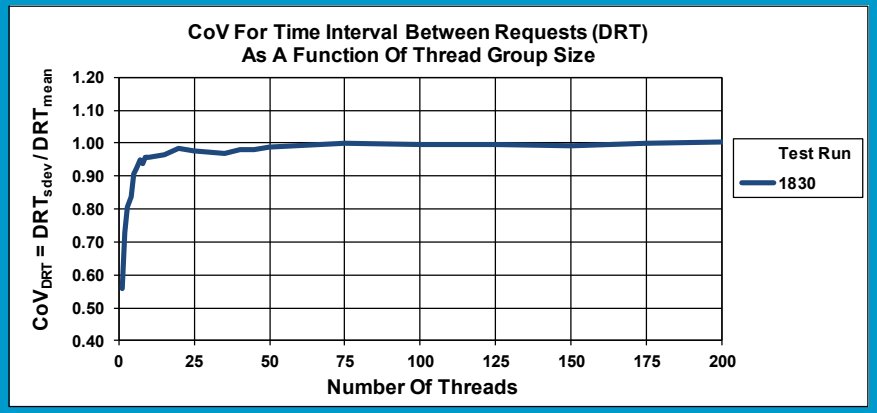
29

CoVDRT By User Thread Grouping, 1-1, 1-1 And 1-2, ...

CoV_{DRT} Vs Thread Group Size

(Test Run 1830)

$$CoV_{DRT} = \frac{DRT_{sdev}}{DRT_{mean}}$$



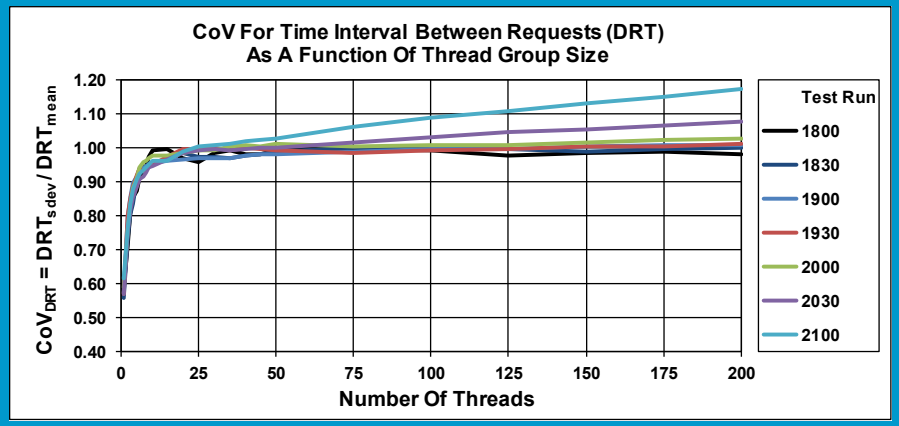
Test Run	1830		Time Interval Between Requests (ms)		
Threads	Trans	Tps	DRT_{mean}	DRT_{sdev}	CoV_{DRT}
1	187	0.16	6391.96	3555.83	0.56
2	360	0.30	3323.87	2423.37	0.73
3	550	0.46	2175.62	1751.27	0.80
4	747	0.62	1603.27	1339.43	0.84
5	939	0.78	1275.45	1157.44	0.91
6	1122	0.94	1067.42	986.39	0.92
7	1317	1.10	909.37	862.32	0.95
8	1509	1.26	794.09	745.60	0.94
9	1694	1.41	707.37	676.15	0.96
10	1875	1.56	639.65	611.60	0.96
15	2877	2.40	416.95	402.70	0.97
20	3846	3.21	311.90	306.66	0.98
25	4814	4.01	249.23	243.05	0.98
30	5776	4.81	207.72	202.35	0.97
35	6710	5.59	178.80	173.23	0.97
40	7685	6.41	156.12	152.82	0.98
45	8606	7.17	139.41	136.55	0.98
50	9566	7.97	125.42	124.02	0.99
75	14292	11.91	83.95	83.88	1.00
100	19089	15.91	62.86	62.55	1.00
125	23864	19.89	50.28	50.03	1.00
150	28580	23.82	41.99	41.60	0.99
175	33276	27.73	36.06	36.00	1.00
200	38072	31.73	31.52	31.59	1.00

DRT **– Time Interval Between Requests (D) Based On Round Trip (RT)**

CoV_{DRT} Vs Thread Group Size

(All Seven Test Runs)

