

Lab 5 Report

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1 Test Plan

1.1 Summary

在軟體需求規格當中可分為「功能性需求」及「非功能性需求」，功能性需求是在定義軟體系統應該要提供的功能及服務，而我們可透過各種測試技巧(如：撰寫單元測試)來驗證驗證程式的功能是否正確。非功能性需求則是指依照一些條件來判斷系統運作情形是否滿足標準或客戶的期待，包含系統的效能、安全性、可用性、可測試性及可擴展性等，而非功能性需求又因為結果的高度不確定性，因此非功能性需求的測試又較功能性需求的測試困難許多。

本次 Lab 5 主要希望我們利用「JMeter」這套 Java Application 來對一圖書館 Web 系統的部分功能進行「負載測試」。

1.2 Feature to be tested

以下列出本次實驗待測的 Features：

(1) Login / Logout:

- User login and logout feature.

(2) ISBN search books:

- User search books with ISBN code feature.

(3) Check in / Check out books:

- User check in and check out books with book code.

1.3 Success criteria of completing the test

本次測試屬於負載測試，我們必須分析使用者實際操作系統的行為並模擬其過程，因此我將採用 User scenario 作為測試案例設計的方法。測試案例通過的標準(也就是系統否能夠 Release 的標準)為每個分析過後的 User scenario 都至少要被一個測試案例所包含，並且每個 Test case 的測試結果的總錯誤率應低於 5%。

1.4 Test environment and infrastructure

(1) Laptop Hardware:

- CPU: Intel Core i5 2.9 GHz
- RAM: 16 GB 2133 MHz LPDDR3
- SSD: 250G

(2) Laptop Software:

- OS: macOS High Sierra 10.13.4
- Apache JMeter: 4.0
- Docker version: 18.03.1-ce

1.5 Test Approach

如同 *section 1.3* 所述，本次測試屬於高階的負載測試，因此我們將先觀察使用者操作系統時的 User scenarios，接著便分析出這些 User scenarios 的 preconditions、input actions、expected output 及預期的 design workload。最終，將分析出來的結果整合成執行測試的 Test scenarios，詳細的 Test scenarios 請參照 *section 2*。

1.6 Test Tasks

No.	Activity Name	Plan hours	Schedule Date
1	Familiar with JMeter tool	4 Hr	2018/6/8
2	Analysis user scenario and design test scenarios	2 Hr	2018/6/8
3	Implement test cases & perform tests	10 Hr	2018/6/9- 2018/6/11
4	Complete Lab5 report	3 Hr	2018/6/12

2 Test Design

(1) Login / Logout feature:

Login and Logout without ramp-up	
Precondition	<ul style="list-style-type: none">● 使用者已進入本系統。
User scenario	<ol style="list-style-type: none">1. 使用者輸入帳號及密碼。2. 使用者確認登入系統。3. 系統顯示使用者登入成功及書籍資訊頁面。4. 使用者點選登出。
Expected output	<ul style="list-style-type: none">● 使用者成功地先登入再登出系統。
Design workload	<ol style="list-style-type: none">1. 必須待所有使用者皆完成登入後，再一起登出系統。2. 共設計 10 個 Thread group，每個 Thread group 分別為 2/4/8/16/32/64/128/256/512/1024 個 threads，且這些 Threads 皆沒有設定 ramp-up。

Login and Logout with ramp-up	
Precondition	<ul style="list-style-type: none">● 使用者已進入本系統。
User scenario	<ol style="list-style-type: none">1. 使用者輸入帳號及密碼。2. 使用者確認登入系統。3. 系統顯示使用者登入成功及書籍資訊頁面。4. 使用者點選登出。
Expected output	<ul style="list-style-type: none">● 使用者成功地先登入再登出系統。
Design workload	<ol style="list-style-type: none">1. 必須待所有使用者皆完成登入後，再一起登出系統。2. 共設計 10 個 Thread group，每個 Thread group 分別為 2/4/8/16/32/64/128/256/512/1024 個 threads，且：<ul style="list-style-type: none">● Thread group 256 的 ramp-up period 設定為 10 秒● Thread group 512 的 ramp-up period 設定為 20 秒● Thread group 1024 的 ramp-up period 設定為 40 秒● 其餘 Thread groups 的 ramp-up 不進行設定。

(2) ISBN search books feature:

ISBN search books asynchronous	
Precondition	<ul style="list-style-type: none"> ● 使用者已進入本系統。
User scenario	<ol style="list-style-type: none"> 1. 使用者在查尋欄位輸入書籍的 ISBN Code。 2. 使用者確認進行查尋。 3. 系統顯示查尋到的書籍結果頁面。
Expected output	<ul style="list-style-type: none"> ● 使用者成功地利用 ISBN Code 查尋到該書籍。
Design workload	<ol style="list-style-type: none"> 1. 必須待所有使用者皆完成查尋書籍後，再一起登出系統。 2. ISBN Code 需利用 JMeter 隨機挑選。 3. 共設計 10 個 Thread group，每個 Thread group 分別為 2/4/8/16/32/64/128/256/512/1024 個 threads，且： <ul style="list-style-type: none"> ● Thread group 256 的 ramp-up period 設定為 10 秒 ● Thread group 512 的 ramp-up period 設定為 20 秒 ● Thread group 1024 的 ramp-up period 設定為 40 秒 ● 其餘 Thread groups 的 ramp-up 不進行設定。

ISBN search books synchronous	
Precondition	<ul style="list-style-type: none"> ● 使用者已進入本系統。
User scenario	<ol style="list-style-type: none"> 1. 使用者在查尋欄位輸入書籍的 ISBN Code。 2. 使用者確認進行查尋。 3. 系統顯示查尋到的書籍結果頁面。
Expected output	<ul style="list-style-type: none"> ● 使用者成功地利用 ISBN Code 查尋到該書籍。
Design workload	<ol style="list-style-type: none"> 1. 必須待所有使用者皆完成登入後，再一起進行書籍的查詢。 2. 必須待所有使用者皆完成書籍的查詢後，再一起進行登出。 3. 共設計 10 個 Thread group，每個 Thread group 分別為 2/4/8/16/32/64/128/256/512/1024 個 threads，且： <ul style="list-style-type: none"> ● Thread group 256 的 ramp-up period 設定為 10 秒 ● Thread group 512 的 ramp-up period 設定為 20 秒 ● Thread group 1024 的 ramp-up period 設定為 40 秒 ● 其餘 Thread groups 的 ramp-up 不進行設定。

(3) Check out / Check in books feature:

Check out and Check in book asynchronous	
Precondition	<ul style="list-style-type: none"> 使用者已進入本系統。
User scenario	<ol style="list-style-type: none"> 使用者進入借/還書頁面。 使用者輸入 Student ID 及 Book Code 進行書籍的借閱。 系統顯示使用者借閱成功後的書籍借閱清單。 使用者輸入 Student ID 及 Book Code 進行書籍的歸還。 系統顯示使用者歸還成功後的書籍借閱清單。
Expected output	<ul style="list-style-type: none"> 使用者成功地先進行書籍的借閱再進行書籍的歸還。
Design workload	<ol style="list-style-type: none"> 必須待所有使用者皆完成歸還書籍後，再一起登出系統。 Book Code 需利用 JMeter 隨機挑選。 共設計 10 個 Thread group，每個 Thread group 分別為 2/4/8/16/32/64/128/256/512/1024 個 threads，且： <ul style="list-style-type: none"> Thread group 64 的 ramp-up period 設定為 10 秒 Thread group 128 的 ramp-up period 設定為 20 秒 Thread group 256 的 ramp-up period 設定為 40 秒 其餘 Thread groups 的 ramp-up 不進行設定。

