Module Code	**:**	CT071-3-3-DDAC
Module Title	**:**	Designing and Developing Applications on the Cloud
Intake Code	**:**	UC3F1701SE
Lecturer Name	**:**	DR. KALAI ANAND A/L RATNAM
Hand in Date	**:**	2nd October 2017
Student Name	**:**	Thum Choon Tat
Student ID	**:**	TP030470

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Introduction

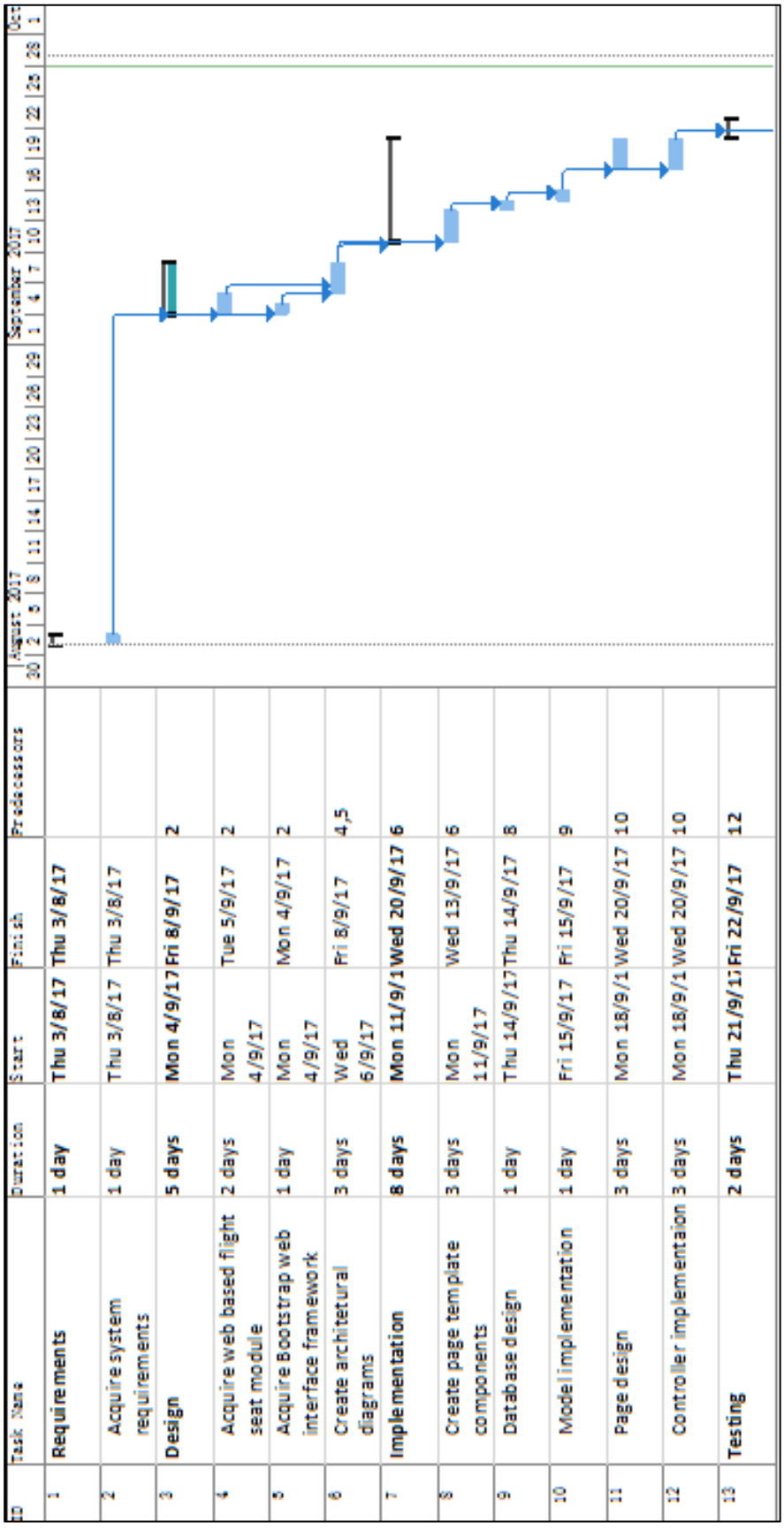
Online shoppers are notoriously fickle. If a website lags for even a few seconds, shoppers are just a couple of clicks away from many more options. Ukraine International Airlines (UIA) is the flagship carrier and largest airline in Ukraine. It operates domestic and international passenger flights and cargo services to Europe, the Middle East, the United States, and Asia.

The airline is eager to expand into new markets, but problems with its website prevented it from adequately serving customers beyond Ukraine. The site experienced severe denial-of-service (DOS) attacks, which hurt site performance and reliability, and it did not have the performance needed to host visitors from many parts of the world.

UIA has long used technology to reduce costs, innovate, and improve customer service. It has gone to a paperless cockpit and uses sophisticated software for analysing fuel economy. The airline decided that it once again needed to innovate its way out of its web challenges.

Dmitriy Prudnikov, Chief Information Officer at Ukraine International Airlines, realized that migrating the website out of UIA datacentres into a public cloud could solve all these problems. Therefore, an Online Flight Booking System will be developed and hosted into Microsoft Azure cloud service, which allow users to create user accounts and book tickets.

Project plan



ID	Task Name	Duration	Start	Finish	Predecessors
1	**Requirements**	**1 day**	**Thu 3/8/17**	**Thu 3/8/17**	
2	Acquire system requirements	1 day	Thu 3/8/17	Thu 3/8/17	
3	**Design**	**5 days**	**Mon 4/9/17**	**Fri 8/9/17**	2
4	Acquire web based flight seat module	2 days	Mon 4/9/17	Tue 5/9/17	2
5	Acquire Bootstrap web interface framework	1 day	Mon 4/9/17	Mon 4/9/17	2
6	Create architetural diagrams	3 days	Wed 6/9/17	Fri 8/9/17	4,5
7	**Implementation**	**8 days**	**Mon 11/9/17**	**Wed 20/9/17**	6
8	Create page template components	3 days	Mon 11/9/17	Wed 13/9/17	6
9	Database design	1 day	Thu 14/9/17	Thu 14/9/17	8
10	Model implementation	1 day	Fri 15/9/17	Fri 15/9/17	9
11	Page design	3 days	Mon 18/9/17	Wed 20/9/17	10
12	Controller implementaion	3 days	Mon 18/9/17	Wed 20/9/17	10
13	**Testing**	**2 days**	**Thu 21/9/17**	**Fri 22/9/17**	12

Design

Cloud pattern design

Cloud design patterns are useful in developing a reliable, scalable and secure applications in the cloud (Christopher Bennage, 2017). Index Table pattern has been chosen to be implemented into this system. Index Table pattern is implemented by creating indexes on columns which are frequently being queried to improve the performance on getting indexed data (Christopher Bennage, 2017).