$$CoV_{DRT} = \frac{DRT_{sdev}}{DRT_{mean}}$$

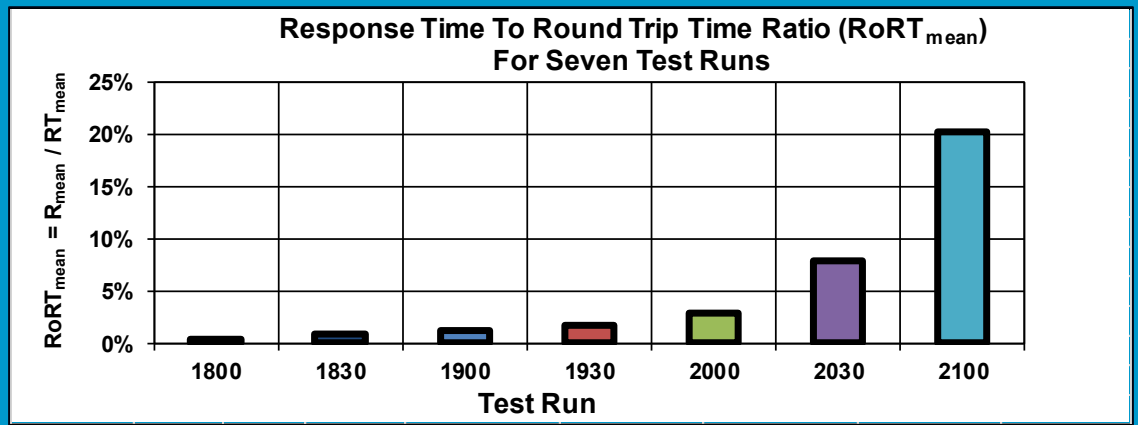


Test Run	1800	1830	1900	1930	2000	2030	2100
Threads	$CoV_{DRT} = DRT_{sdev} / DRT_{mean}$						
1	0.59	0.56	0.57	0.57	0.59	0.57	0.61
2	0.71	0.73	0.79	0.80	0.76	0.75	0.76
3	0.81	0.80	0.85	0.85	0.83	0.81	0.83
4	0.85	0.84	0.90	0.89	0.88	0.85	0.88
5	0.87	0.91	0.91	0.92	0.91	0.88	0.91
6	0.91	0.92	0.94	0.94	0.94	0.91	0.92
7	0.92	0.95	0.94	0.93	0.96	0.92	0.93
8	0.94	0.94	0.95	0.94	0.96	0.93	0.94
9	0.97	0.96	0.95	0.95	0.97	0.94	0.95
10	0.99	0.96	0.95	0.95	0.98	0.95	0.96
15	1.00	0.97	0.96	0.97	0.98	0.97	0.96
20	0.97	0.98	0.97	1.00	0.99	0.98	0.99
25	0.96	0.98	0.97	1.00	0.99	0.99	1.01
30	0.98	0.97	0.97	1.00	0.99	1.00	1.01
35	0.99	0.97	0.97	0.99	1.01	0.99	1.01
40	0.98	0.98	0.98	1.00	1.01	1.00	1.02
45	0.98	0.98	0.98	0.99	1.01	1.00	1.02
50	0.99	0.99	0.98	0.99	1.01	1.00	1.03
75	1.00	1.00	0.99	0.99	1.01	1.02	1.06
100	0.99	1.00	1.00	0.99	1.01	1.03	1.09
125	0.98	1.00	1.00	1.00	1.01	1.05	1.11
150	0.98	0.99	1.00	1.00	1.02	1.05	1.13
175	0.99	1.00	1.01	1.01	1.02	1.07	1.15
200	0.98	1.00	1.01	1.01	1.03	1.08	1.17

DRT **– Time Interval Between Requests (D) Based On Round Trip (RT)**

Response Time To Round Trip Time Ratio For All Seven Test Runs

$$RoRT_{mean} = \frac{R_{mean}}{RT_{mean}}$$



	Milliseconds			CoV_R	RT_{mean}	$RoRT_{mean}$	Tps	N
Test Run	Z_{mean}	R_{mean}	R_{sdev}	R_{sdev} / R_{mean}	Z_{mean} + R_{mean}	R_{mean} / RT_{mean}	Trans / Sec	Tps x RT
1800	12500	53	155	2.89	12553	0.43%	15.91	200
1830	6250	53	156	2.95	6303	0.84%	31.73	200
1900	4200	54	167	3.08	4254	1.27%	46.79	199
1930	3250	59	179	3.03	3309	1.79%	60.26	199
2000	2500	75	229	3.06	2575	2.91%	77.56	200
2030	1563	134	357	2.67	1697	7.88%	118.03	200
2100	1000	254	536	2.11	1254	20.23%	159.16	200

CoV_R And RoRT

Summary

1. A Load Generator's Fixed User Thread Pool Can Sync Up And Produce A Spiky Request Timing Pattern.
   - Heavy Workload
   - Think Time Method Used
   - Closed Loop Feedback
2. Real Users Launch Requests Independently
   - Time Interval Between Request CoV~1.0
3. Example Load Test With web-generator-toolkit Data and Analysis Tools.
4. Divergence Situation Analyzed (CoV_{DRT}>1.0)
5. How Robust Is The Pure Virtual User Model That Everyone Relies Upon?

References

- J. F. Brady, "The Rosetta Stone of Traffic Concepts and Its Load Testing Implications," CMG MeasureIT, (September 2009), https://jamesbrady.academia.edu/research
- J. F. Brady, "When Load Testing Large User Population Web Applications the Devil Is In the (Virtual) User Details," CMG Conference 2012, http://www.perfdynamics.com/Classes/Materials/Brady-CMG12.pdf
- J. F. Brady, "It's Time to Retire Our 1970's User Demand Model for Transaction Computing and Adopt One That Reflects Modern Web User Traffic Flow," CMG Conference, 2014, https://jamesbrady.academia.edu/research
- J. F. Brady and N. J. Gunther, "How to Emulate Web Traffic Using Standard Load Testing Tools," CMG Conference, 2016, https://arxiv.org/abs/1607.05356
- J. F. Brady and N. J. Gunther, "web-generator-toolkit", https://github.com/DrQz/web-generator-toolkit

QUESTIONS

? ? ?