Check out and Check in book synchronous	
Precondition	<ul style="list-style-type: none"> 使用者已進入本系統。
User scenario	<ol style="list-style-type: none"> 使用者進入借/還書頁面。 使用者輸入 Student ID 及 Book Code 進行書籍的借閱。 系統顯示使用者借閱成功後的書籍借閱清單。 使用者輸入 Student ID 及 Book Code 進行書籍的歸還。 系統顯示使用者歸還成功後的書籍借閱清單。
Expected output	<ul style="list-style-type: none"> 使用者成功地先進行書籍的借閱再進行書籍的歸還。
Design workload	<ol style="list-style-type: none"> 必須待所有使用者皆完成登入後，再一起進行書籍的借閱。 必須待所有使用者皆完成書籍的歸還後，再一起登出系統。 Book Code 需利用 JMeter 隨機挑選。 共設計 10 個 Thread group，每個 Thread group 分別為 2/4/8/16/32/64/128/256/512/1024 個 threads，且： <ul style="list-style-type: none"> Thread group 64 的 ramp-up period 設定為 10 秒 Thread group 128 的 ramp-up period 設定為 20 秒 Thread group 256 的 ramp-up period 設定為 40 秒 其餘 Thread groups 的 ramp-up 不進行設定。

3 Test Implementation

本次 Lab 採用 JMeter 這套工具來對一 Web 圖書館系統進行負載測試。依照不同的 Feature 及相對應的 Test scenarios 總共撰寫了 6 個 Test cases。

首先，因為是要對 Web Application 進行測試，必須要發送 HTTP Request，又因測試過程當中多數的 HTTP Request 內容有部份相同，我們利用 Login Request Defaults 這個 Config Element 來設定共同的 HTTP Request 內容(如 Server IP 及 Protocol)。另外為了要達成登入/登出的功能，必須要在 JMeter 設定由 CSV 檔讀入帳號密碼，並將帳號密碼綁定到動態變數上(CSV 資料設定)。

針對不同 Scenario 的 Workload 需求，我將設定每個 Test case 中的 Preprocessor(利用 BeanShell 撰寫隨機挑選 ISBN Code 及 Book Code)、Sampler、及 Thread group 中的 Ramp-up period，並且也利用 Synchronizing Timer 來達成需求中須等待所有 Threads 事先完成某項需求才能繼續向下執行的要求。最後，將利用 Response Assertion 來驗證 HTTP Request 所回傳的資訊是否正確。

詳細的 Test implementation 程式碼請參考下列的 GitLab 超連結：

(1) Login and Logout without ramp-up :

https://stv.csie.ntut.edu.tw/106598014/GeoProject/blob/master/Lab5/Login_and_Logout_without_ramp-up.jmx

(2) Login and Logout with ramp-up :

https://stv.csie.ntut.edu.tw/106598014/GeoProject/blob/master/Lab5/Login_and_Logout_with_ramp-up.jmx

(3) ISBN search books asynchronous :

https://stv.csie.ntut.edu.tw/106598014/GeoProject/blob/master/Lab5/ISBN_search_books_asynchronous.jmx

(4) ISBN search books synchronous :

https://stv.csie.ntut.edu.tw/106598014/GeoProject/blob/master/Lab5/ISBN_search_books_synchronous.jmx

(5) Check out and Check in book asynchronous :

https://stv.csie.ntut.edu.tw/106598014/GeoProject/blob/master/Lab5/Check_out_and_Check_in_book%20asynchronous.jmx

(6) Check out and Check in book synchronous :

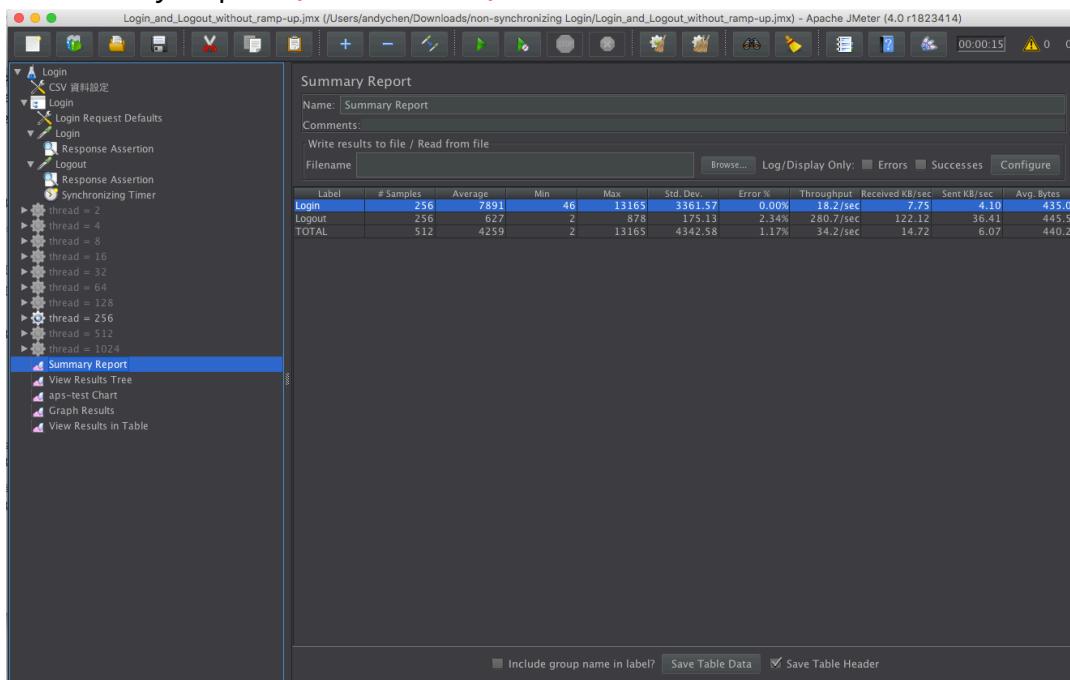
https://stv.csie.ntut.edu.tw/106598014/GeoProject/blob/master/Lab5/Check_out_and_Check_in_book%20synchronous.jmx

4 Test Results

本次測試 *section 2* 所分析出來的 6 個 Test scenario 皆有被 *section 3* 所設計的 6 個 Test cases 包含，最終的測試執行結果總錯誤率皆低於 5%，因此本次測試全數通過，詳細的執行結果可參考下方截圖(以下截圖結果均採用 Thread group = 256 為例)：

(1) Login and Logout without ramp-up :