#	Name	Type	Collation	Attributes	Null	Default	Extra
1	flightID	int(11)			No	*None*	AUTO_INCREMENT
2	departureTime	timestamp			No	CURRENT_TIMESTAMP	
3	arrivalTime	timestamp			Yes	*NULL*	
4	source	varchar(3)			No	*None*	
5	destination	varchar(3)			No	*None*	
6	fare	float			No	*None*	

Figure 1: Flight table

The image above shows the table structure for flight table, which has departure time column indexed. The reason of indexing departure time column is to improve the performance of user searching flight based on departure time. Although it is possible to search a flight by flight ID, but the user prefers to search flight by departure time because flight ID in this table are auto incremented. Plus, auto incremented flight ID is meaningless and only used to identify unique flights. Without creating an index on departure time, the query performance will drop because the user can only search flights by departure time. Therefore, the decision of indexing departure time column is made.

Architectural diagrams

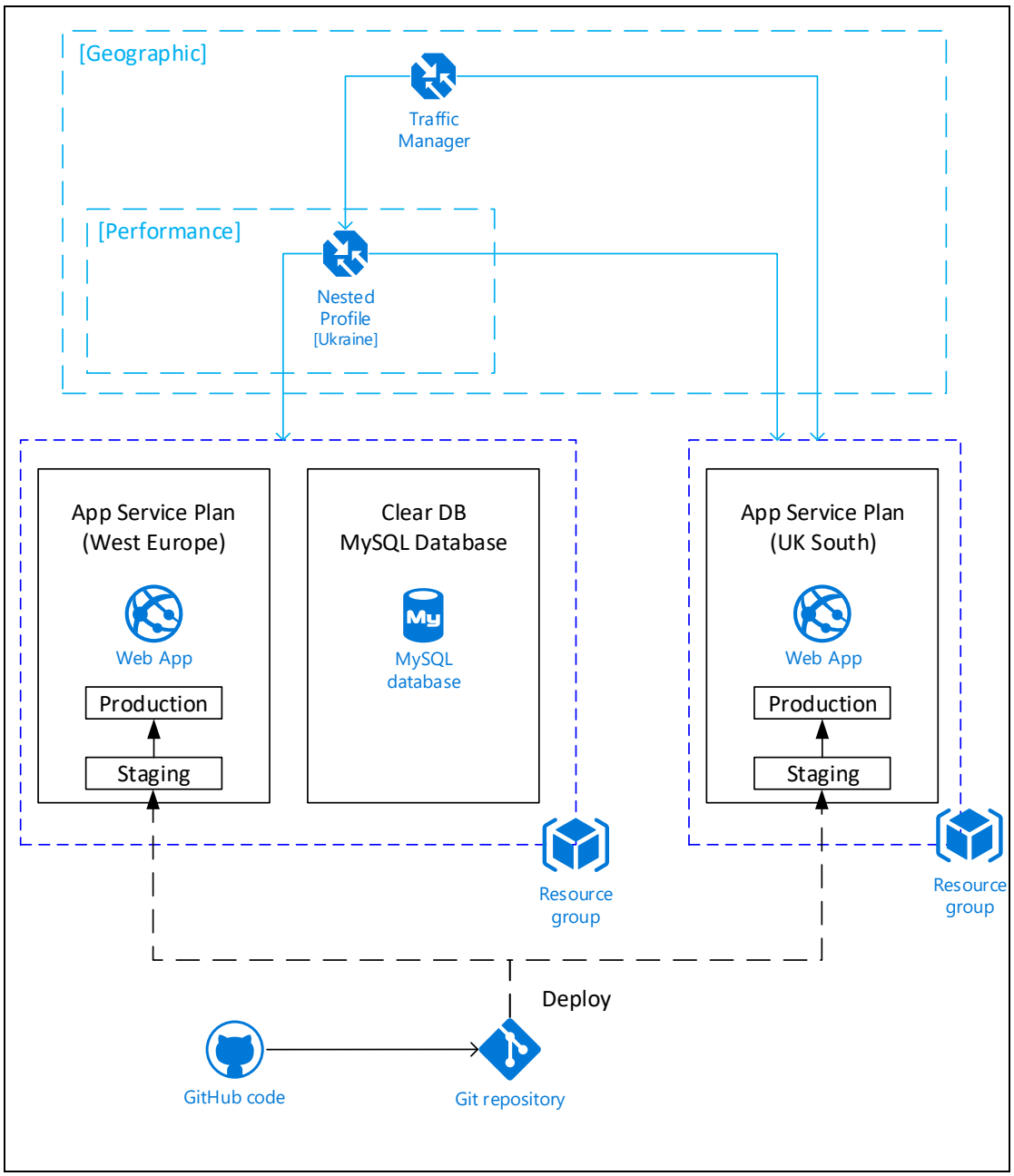


Figure 2: Cloud architecture

Estimated pricing

Microsoft Azure Estimate

Service type	Region	Description	Estimated Cost
App Service	West Europe	1 instance(s) x 1 Months, Size: S1, Standard tier	RM331.08
App Service	UK South	1 instance(s) x 1 Months, Size: S1, Standard tier	RM413.85
Traffic Manager	West Europe	1 million DNS queries/month, 1 Azure endpoint(s)	RM4.005
Traffic Manager	West Europe	1 million DNS queries/month, 2 Azure endpoint(s)	RM5.607
ClearDB MySQL database	West Europe	Pricing Tier: Venus Backup ready	RM42.00
Support		Support	RM0.00
		Monthly Total	RM796.542
		Annual Total	RM9,558.504

The estimated pricing for each service type listed above, except ClearDB MySQL database, are retrieved from Microsoft Azure Pricing Calculator.

Design considerations

As the main users of Online Flight Booking System are mostly from Ukraine, the web application service as well as database will require to be hosted in Azure datacentre near Ukraine to provide high availability system for them. A secondary web application service will be hosted in the second nearest datacentre for other users to access the web application and will uses the database service hosted in nearest datacentre. With limited credit of RM150 provided, the number of web application hosting days will be reduced and all performance tests are required to be completed in limited time as the monthly cost for hosting the web applications are around RM796 as described above.