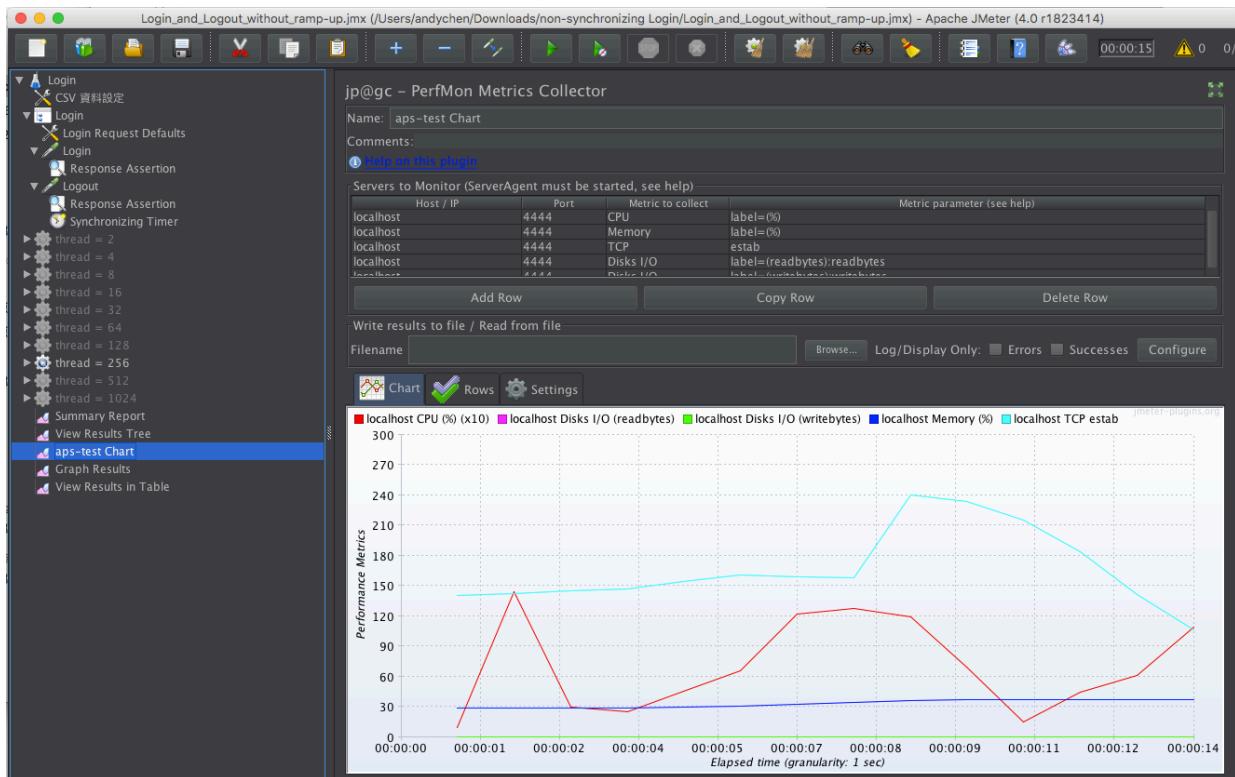
- Summary Report (Error: 1.17%)



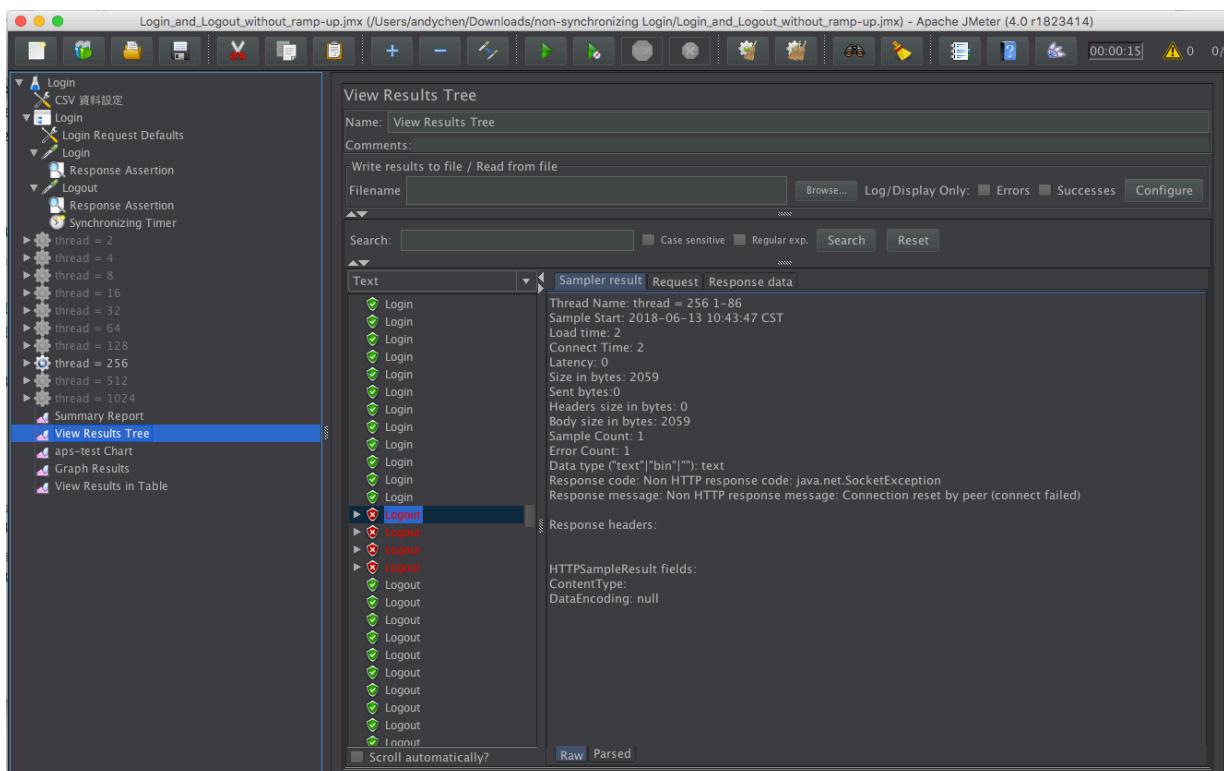
- Table Results in Table

Sample #	Start Time	Thread Name	Label	Sample Time...	Status	Bytes	Sent Bytes	Latency	Connect Ti...
236	10:43:34.317	thread # 256 1-150	Login	13163	✓	435	230	13163	1
237	10:43:34.321	thread # 256 1-151	Login	13163	✓	435	230	13163	1
238	10:43:34.629	thread # 256 1-242	Login	12659	✓	435	230	12659	1
239	10:43:34.798	thread # 256 1-239	Login	12692	✓	435	230	12692	3
240	10:43:34.843	thread # 256 1-243	Login	12655	✓	435	230	12654	0
241	10:43:34.858	thread # 256 1-246	Login	12642	✓	435	230	12642	1
242	10:43:34.862	thread # 256 1-240	Login	12678	✓	435	230	12678	1
243	10:43:34.864	thread # 256 1-240	Login	12610	✓	435	230	12610	1
244	10:43:34.783	thread # 256 1-228	Login	13730	✓	435	230	12730	1
245	10:43:34.851	thread # 256 1-244	Login	12667	✓	435	230	12667	1
246	10:43:34.861	thread # 256 1-247	Login	12662	✓	435	230	12662	1
247	10:43:34.856	thread # 256 1-245	Login	12677	✓	435	230	12677	0
248	10:43:34.883	thread # 256 1-251	Login	12652	✓	435	230	12652	1
249	10:43:34.901	thread # 256 1-255	Login	12636	✓	435	230	12636	1
250	10:43:34.895	thread # 256 1-254	Login	12656	✓	435	230	12656	1
251	10:43:34.869	thread # 256 1-249	Login	12685	✓	435	230	12685	1
252	10:43:34.885	thread # 256 1-252	Login	12671	✓	435	230	12671	1
253	10:43:34.866	thread # 256 1-259	Login	12653	✓	435	230	12653	1
254	10:43:34.678	thread # 256 1-200	Login	12682	✓	435	230	12682	1
255	10:43:34.867	thread # 256 1-248	Login	12696	✓	435	230	12696	1
256	10:43:34.890	thread # 256 1-253	Login	12726	✓	435	230	12726	1
257	10:43:47.644	thread # 256 1-86	Logout	2	✗	2059	0	0	2
258	10:43:47.646	thread # 256 1-92	Logout	105	✗	2205	0	0	104
259	10:43:47.689	thread # 256 1-232	Logout	106	✗	2205	0	0	106
260	10:43:47.688	thread # 256 1-233	Logout	107	✗	2205	0	0	107
261	10:43:47.626	thread # 256 1-19	Logout	244	✓	405	136	244	1
262	10:43:47.631	thread # 256 1-41	Logout	241	✓	405	136	241	1
263	10:43:47.622	thread # 256 1-2	Logout	251	✓	405	136	251	1
264	10:43:47.621	thread # 256 1-39	Logout	252	✓	405	136	252	1
265	10:43:47.639	thread # 256 1-39	Logout	242	✓	405	136	242	0
266	10:43:47.632	thread # 256 1-43	Logout	240	✓	405	136	240	0
267	10:43:47.629	thread # 256 1-22	Logout	243	✓	405	136	243	1
268	10:43:47.632	thread # 256 1-42	Logout	244	✓	405	136	240	0
269	10:43:47.631	thread # 256 1-36	Logout	245	✓	405	136	241	0

- View Results Tree



- PerfMon Metrics Collector



(2) Login and Logout with ramp-up :

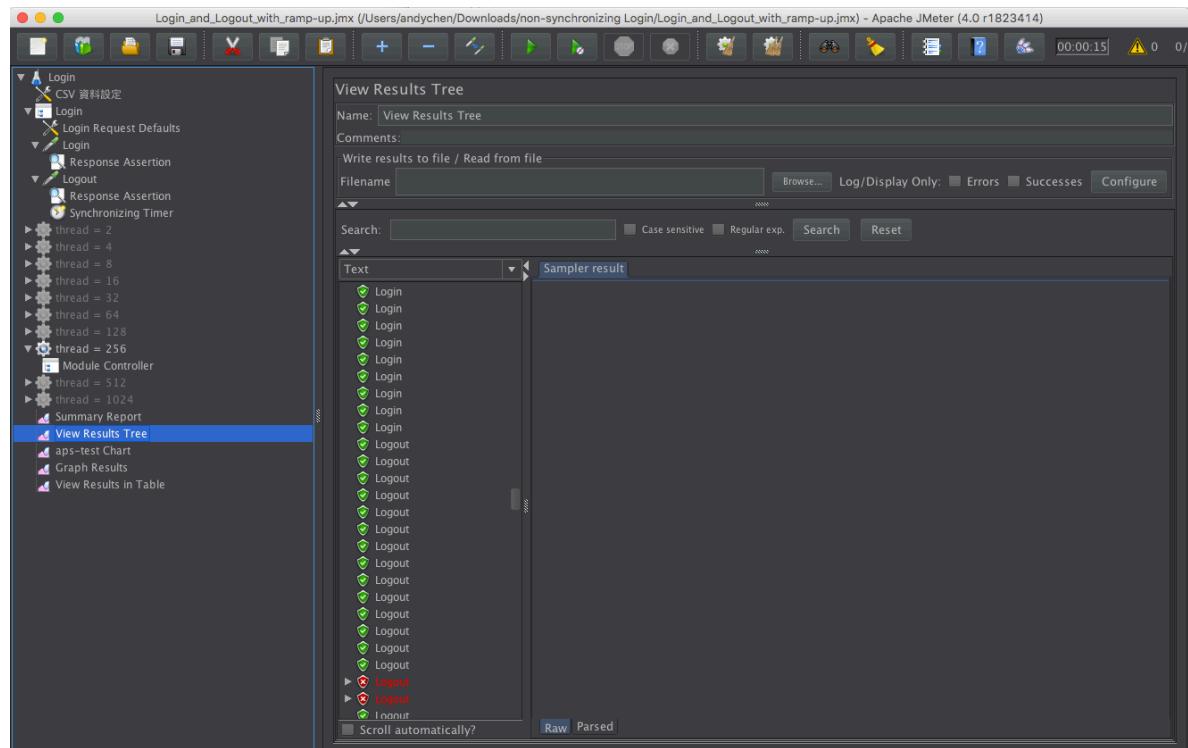
- Summary Report (Error: 1.76%)

Label	# Samples	Average	Min	Max	Std. Dev.	Error %	Throughput	Received KB/sec	Sent KB/sec	Avg. Bytes
Login	256	3756	6	5498	1104.00	0.00%	18.0/sec	7.64	4.04	435.0
Logout	256	388	1	630	160.11	3.52%	332.0/sec	150.92	42.55	465.4
TOTAL	512	2072	1	5498	1859.70	1.76%	34.1/sec	15.00	6.02	450.2