Modelling

Use case

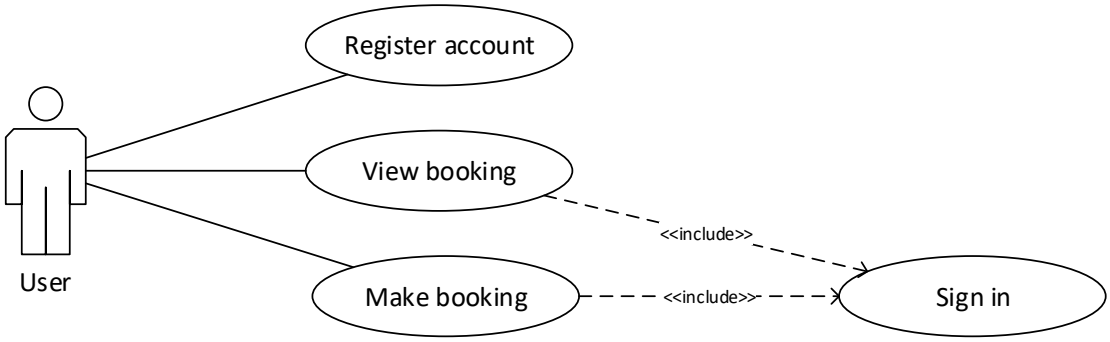


Figure 3: Use case diagram

Sequence

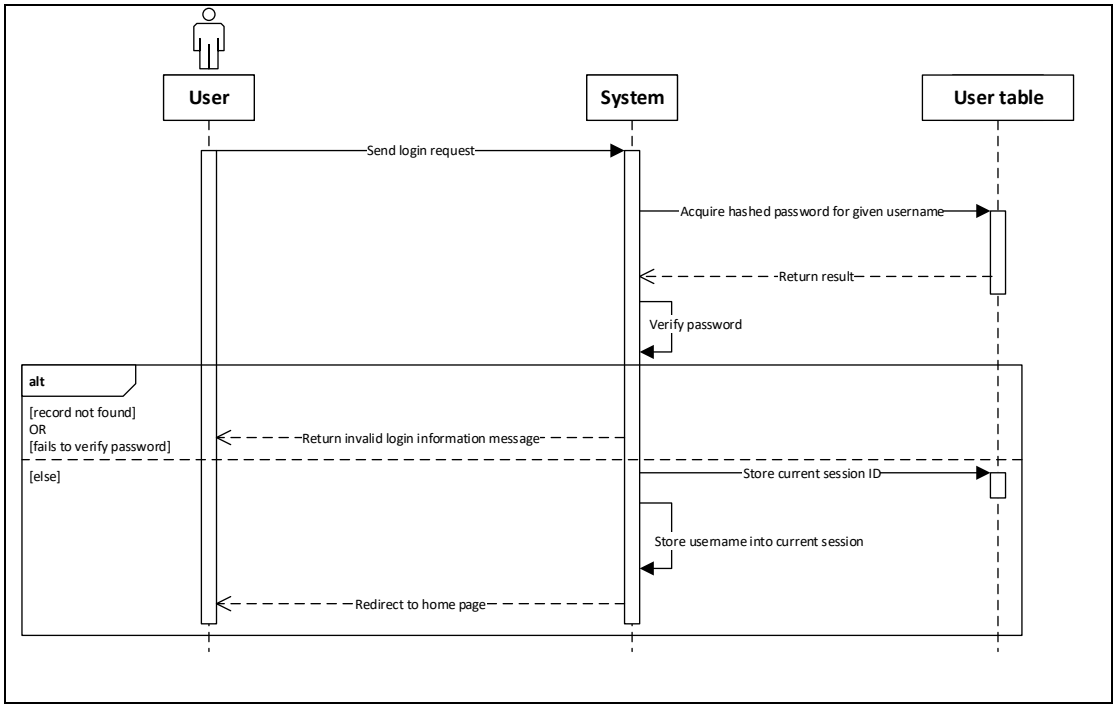


Figure 4: Login

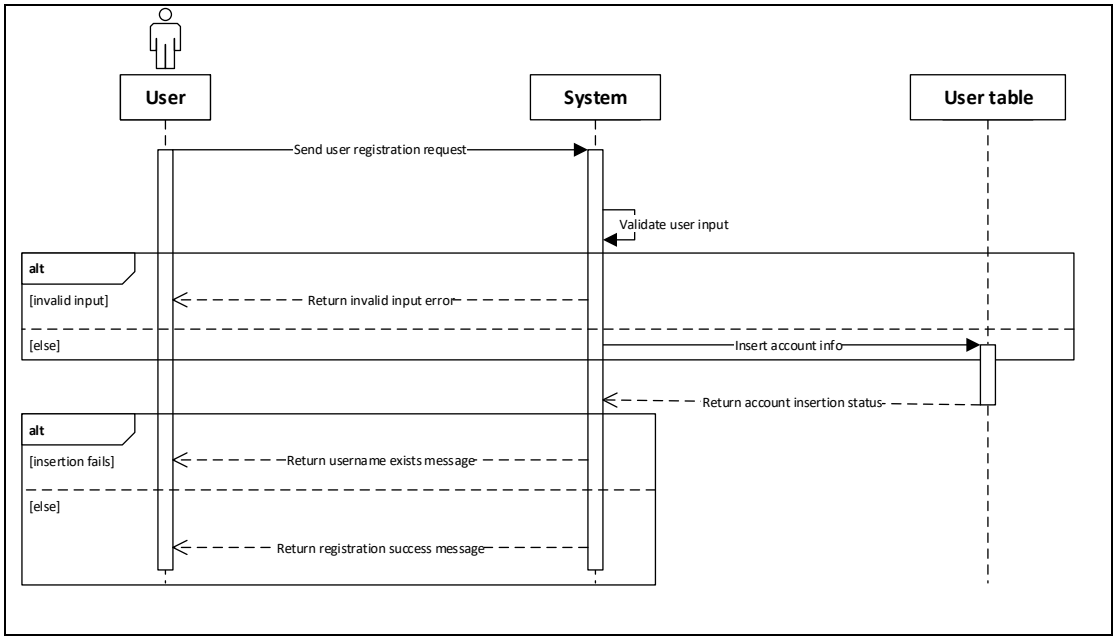


Figure 5: Register

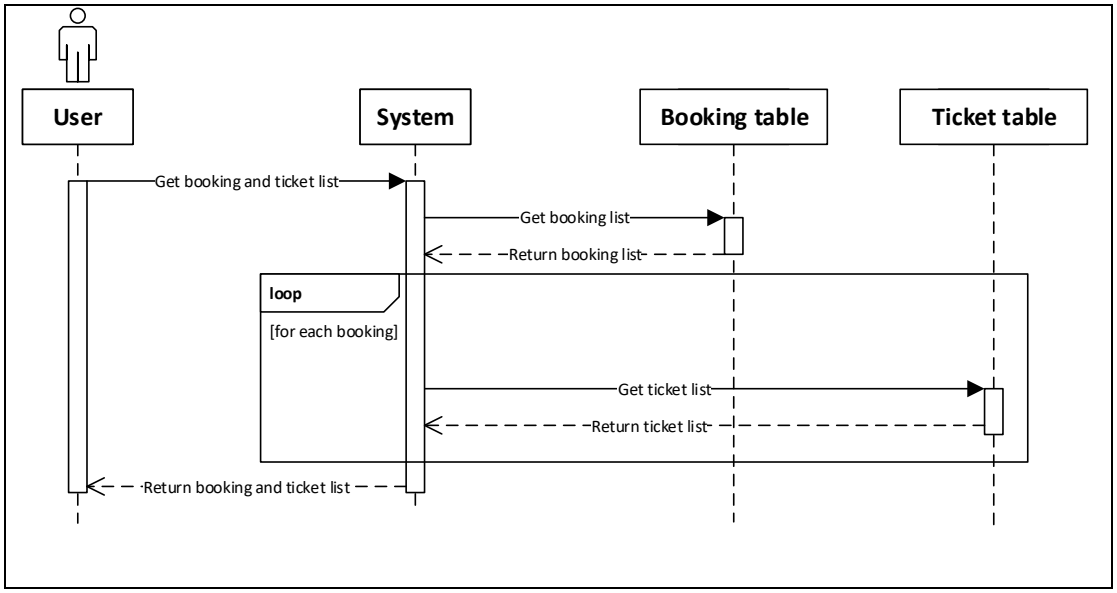


Figure 6: View booking

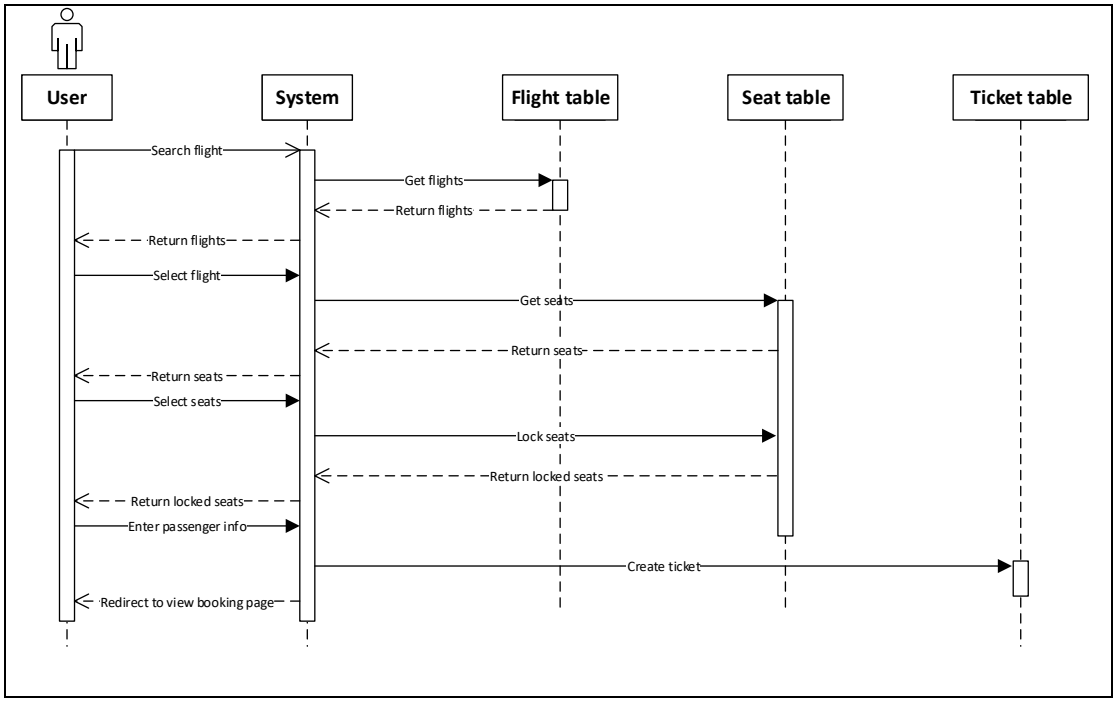


Figure 7: Make booking

Page flow

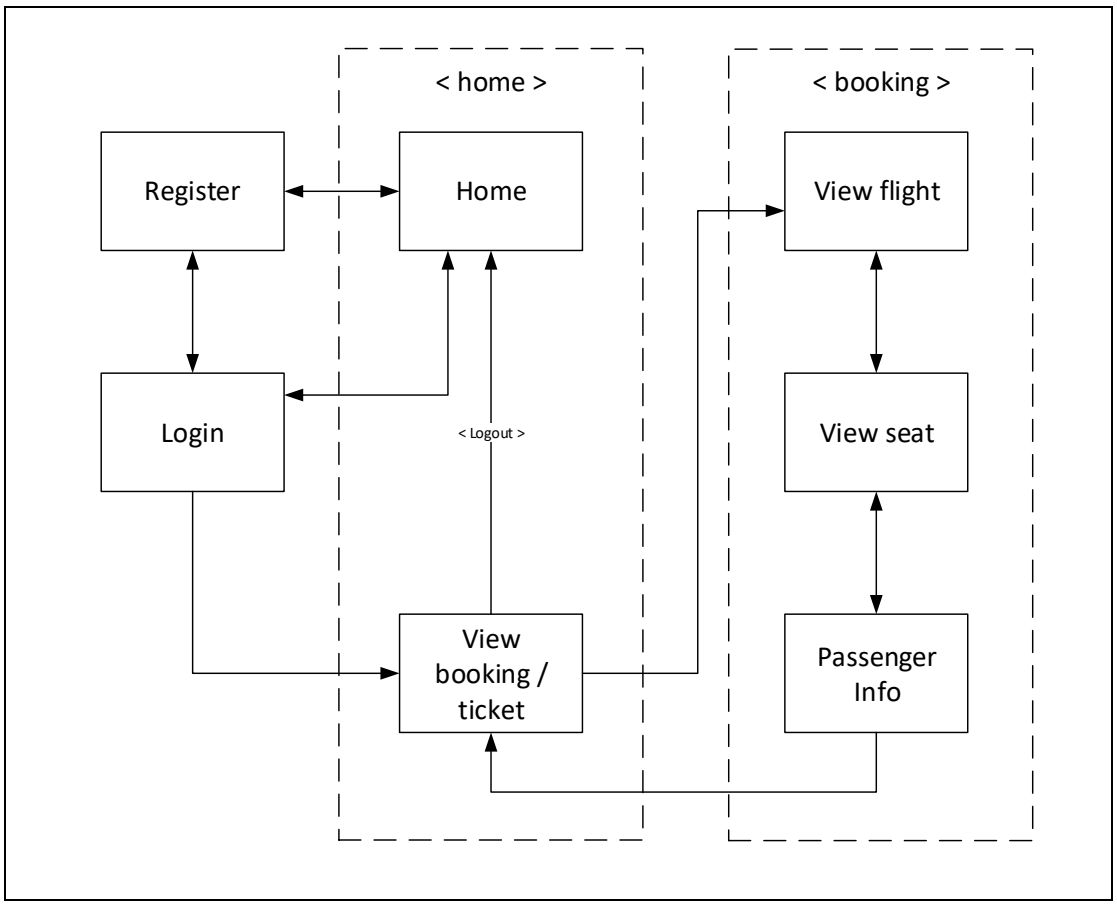


Figure 8: Page flow

ERD

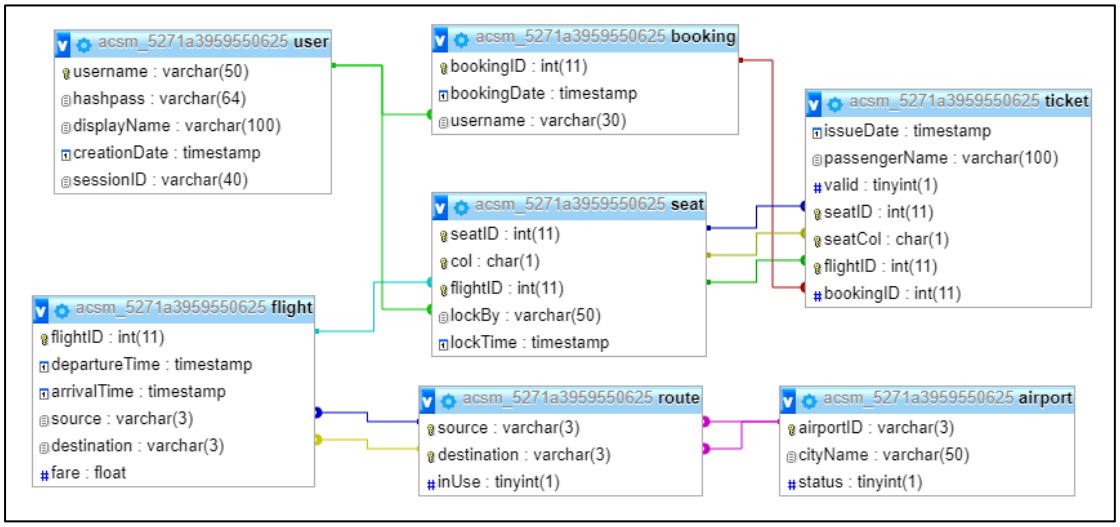
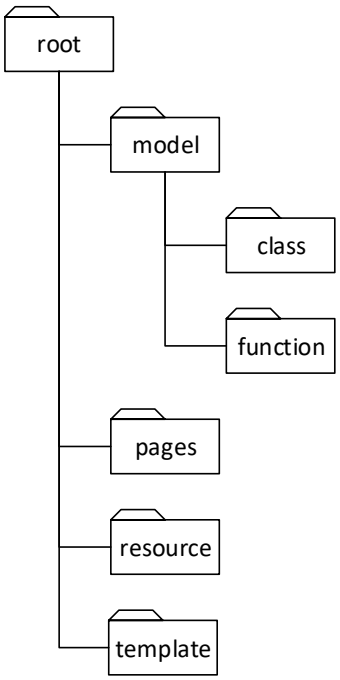


Figure 9: ERD

Implementation

File system architecture

The UIA flight booking system is developed with PHP with MVC architecture implemented. The directories for the system are as follows:



Directory	Description
Root	System root directory
Model	Contains model components
Class	Store database connector, message and user classes
Function	Stores flight, seat and ticket functions
Pages	Contains view and controller components
Resource	Contains web page resources, such as CSS, JS and images
Template	Stores common view for pages across the system

Every request received by this system will be redirected to index page and load page contents from pages directory based on user privilege and requested page. The request redirect rule is written in configuration file named ".htaccess". Header and footer will be included in every page fetched from Template directory. The purpose of redirecting all requests to index page is to restrict user from accessing and modifying system files such as configuration files.

Each directory in Pages directory are treated as a page with 3 files, which are core file, resources file and content file. Core file act as the controller for the page, resources file act as the container of additional web file resources such as cascading stylesheets and JavaScript, and content file act as the view component of the page. The index page will load these files based on the URL entered by the user. For example, if the user enters "/login" at the end of the domain URL, the index script will fetch the 3 files from "/pages/login" directory. Any other files included in pages directory will not affect the system behaviour and will be ignored by the system. If the content file does not exist in the page, a temporary page content will be fetched from Template directory stating that the page is empty. The purpose of separating controller file from content file is to enable the controller to perform page redirect action as page redirect action is not available after writing response contents.

System hosting on cloud

After the system is developed and tested on local server in local machine, the system is then deployed into cloud in West Europe region and UK South region. The reason of deploying the application in these regions is to conduct user load test by simulating traffics coming from regions near Ukraine. Although Germany region is closer to Ukraine compared with West Europe, the option to deploy the web application on Germany data centre is not available.

Web application hosted on both regions are deployed using single repository in GitHub source control management service, therefore changes of web application will updates both hosted web application at once. Both web application uses app service with standard pricing tier (S1 Standard) applied. The reason of choosing standard pricing tier is to allow the web application to be configured in traffic manager.

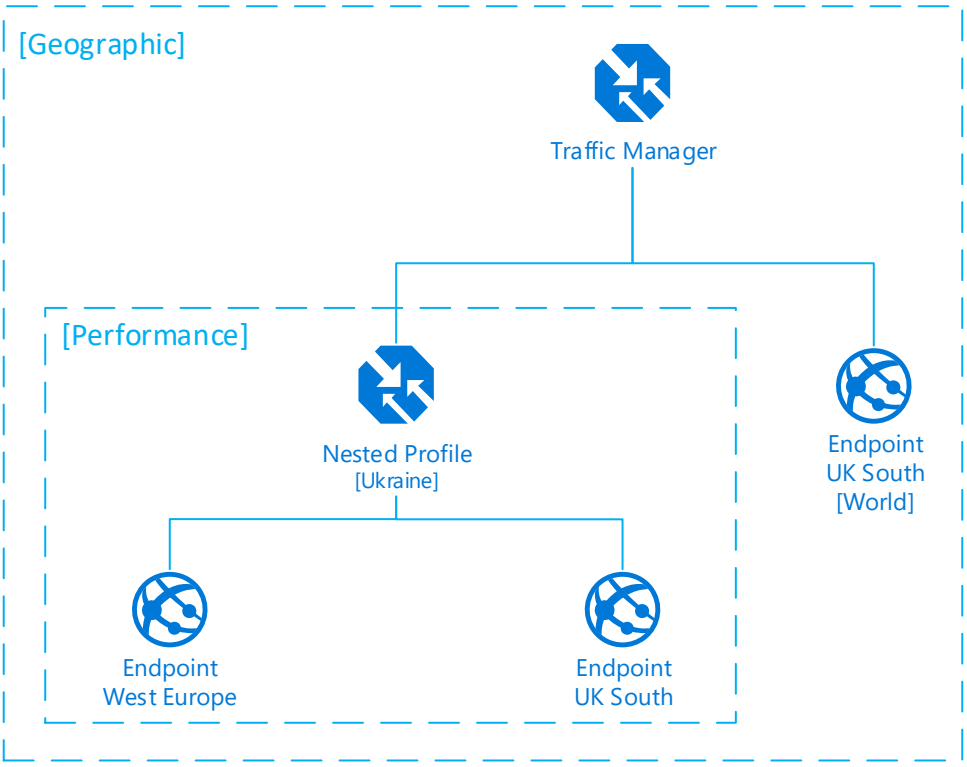


Figure 10: Traffic manager

The traffic manager is configured to use geographical routing method and added endpoints to both web application deployed in West Europe and UK South region. Additional traffic manager profile with performance routing method is created to be included as a nested profile for the geographical routed traffic manager as shown above. As the main users of this system are from Ukraine, the endpoint in West Europe is only exposed to users from Ukraine and will have experience on high performance web application.