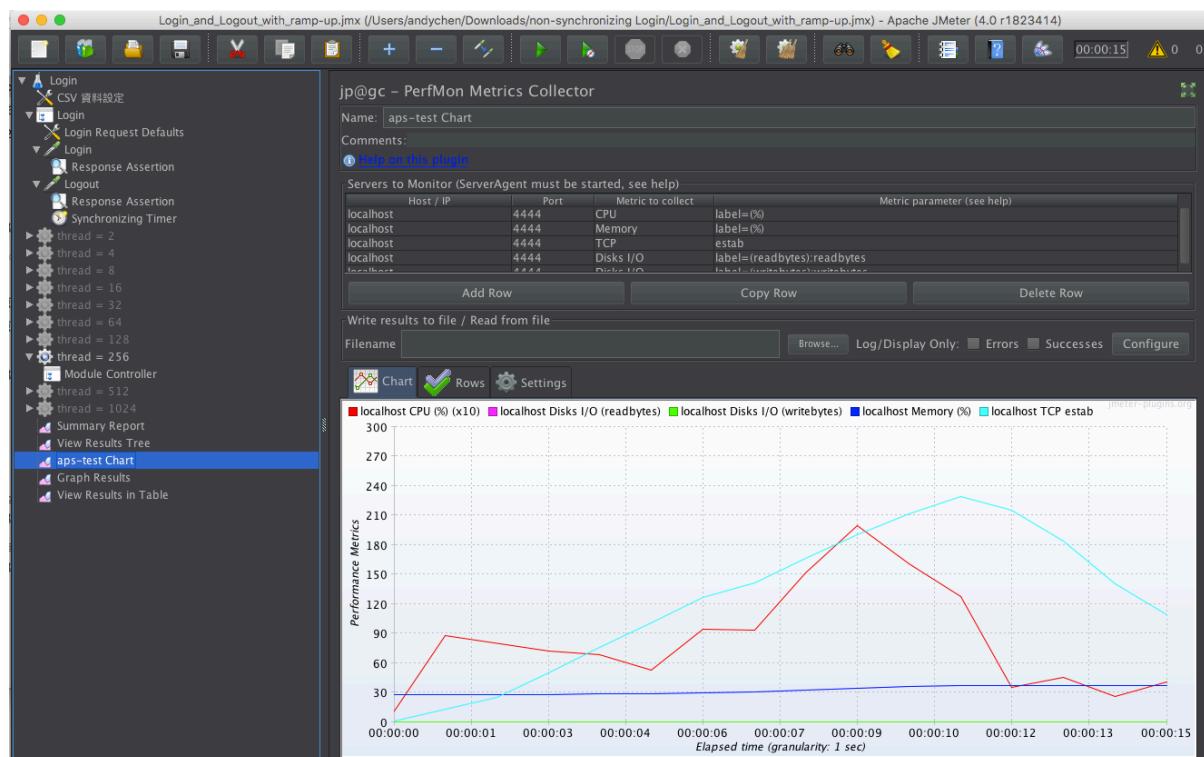
- Table Results in Table

Sample #	Start Time	Thread Name	Label	Sample Time(ms)	Status	Bytes	Sent Bytes	Latency	Connect Time(...)
243	11:07:08.393	thread = 256...	Login	4782	✓	435	230	4782	1
244	11:07:08.551	thread = 256...	Login	4638	✓	435	230	4638	1
245	11:07:08.590	thread = 256...	Login	4599	✓	435	230	4599	0
246	11:07:08.627	thread = 256...	Login	4564	✓	435	230	4564	1
247	11:07:08.670	thread = 256...	Login	4534	✓	435	230	4534	0
248	11:07:08.706	thread = 256...	Login	4500	✓	435	230	4500	0
249	11:07:08.787	thread = 256...	Login	4421	✓	435	230	4421	1
250	11:07:08.749	thread = 256...	Login	4461	✓	435	230	4461	1
251	11:07:08.826	thread = 256...	Login	4385	✓	435	230	4385	1
252	11:07:08.865	thread = 256...	Login	4348	✓	435	230	4348	1
253	11:07:08.904	thread = 256...	Login	4314	✓	435	230	4314	1
254	11:07:08.943	thread = 256...	Login	4276	✓	435	230	4276	3
255	11:07:08.981	thread = 256...	Login	4255	✓	435	230	4255	2
256	11:07:09.022	thread = 256...	Login	4216	✓	435	230	4216	2
257	11:07:13.241	thread = 256...	Logout	25	✗	405	136	25	3
258	11:07:13.240	thread = 256...	Logout	31	✗	405	136	31	3
259	11:07:13.241	thread = 256...	Logout	27	✗	405	136	27	4
260	11:07:13.243	thread = 256...	Logout	32	✗	405	136	31	6
261	11:07:13.238	thread = 256...	Logout	37	✗	405	136	37	7
262	11:07:13.244	thread = 256...	Logout	34	✗	405	136	34	6
263	11:07:13.238	thread = 256...	Logout	48	✗	405	136	48	3
264	11:07:13.257	thread = 256...	Logout	67	✗	405	136	67	2
265	11:07:13.245	thread = 256...	Logout	83	✗	405	136	83	6
266	11:07:13.238	thread = 256...	Logout	91	✗	405	136	91	7
267	11:07:13.238	thread = 256...	Logout	96	✗	405	136	95	18
268	11:07:13.258	thread = 256...	Logout	76	✗	405	136	76	3
269	11:07:13.251	thread = 256...	Logout	83	✗	405	136	83	3
270	11:07:13.254	thread = 256...	Logout	84	✗	405	136	84	8
271	11:07:13.346	thread = 256...	Logout	1	✗	2059	0	0	1
272	11:07:13.359	thread = 256...	Logout	1	✗	2059	0	0	1
273	11:07:13.260	thread = 256...	Logout	152	✗	405	136	152	2
274	11:07:13.259	thread = 256...	Logout	153	✗	405	136	153	3
275	11:07:13.249	thread = 256...	Logout	172	✗	405	136	172	3
276	11:07:13.252	thread = 256...	Logout	169	✗	405	136	169	2

- View Results Tree



- PerfMon Metrics Collector



(3) ISBN search books asynchronous:

- Summary Report (Error: 0.65%)

Label	# Samples	Average	Min	Max	Std. Dev.	Error %	Throughput	Received KB/sec	Sent KB/sec	Avg. Bytes
Login	256	654	3	1944	699.99	0.00%	21.4/sec	9.09	4.80	435.0
Search books	256	6	2	24	4.16	0.00%	21.4/sec	12.23	5.11	585.9
Logout	256	301	0	437	106.05	1.95%	502.9/sec	216.91	65.49	441.6
TOTAL	768	321	0	1944	487.14	0.65%	61.5/sec	29.27	12.17	487.5

- Table Results in Table

Sample #	Start Time	Thread Name	Label	Sample Time(ms)	Status	Bytes	Sent Bytes	Latency	Connect Time...
492	11:13:51.560	thread = 256...	Search books	6	✓	569	245	6	0
493	11:13:51.320	thread = 256...	Login	278	✓	435	230	278	1
494	11:13:51.600	thread = 256...	Search books	4	✓	551	245	4	0
495	11:13:51.366	thread = 256...	Login	275	✓	435	230	275	1
496	11:13:51.643	thread = 256...	Search books	2	✓	653	245	2	0
497	11:13:51.410	thread = 256...	Login	276	✓	435	230	276	1
498	11:13:51.689	thread = 256...	Search books	8	✓	545	245	8	0
499	11:13:51.459	thread = 256...	Login	287	✓	435	230	287	1
500	11:13:51.747	thread = 256...	Search books	4	✓	579	245	4	0
501	11:13:51.503	thread = 256...	Login	276	✓	435	230	276	0
502	11:13:51.780	thread = 256...	Search books	5	✓	579	245	5	0
503	11:13:51.444	thread = 256...	Login	288	✓	435	230	288	1
504	11:13:51.834	thread = 256...	Search books	8	✓	557	245	8	0
505	11:13:51.587	thread = 256...	Login	281	✓	435	230	281	0
506	11:13:51.870	thread = 256...	Search books	13	✓	581	245	13	0
507	11:13:51.633	thread = 256...	Login	288	✓	435	230	288	1
508	11:13:51.923	thread = 256...	Search books	12	✓	592	245	12	0
509	11:13:51.673	thread = 256...	Login	286	✓	435	230	285	1
510	11:13:51.961	thread = 256...	Search books	6	✓	573	245	6	0
511	11:13:51.715	thread = 256...	Login	295	✓	435	230	295	1
512	11:13:52.012	thread = 256...	Search books	13	✓	545	245	13	0
513	11:13:52.025	thread = 256...	Logout	10	✓	404	136	10	0
514	11:13:52.082	thread = 256...	Logout	0	✗	2059	0	0	0
515	11:13:52.082	thread = 256...	Logout	1	✗	2205	0	0	0
516	11:13:52.025	thread = 256...	Logout	148	✓	405	136	148	1
517	11:13:52.099	thread = 256...	Logout	74	✓	404	136	74	0
518	11:13:52.099	thread = 256...	Logout	74	✓	404	136	74	0
519	11:13:52.098	thread = 256...	Logout	80	✓	404	136	80	0
520	11:13:52.098	thread = 256...	Logout	80	✓	404	136	80	0
521	11:13:52.100	thread = 256...	Logout	81	✓	404	136	81	0
522	11:13:52.098	thread = 256...	Logout	83	✓	404	136	83	0
523	11:13:52.101	thread = 256...	Logout	80	✓	404	136	80	0
524	11:13:52.100	thread = 256...	Logout	81	✓	404	136	81	0
525	11:13:52.099	thread = 256...	Logout	87	✓	404	136	87	0

- View Results Tree

The screenshot shows the Apache JMeter interface with the 'View Results Tree' listener selected. The left pane displays the test plan structure, including a 'Logout' controller containing 'Logout' samplers. The right pane shows the results of these samplers, specifically the 'Logout' ones, with a detailed stack trace of the error. The stack trace indicates multiple attempts to connect to the server, with each attempt failing due to a connection reset.

- PerfMon Metrics Collector

The screenshot shows the Apache JMeter interface with the 'PerfMon Metrics Collector' listener selected. The left pane displays the test plan structure, including a 'Logout' controller containing 'Logout' samplers. The right pane shows a chart titled 'jp@gc - PerfMon Metrics Collector' displaying performance metrics over time. The chart includes four data series: 'localhost CPU %', 'localhost Disks I/O (readbytes)', 'localhost Disks I/O (writebytes)', and 'localhost Memory (%)'. The 'localhost Memory (%)' series remains relatively flat around 40%, while the other three metrics show a steady increase over the 13-second duration.