Managed database

Platform as a service (PaaS) is a category in cloud computing which provides platform and environment for developers to build applications and services (Interoute Communications, 2017). Therefore, the developers will not require to install additional hardware and software to develop and run applications (Rouse, 2015) as they are provided by cloud service provider or partners of cloud service provider.

In the case of this application, MySQL database provided by ClearDB is selected to store flights and bookings data hosted in West Europe. The reason of hosting database in West Europe is to reduce latency of users from Ukraine accessing booking

and flights data as it is located near Ukraine. Plus, the pricing for the selected database is lower than MySQL database provided by Microsoft Azure.

MySQL database provided by ClearDB guarantees service availability of 99.5% Service Level Agreement for single instance database (ClearDB, 2017), which is current being used in this system. ClearDB also provides scheduled backups in multiple regions in multiple time zones and have their teams constantly monitoring databases to fulfil their SLA (ClearDB, 2017).

By hosting large databases from the cloud, the cost of managing it will be reduced as scaling databases is cheaper on the cloud than purchasing and configure additional servers manually (Howell, 2013). Also, backup services are automated and available for disaster recovery and remote access to the database (Network Specialists, 2014). Although hosting databases on cloud provide significant advantages, but the user will not have full control on the servers hosting the databases (Network Specialists, 2014). Plus, there will be hesitations on storing sensitive data on the cloud such as financial data or health reports (Sears, 2014). Taking advantage of storing sensitive data at on site servers and other data on the cloud could be a solution to the security issue on sensitive data, but the user will be responsible for disaster recovery for data stored in on site servers.

Test plan

Unit test

ID	Title	Description	Result	
			Expected	**Actual**
General site test suite				
GS1	403 forbidden	Notify user when accessing valid pages without enough privileges Procedure: 1. Enter "/booking" at the end of domain URL while not logged in	Redirect to error 403 page	403 error page is shown
GS2	404 not found	Notify user when accessing invalid pages Procedure: 1. Enter "/shop" at the end of domain URL	Redirect to error 404 page	404 error page is shown
GS3	Error page direct access	Redirect user to home page when trying to access error page manually Procedure: 1. Enter "/error" at the end of domain URL	Redirect to home page	Home page is shown

ID	Title	Description	Result	
			Expected	**Actual**
GS4	New session	Stores session ID into database when logged in Procedure: 1. Login with valid user credential	Store session ID into database	Session ID is stored
GS5.1	Destroy session	User session destroys when user logs out Procedure: 1. While logged in, click on “Logout” button at the right side of navigation bar	Redirect user to home page with sign in and register option enabled	User is redirected to home page with login and register option enabled
GS5.2		User session destroys when user closes web browser Procedure: 1. Closes web browser while logged in 2. Open web browser with domain URL entered	Show home page with sign in and register option	Home page with sign in and register option is shown
GS5.3		User session destroys when same account is being used in another web browser Procedure: 1. Sign in with valid user credential in web browser A 2. Sign in with same user credential in web browser B 3. Refresh ticket list page in web browser A	Web browser A shows home page with sign in and register option enabled	Web browser A redirected to public home page

ID	Title	Description	Result	
			Expected	**Actual**
User privilege test suite				
UP1	User navigation links	Loads user navigation links when logged in Procedure: 1. Sign in with valid user credential	Show booking navigation link	Booking navigation link is shown
Navigation bar test suite				
NB1.1	Website title	Redirect user to home page when clicked on “UIA” while not signed in	Redirect user to public home page	Redirect user to public home page
NB1.2		Redirect user to home page when clicked on “UIA” while signed in	Redirect user to ticket list page	Redirect user to ticket list page
NB2.1	Home page	Redirect user to home page when clicked on “Home” while not signed in	Redirect user to public home page	Redirect user to public home page
NB2.2		Redirect user to home page when clicked on “Home” while signed in	Redirect user to ticket list page	Redirect user to ticket list page
NB3	Booking page	Redirect user to boking page when clicked on “Booking” while signed in	Redirect user to booking page	Redirect user to booking page
Home page test suite				

ID	Title	Description	Result	
			Expected	Actual
HP1.1	Page content	Shows home page while not logged in	Show home page with website title	Home page with website title is shown
HP1.2		Shows home page while logged in	Show ticket list page	Ticket list page is shown
HP2.1	Search tickets	Shows ticket list with valid booking date range Procedure: 1. Enter valid booking date range 2. Click on “Search Tickets” button	Show tickets associate with booking date range	Tickets are shown
HP2.2		Shows ticket list with invalid booking date range Procedure: 1. Enter valid booking date range 2. Click on “Search Tickets” button	Does not show ticket list	Tickets are not shown
Login page test suite				
LP1.1	Login	Shows alert on invalid user credential used to sign in Procedure: 1. Enter invalid username and password 2. Click on “Login”	Show alert with “Invalid username / password” message	Alert shown

ID	Title	Description	Result	
			Expected	**Actual**
LP1.2		Redirect user to home page upon successful login Procedure: 1. Enter valid username and password 2. Click on “Login”	Redirect user to ticket list page	Ticket list page shown
LP2	Register link	Redirect user to registration page Procedure: 1. Click on “here” link at the bottom of “Login” button	Redirect user to register page	Registration page is shown
Registration page test suite				
RP1.1	Input field hints	Show hint on focus of “Display Name” text field Procedure: 1. Click on “Display Name” text field	Show hint	Hint shown
RP1.2		Show hint on focus of “Username” text field Procedure: 1. Click on “Username” text field	Show hint	Hint shown
RP1.3		Show hint on focus of “Password” text field Procedure: 1. Click on “Password” text field	Show hint	Hint shown

ID	Title	Description	Result	
			Expected	**Actual**
RP1.4		Show hint on focus of “Reenter Password” text field Procedure: 1. Click on “Reenter Password” text field	Show hint	Hint shown
RP2	Clear form	Clear registration form when clicked on “Clear” button Procedure: 1. Enter user registration info 2. Click on “Clear” button	Clear registration form	Form is cleared
RP3.1	Registration	Register user account with invalid input field Procedure: 1. Enter invalid user account info 2. Click on “Register” button	Error message shown on top of every text field with invalid information entered	Error messages shown
RP3.2		Register user account with valid input field Procedure: 1. Enter valid user account info 2. Click on “Register” button	Show alert with “Registration successful” message	Alert shown
Booking page test suite				