(4) ISBN search books synchronous:

- Summary Report (Error: 2.86%)

Label	# Samples	Average	Min	Max	Std. Dev.	Error %	Throughput	Received KB/sec	Sent KB/sec	Avg. Bytes
Login	256	469	3	1563	524.03	0.00%	22.2/sec	9.43	4.99	435.0
Search books	256	2753	45	7307	3196.76	7.81%	34.9/sec	24.26	7.69	712.5
Logout	256	399	1	639	114.77	0.78%	385.5/sec	157.35	50.80	417.9
TOTAL	768	1207	1	7307	2167.49	2.86%	39.3/sec	20.03	7.56	521.8

- Table Results in Table

Sample #	Start Time	Thread Name	Label	Sample Time(ms)	Status	Bytes	Sent Bytes	Latency	Connect Time(..)
494	11:20:31.424	thread = 256...	Search books	7274	✓	552	245	7274	226
495	11:20:31.417	thread = 256...	Search books	7283	✓	654	245	7283	226
496	11:20:31.422	thread = 256...	Search books	7279	✓	546	245	7279	226
497	11:20:31.417	thread = 256...	Search books	7286	✓	558	245	7286	226
498	11:20:31.422	thread = 256...	Search books	7283	✓	546	245	7283	226
499	11:20:31.420	thread = 256...	Search books	7286	✓	558	245	7286	227
500	11:20:31.418	thread = 256...	Search books	7290	✓	570	245	7290	227
501	11:20:31.421	thread = 256...	Search books	7289	✓	546	245	7289	227
502	11:20:31.421	thread = 256...	Search books	7291	✓	558	245	7290	227
503	11:20:31.427	thread = 256...	Search books	7286	✓	558	245	7286	341
504	11:20:31.427	thread = 256...	Search books	7289	✓	624	245	7289	341
505	11:20:31.426	thread = 256...	Search books	7294	✓	570	245	7294	342
506	11:20:31.427	thread = 256...	Search books	7295	✓	564	245	7295	341
507	11:20:31.425	thread = 256...	Search books	7297	✓	573	245	7297	343
508	11:20:31.426	thread = 256...	Search books	7298	✓	648	245	7298	342
509	11:20:31.426	thread = 256...	Search books	7301	✓	666	245	7301	342
510	11:20:31.426	thread = 256...	Search books	7302	✓	570	245	7302	342
511	11:20:31.426	thread = 256...	Search books	7304	✓	570	245	7304	342
512	11:20:31.426	thread = 256...	Search books	7307	✓	606	245	7307	342
513	11:20:38.748	thread = 256...	Logout	1	✗	2059	0	0	1
514	11:20:38.741	thread = 256...	Logout	151	✓	405	136	151	1
515	11:20:38.745	thread = 256...	Logout	147	✓	405	136	147	0
516	11:20:38.736	thread = 256...	Logout	156	✓	405	136	156	1
517	11:20:38.741	thread = 256...	Logout	151	✓	405	136	151	0
518	11:20:38.737	thread = 256...	Logout	155	✓	405	136	155	1
519	11:20:38.739	thread = 256...	Logout	153	✓	405	136	153	0
520	11:20:38.782	thread = 256...	Logout	119	✗	2059	0	0	119
521	11:20:38.745	thread = 256...	Logout	173	✓	405	136	173	1
522	11:20:38.743	thread = 256...	Logout	175	✓	405	136	175	1
523	11:20:38.745	thread = 256...	Logout	173	✓	405	136	173	1
524	11:20:38.745	thread = 256...	Logout	175	✓	405	136	175	0
525	11:20:38.745	thread = 256...	Logout	175	✓	405	136	175	0
526	11:20:38.735	thread = 256...	Logout	190	✓	405	136	190	0
527	11:20:38.734	thread = 256...	Logout	191	✓	405	136	191	1

- View Results Tree

The screenshot shows the Apache JMeter interface with the 'View Results Tree' listener selected. The left sidebar contains a tree view of the test plan. The right panel displays the results for the 'Logout' sampler. The results table has three columns: Sampler result, Request, and Response data. The 'Sampler result' column shows 256 entries, each with a green checkmark. The 'Request' and 'Response data' columns provide detailed information for each sample, including Thread Name, Sample Start, Load time, Connect Time, Latency, Size in bytes, Sent bytes, Headers size in bytes, Body size in bytes, Sample Count, Error Count, Data type, Response code, and Response message.

- PerfMon Metrics Collector

The screenshot shows the Apache JMeter interface with the 'PerfMon Metrics Collector' listener selected. The left sidebar contains a tree view of the test plan. The right panel displays a chart titled 'jp@gc - PerfMon Metrics Collector'. The chart shows performance metrics over time, with four data series: localhost CPU (%), localhost Disks I/O (readbytes), localhost Memory (%), and localhost TCP estab. The chart includes a legend and a grid for easier reading of values.

(5) Check out and Check in book asynchronous:

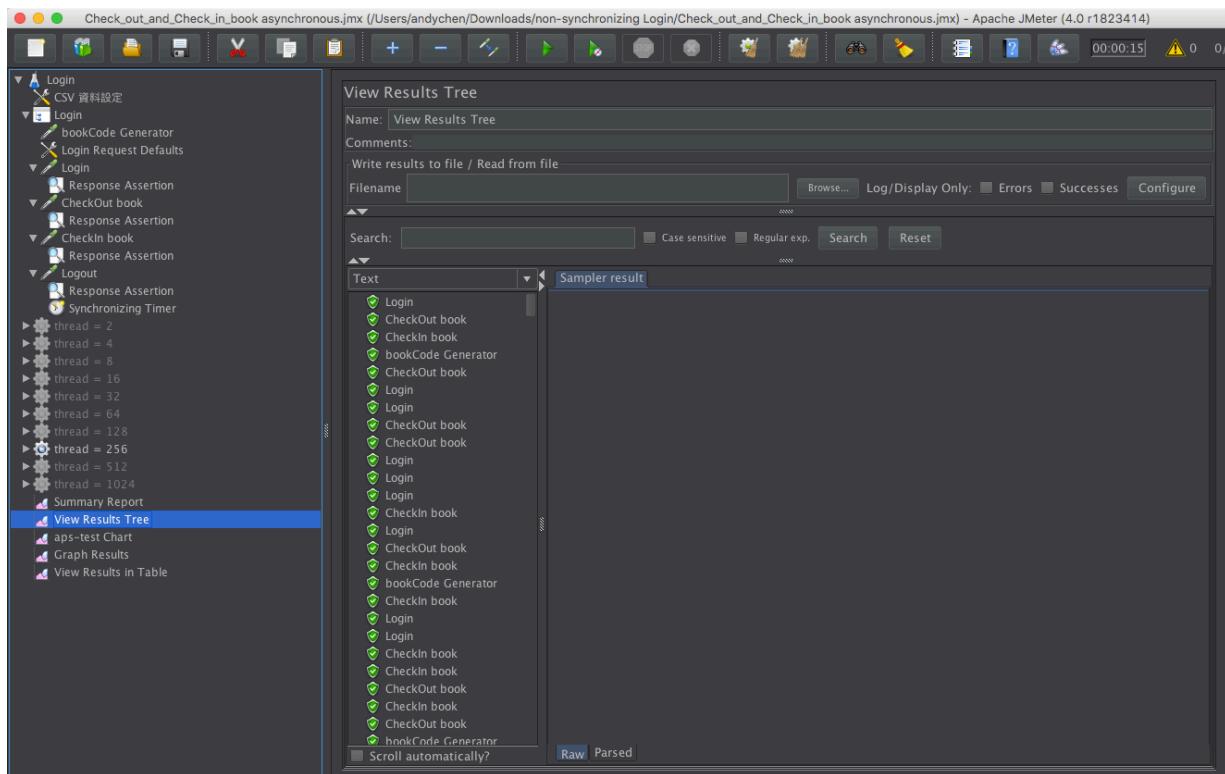
- Summary Report (Error: 0.47%)