ID	Title	Description	Result	
			Expected	**Actual**
BP1	Search flight	Search flight based on entered departure date Procedure: 1. Enter departure date 2. Click on “Search” button	Show flight that matches the given departure date	Flights shown
BP2	Select flight	Redirect user to seat selection page upon selecting a flight Procedure: 1. Select a flight from flight list	Redirect user to seat selection page	Redirected to seat selection page
Select Seat page test suite				
SSP1	Flight info	Display selected flight info	Show flight info	Flight info shown
SSP2.1.1	Seat selection	Select available seats Procedure: 1. Click on available seats	Highlight selected seats	Seats are highlighted
SSP2.1.2			Enable “Book Selected Seat” button	Button enabled
SSP2.2.1		Deselect selected seats Procedure:	Remove highlight on selected seats	Highlights removed

ID	Title	Description	Result	
			Expected	**Actual**
SSP2.2.2		1. Click on selected seats	Disable "Book Selected Seat" button if no seats are selected	Button disabled
SSP2.3		Select booked seats Procedure: 1. Click on booked seats	Seat is not selected	Seat not selected
SSP2.4		Select locked seats Procedure: 1. Click on locked seats	Seat is not selected	Seat not selected
SSP3	Reselect flight	Redirect user to flight selection page Procedure: 1. Click on "Back to flight selection" button	Redirect user to flight selection page	Flight selection page shown
SSP4.1	Confirm seats	Book seats without selecting any seats Procedure: 1. Click on "Book Selected Seat" button without selecting any seat	User is not redirected to passenger info page	Nothing happens

ID	Title	Description	Result	
			Expected	**Actual**
SSP4.2		Book seats with at seats selected Procedure: 1. Click on “Book Selected Seat” button with at least 1 seat selected	User is redirected to passenger info page	Passenger info page shown
Passenger Details page test suite				
PDP1	Flight info	Display selected flight info	Show flight info	Flight info shown
PDP2.1	Name fields	Display name fields for each selected seat	Show name fields	Name fields shown
PDP2.2		Show hints for each text fields Procedure: 1. Click on each text field	Show hints	Hints shown
PDP3.1	Book ticket	Book ticket without name field entered Procedure: 1. Click on “Book” button with at least 1 empty field	No action is taken	Nothing happens
PDP3.2		Book ticket with invalid name entered Procedure: 1. Click on “Book” button with at least 1 field with invalid name entered	Show alert on invalid passenger name entered	Alert shown

ID	Title	Description	Result	
			Expected	**Actual**
PDP3.3		Book ticket with valid names entered Procedure: 1. Click on “Book” button with all valid names entered	Redirect user to ticket list page with ticket list updated	Booked ticket list shown
PDP4	Reselect seat	Redirect user to reselect seat page on click on “Reselect Seats” button	Redirect user to seat selection page	Seat selection page shown
PDP5	Cancel booking	Cancels booking and redirect user to ticket list page	Redirect user to ticket list page	Ticket list page is shown

Performance test

The performance tests conducted in duration of 5 minutes with traffic load source generated from West Europe to root traffic manager on 26th September 2017. The load tests are tested on slack hours and peak hours based on Ukraine time.

Summary

Test						Performance (average in sec)	
ID	Ukraine time		Local time		User load	Response time	Request
	Start	End	Start	End			
16	07:49	07:54	12:49	12:54	250	0.3	827.37
20	13:26	13:32	18:26	18:32		0.27	825.2
17	08:02	08:07	13:02	13:07	500	0.97	868.84
21	13:48	13:53	18:48	18:53		0.87	852.65
18	08:39	08:45	13:39	13:45	750	1.32	858.56
22	14:07	14:12	19:07	19:12		1.42	841.56