Label	# Samples	Average	Min	Max	Std. Dev.	Error %	Throughput	Received KB/sec	Sent KB/sec	Avg. Bytes
bookCode G...	256	1	0	3	0.68	0.00%	23.2/sec	0.00	0.00	.0
Login	256	1954	7	2769	433.53	0.00%	19.7/sec	8.38	4.43	435.5
CheckOut b...	256	934	9	2451	929.38	0.00%	17.9/sec	3.93	4.55	225.5
Checkin book	256	648	5	2661	934.02	0.00%	17.7/sec	3.89	4.50	225.3
Logout	256	332	0	469	108.53	2.34%	472.3/sec	204.90	61.26	444.2
TOTAL	1280	774	0	2769	912.47	0.47%	84.9/sec	22.06	14.68	266.0

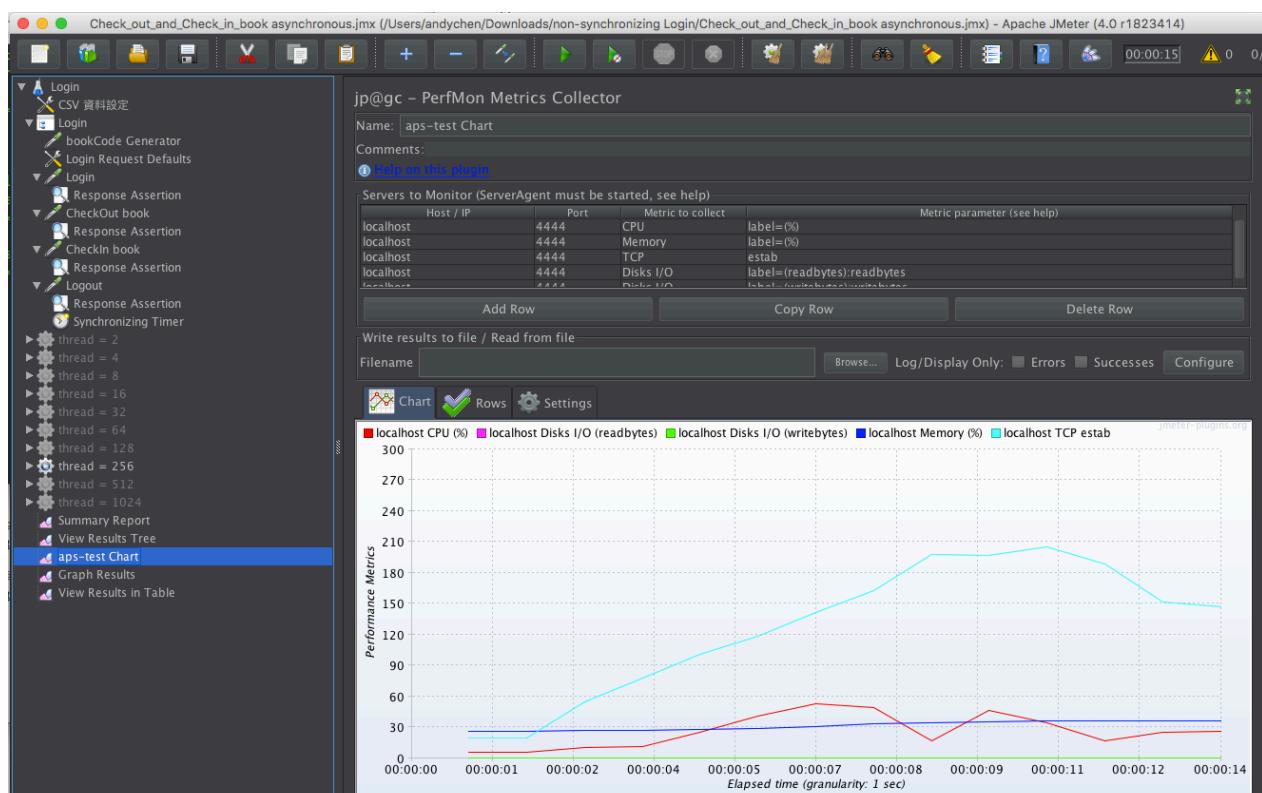
- Table Results in Table

Sample #	Start Time	Thread Name	Label	Sample Time...	Status	Bytes	Sent Bytes	Latency	Connect Time...
1	11:25:34.373	thread = 256...	bookCode Generator	2	✓	0	0	0	0
2	11:25:34.376	thread = 256...	Login	13	✓	435	230	13	1
3	11:25:34.389	thread = 256...	CheckOut book	27	✓	225	261	27	0
5	11:25:34.416	thread = 256...	Checkin book	17	✓	225	261	17	0
4	11:25:34.429	thread = 256...	bookCode Generator	2	✓	0	0	0	0
6	11:25:34.431	thread = 256...	Login	11	✓	435	230	11	1
7	11:25:34.442	thread = 256...	CheckOut book	17	✓	225	261	17	0
9	11:25:34.459	thread = 256...	Checkin book	18	✓	225	261	18	0
8	11:25:34.465	thread = 256...	bookCode Generator	2	✓	0	0	0	0
10	11:25:34.467	thread = 256...	Login	11	✓	435	230	11	0
11	11:25:34.478	thread = 256...	CheckOut book	17	✓	225	261	17	0
12	11:25:34.495	thread = 256...	Checkin book	12	✓	225	261	12	0
13	11:25:34.514	thread = 256...	bookCode Generator	1	✓	0	0	0	0
14	11:25:34.515	thread = 256...	Login	9	✓	435	230	9	1
15	11:25:34.524	thread = 256...	CheckOut book	13	✓	225	261	13	0
16	11:25:34.537	thread = 256...	Checkin book	11	✓	225	261	11	0
17	11:25:34.557	thread = 256...	bookCode Generator	2	✓	0	0	0	0
18	11:25:34.559	thread = 256...	Login	7	✓	435	230	7	0
19	11:25:34.566	thread = 256...	CheckOut book	11	✓	225	261	11	0
20	11:25:34.577	thread = 256...	Checkin book	7	✓	225	261	7	0
21	11:25:34.604	thread = 256...	bookCode Generator	2	✓	0	0	0	0
26	11:25:34.606	thread = 256...	Login	218	✓	435	230	218	0
22	11:25:34.651	thread = 256...	bookCode Generator	1	✓	0	0	0	0
52	11:25:34.653	thread = 256...	Login	1179	✓	435	230	1179	0
23	11:25:34.697	thread = 256...	bookCode Generator	1	✓	0	0	0	0
53	11:25:34.698	thread = 256...	Login	1139	✓	435	230	1139	1
24	11:25:34.745	thread = 256...	bookCode Generator	2	✓	0	0	0	0
81	11:25:34.747	thread = 256...	Login	2085	✓	435	230	2085	0
25	11:25:34.795	thread = 256...	bookCode Generator	1	✓	0	0	0	0
82	11:25:34.796	thread = 256...	Login	2038	✓	435	230	2038	1
27	11:25:34.824	thread = 256...	CheckOut book	14	✓	225	261	14	0
29	11:25:34.838	thread = 256...	Checkin book	9	✓	225	261	9	0
28	11:25:34.840	thread = 256...	bookCode Generator	1	✓	0	0	0	0
83	11:25:34.842	thread = 256...	Login	1997	✓	435	230	1997	1