Charts

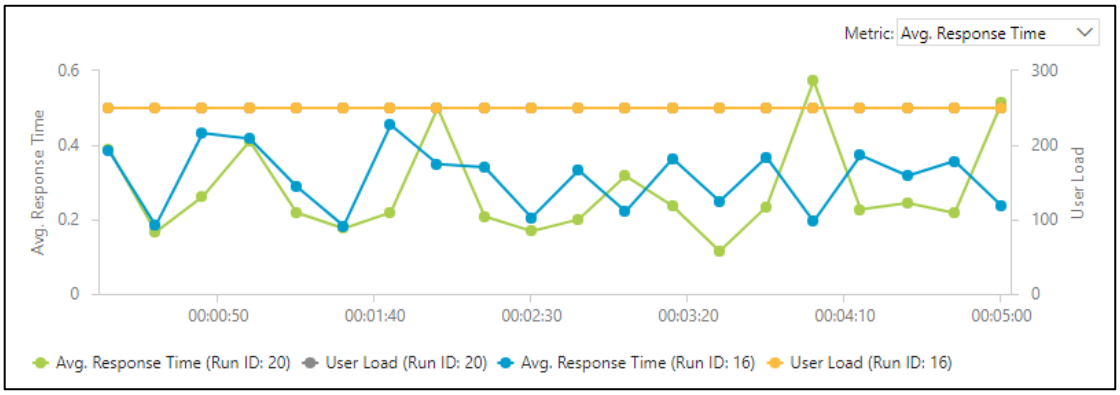


Figure 11: Average response time with user load of 250

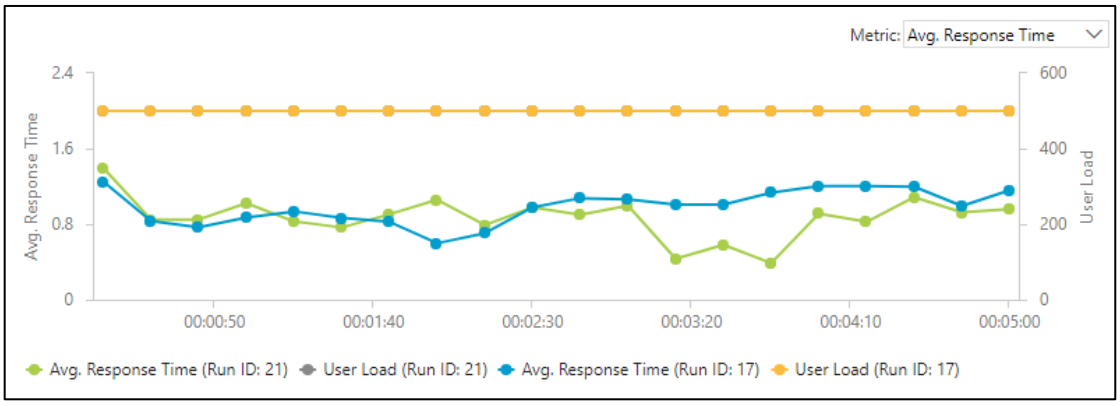


Figure 12: Average response time with user load of 500

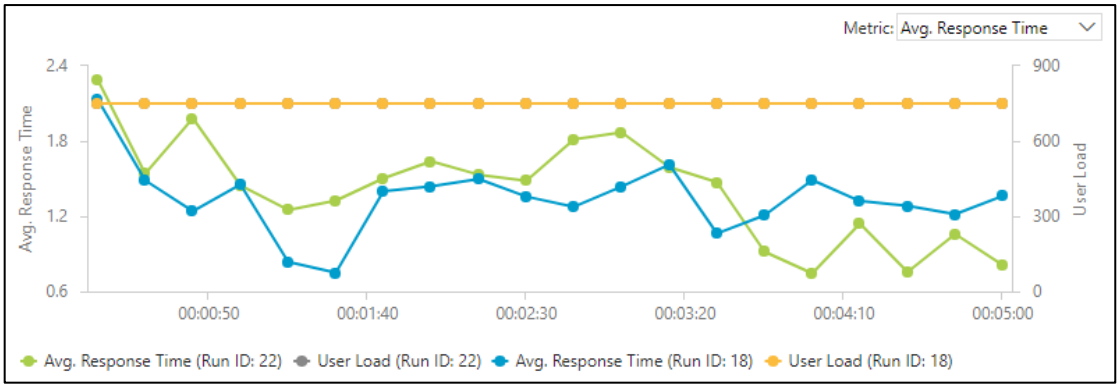


Figure 13: Average response time with user load of 750

Analysis

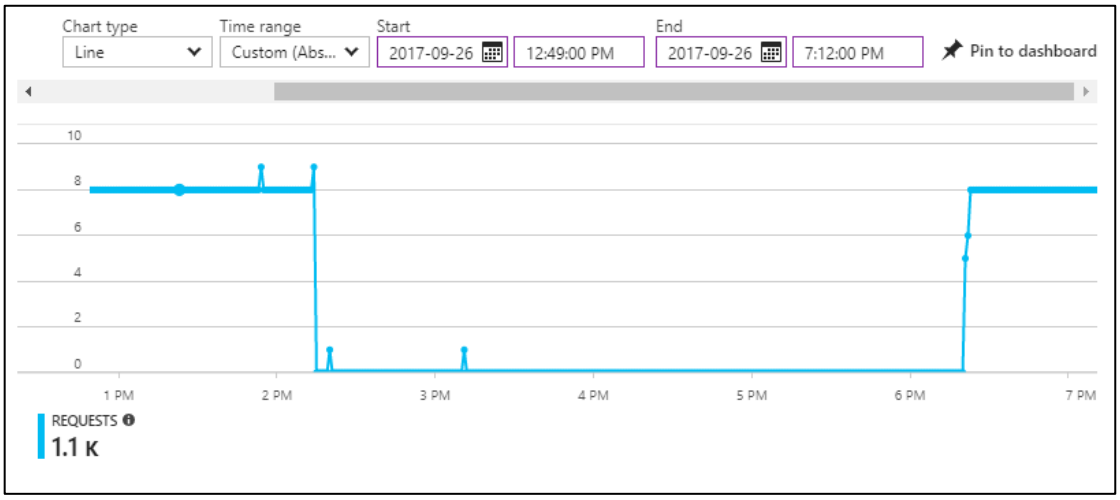


Figure 14: Requests during test (West Europe)

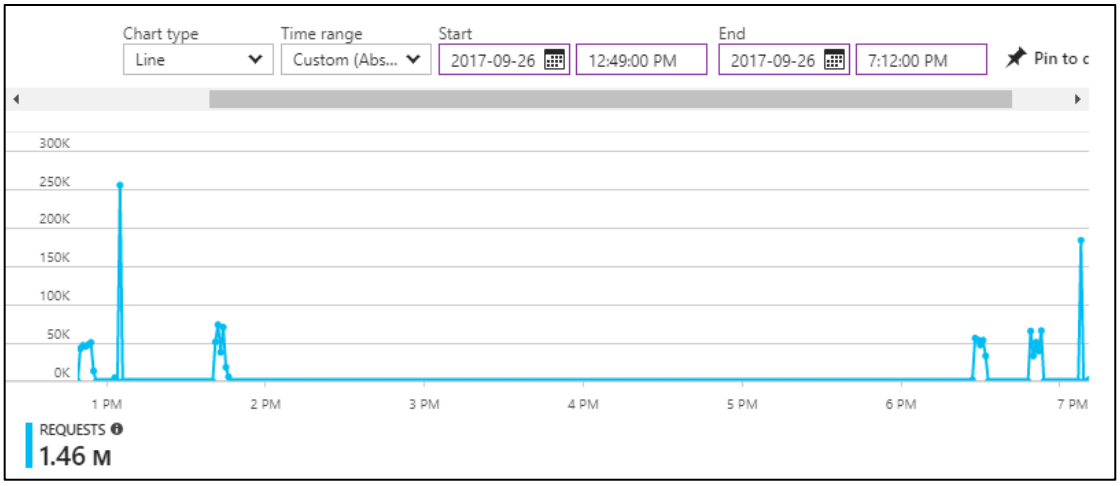


Figure 15: Requests during test (UK South)

Figure 14 and Figure 15 shows the number of requests received during performance tests conducted. Although both test result in Figure 14 and Figure 15 shows that the load test for 750 concurrent users end at 1:07PM on local time based on

summary of the load test, the requests are still coming in from Ukraine with the assumptions of:

- Virtual users are generated in multiple loops or cycles
- Virtual users generated begins to keep send requests once it is generated until the process has been stopped
- The data capturing of the load test does not start until all virtual users requested by the user are generated
- Once the testing duration has reached the target, generated virtual users service are stopped in phases, but the requests from uninterrupted virtual users continue to send request

The requests received at around 3:10PM as shown in Figure 14 is not part of the load test, but the requests for updating “readme.md” markdown file from GitHub. The number of request received from UK South is more than West Europe is due to the settings of traffic manager as explained above.

Based on the load test conducted, the difference of average response time is small with 250 concurrent virtual users tested shows that the web application can serve 250 or lesser concurrent users with similar response time. Meanwhile, the huge difference between peak hours and slack hours begin from 500 and 750 concurrent users accessing the web application shows that the application is starting to slow down and might be unable to handle successful requests, although the test result does not suggest it.

Conclusion

Hosting applications on the cloud has given significant advantages, such as performance monitoring, to many organizations, therefore more organizations are moving their solutions to the cloud as more technologies and features are to be available on the cloud. Although some organization hesitates to move sensitive information to the cloud, most of them still chooses to move their solution to the cloud as it may had solved many issues such as maintenance cost.

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Appendix

Project URL

https://github.com/thumchoontat/ukraine-air

Video URL