- View Results Tree



- PerfMon Metrics Collector



(6) Check out and Check in book synchronous:

- Summary Report (Error: 2.27%)

Label	# Samples	Average	Min	Max	Std. Dev.	Error %	Throughput	Received KB/sec	Sent KB/sec	Avg. Bytes
bookCode G...	256	2	0	3	0.63	0.00%	23.4/sec	0.00	0.00	.0
Login	256	434	2	1321	474.07	0.00%	22.1/sec	9.41	4.97	435.0
CheckOut b...	256	3291	213	8062	3402.71	1.17%	31.3/sec	6.91	7.98	226.1
CheckIn book	256	678	8	7730	1491.65	5.86%	31.3/sec	7.07	7.99	231.2
Logout	256	225	2	413	112.03	4.30%	603.8/sec	281.83	76.74	478.0
TOTAL	1280	918	0	8062	2054.19	2.27%	62.8/sec	16.82	10.83	274.0

- Table Results in Table

Sample #	Start Time	Thread Name	Label	Sample Time...	Status	Bytes	Sent Bytes	Latency	Connect Tim...
495	11:31:07.483	thread = 256...	bookCode Generator	3	✓	0	0	0	0
496	11:31:06.896	thread = 256...	Login	596	✓	435	230	596	0
497	11:31:07.529	thread = 256...	bookCode Generator	3	✓	0	0	0	0
498	11:31:06.935	thread = 256...	Login	599	✓	435	230	599	1
499	11:31:06.981	thread = 256...	Login	599	✓	435	230	599	0
500	11:31:07.021	thread = 256...	Login	595	✓	435	230	595	0
501	11:31:07.062	thread = 256...	Login	602	✓	435	230	602	0
502	11:31:07.103	thread = 256...	Login	603	✗	435	230	603	0
503	11:31:07.151	thread = 256...	Login	604	✓	435	230	604	1
504	11:31:07.193	thread = 256...	Login	601	✓	435	230	601	1
505	11:31:07.236	thread = 256...	Login	603	✓	435	230	603	0
506	11:31:07.279	thread = 256...	Login	599	✓	435	230	599	0
507	11:31:07.319	thread = 256...	Login	605	✓	435	230	605	1
508	11:31:07.363	thread = 256...	Login	600	✓	435	230	600	1
509	11:31:07.405	thread = 256...	Login	606	✓	435	230	606	0
510	11:31:07.444	thread = 256...	Login	605	✓	435	230	605	1
511	11:31:07.486	thread = 256...	Login	603	✓	435	230	603	0
512	11:31:07.532	thread = 256...	Login	605	✓	435	230	605	1
513	11:31:08.137	thread = 256...	CheckOut book	216	✓	226	261	216	1
514	11:31:08.140	thread = 256...	CheckOut book	213	✓	226	261	213	1
515	11:31:08.137	thread = 256...	CheckOut book	219	✓	225	261	219	0
516	11:31:08.138	thread = 256...	CheckOut book	229	✓	226	261	229	1
517	11:31:08.137	thread = 256...	CheckOut book	230	✓	226	261	230	1
518	11:31:08.142	thread = 256...	CheckOut book	226	✓	226	261	226	5
519	11:31:08.173	thread = 256...	CheckOut book	230	✓	226	261	230	1
520	11:31:08.142	thread = 256...	CheckOut book	266	✓	226	261	266	0
521	11:31:08.158	thread = 256...	CheckOut book	255	✓	226	261	255	3
522	11:31:08.158	thread = 256...	CheckOut book	256	✓	226	261	256	3
523	11:31:08.140	thread = 256...	CheckOut book	274	✓	226	261	274	1
524	11:31:08.141	thread = 256...	CheckOut book	274	✓	226	261	274	1
525	11:31:08.150	thread = 256...	CheckOut book	266	✓	226	261	266	8
526	11:31:08.162	thread = 256...	CheckOut book	255	✓	226	261	255	4
527	11:31:08.164	thread = 256...	CheckOut book	291	✓	226	261	291	5
528	11:31:08.140	thread = 256...	CheckOut book	319	✗	226	261	319	1

- View Results Tree

Check_out_and_Check_in_book_synchronous.jmx (/Users/andychen/Downloads/non-synchronizing Login/Check_out_and_Check_in_book synchronous.jmx) - Apache JMeter (4.0 r1823414)

View Results Tree

Name: View Results Tree
Comments:
Write results to file / Read from file
Filename: Browse... Log/Display Only: Errors Successes Configure

Search: Case sensitive Regular exp. Search Reset

Text Sampler result Request Response data

Thread Name: thread = 256 1-52
Sample Start: 2018-06-13 11:31:09 CST
Load time: 105
Connect Time: 0
Latency: 105
Size in bytes: 323
Sent bytes: 261
Headers size in bytes: 226
Body size in bytes: 97
Sample Count: 1
Error Count: 1
Data type ("text"/"bin"): text
Response code: 200
Response message: OK

Response headers:
HTTP/1.1 200 OK
Date: Wed, 13 Jun 2018 03:31:15 GMT
Server: Apache/2.4.10 (Debian)
Vary: Accept-Encoding
Content-Length: 97
Keep-Alive: timeout=5, max=99
Connection: Keep-Alive
Content-Type: text/html; charset=UTF-8

HTTPSampleResult fields:
Content-Type: text/html; charset=UTF-8
DataEncoding: UTF-8

Raw Parsed

- PerfMon Metrics Collector

Check_out_and_Check_in_book_synchronous.jmx (/Users/andychen/Downloads/non-synchronizing Login/Check_out_and_Check_in_book synchronous.jmx) - Apache JMeter (4.0 r1823414)

jp@gc – PerfMon Metrics Collector

Name: aps-test Chart
Comments:
[Help on this plugin](#)

Servers to Monitor (ServerAgent must be started, see help)

Host / IP	Port	Metric to collect	Metric parameter (see help)
localhost	4444	CPU	label=(%)
localhost	4444	Memory	label=(%)
localhost	4444	TCP	estab
localhost	4444	Disks I/O	label=(readbytes):readbytes
localhost	4444	Disks I/O	label=(writebytes):writebytes

Add Row Copy Row Delete Row

Write results to file / Read from file
Filename: Browse... Log/Display Only: Errors Successes Configure

Chart Rows Settings

Performance Metrics

localhost CPU % localhost Disks I/O (readbytes) localhost Disks I/O (writebytes) localhost Memory (% x10) localhost TCP estab

Elapsed time (granularity: 1 sec)

5 Conclusion

在軟體測試中除了需確認功能性需求是否有達成外，也須注重非功能性需求是否有滿足使用者的期待。當 Web Application 同時有多人上線時，伺服器能否正常運作是很重要的。本次 Lab 是我第一次撰寫針對 Web Application 的負載測試，在這次的測試實作過程當中我學習到了 JMeter 這套壓力測試工具以及 Docker 的基本使用方式。

本次實驗遇到最大的問題是在發送 Logout 的 HTTP Request 時會隨機出現錯誤，而發生錯誤的原因不知道是 JMeter 的問題或是 Web Server 本身的問題。若需驗證 Web Server 端是否有正確的收到封包我們必須要架設如 Wireshark 的封包擷取工具才能得知。

本次測試所撰寫的測試結果均全數通過，且符合 *section 1.3* 所訂定的 Success criteria。