ICS Financial Systems LTD (ICSFS) / Oracle Benchmark Project

**Optimization and high-watermark benchmarking of ICS BANKS®
on Oracle Exadata Database Machine**

An Oracle White Paper Released September 2018

TABLE OF CONTENTS

Executive Summary

In August 2018 ICS Financial Systems (ICSFS) benchmarked their ICS BANKS® software suite on an Oracle Exadata Database environment, achieving their best benchmarking results to-date. These results have enabled both Oracle & ICSFS to derive competitive benchmark data that demonstrates the powerful combination of ICS BANKS® and Oracle stack running on Exadata servers.

Overview & Background

In 1978, International Computer Systems (London) Ltd. - (ICS (London) Ltd.) was established in UK as a system integrator and turn-key solutions provider to many industries. ICS Financial Systems (ICSFS), part of the ICS (London) Ltd. group, was founded in 2004 as a leading provider of modular, universal core banking systems. ICSFS' primary offering is the multiple awards winning solution ICS BANKS® which serves and supports customers across the globe. ICS BANKS is a state-of-the-art software that delivers maximum value to banking clients of all sizes. This universal software is a complete suite of banking business modules with a rich sweep of functionality and features addressing business needs foremost, and automating accounting processes as needed, to enhance a customer's business performance. ICS BANKS uses the latest technologies to cover all business areas such as Core banking, Remittances, Trade Finance, Lending, Credit Facilities & Risk Groups, Finance Leasing, Investment and Islamic Banking. The use of the latest technologies to provide availability, scalability and best performance is one of the goals achieved by implementing ICS BANKS.

ICS BANKS is scalable and modular; each of its modules is parameterized to quickly support a client's unique workflow, as many of its modules are designed to stand-alone, as implementation of any module can be separately accomplished. Therefore, each module can be integrated seamlessly with other business modules, on any platform, and can quickly interface with legacy system, and its open architecture capabilities to quickly interface with third-party applications. This design of the ICS BANKS system modules eliminates the need for any additional interface between modules and the core system, and streamlines data flow within the system, providing faster and easy-to-use software and insuring real STP. Finally, ICS BANKS gives the user the facility to deploy modules at any level, whether head office, branch or external delivery channels, such as Internet banking or Kiosks

ICSFS is an Oracle ISV partner and a Gold level member of Oracle PartnerNetwork (OPN).

This range of tests have been conducted jointly by ICSFS & Oracle in order to have comparative benchmark data of Oracle Exadata environment running ICS BANKS application to support customer requirements.

The Benchmark testing was undertaken at Oracle's UK Lab. by an ICSFS team in partnership with Oracle.

Environment Build

The following hardware and software environment was built at Oracle's UK Lab. on joint specification with ICSFS:

- The benchmark covers both Oracle Database Enterprise Edition 12cR2 and 18cR2
- The Database tier comprises a Half RAC Exadata machine X7 split into 4 nodes. This was loaded with Oracle Database Enterprise edition 12cR2 & 18cR2, Oracle RAC option and ICS BANKS® database.
- The Application Tier comprises 5 Oracle X5-2L Intel servers. These were loaded with Oracle WebLogic Server, Oracle Forms and Reports as well as the latest version of ICS BANKS®.
- A Test injection suite of PCA X5's was loaded with Oracle OATS and used for test simulation.
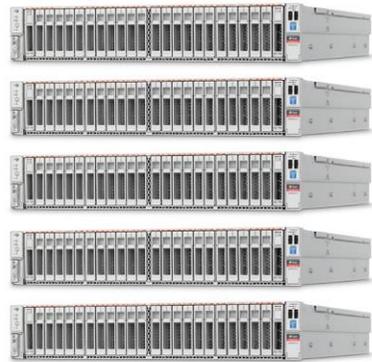
The database was loaded by ICSFS with anonymised Bank data to simulate a typical Tier 1 and Tier 2 Bank.

Environment Chart

Application Tier

5 * X5-2L servers

(Xeon® E5-2699 v3, 2.3GHz, 36 cores, 384GB of RAM, 10x600Gb 2x400GB SSD**)**

Application Database Tier

1 Exadata X7-2

½ rack (4 DB nodes, 7 Cells)

10GB Network

10GB Network

38 Injectors VM 's

2 VM's per CN

Each VM with 32 vcpu / 64 GB of memory / 250 GB of local

Windows server Enterprise 2012 R2 64bit latest service pack

Injectors Tier

1 PCA X5 connected to ZS4-4 with IB

7x CNs with 72 cores each one and 12x CNs with 88 cores each one

10GB Network

OATS Database Tier

1 Virtual VM Exadata

The ICSFS team were:

- Ghassan I. Sarsak, Chief Technology & Innovation Officer
- Ra'ad M. Malkawi, Digital Banking Product Manager
- Ahmad M. Abu Shoshe, Senior Technical Consultant/ Oracle Technology
- Sultan Al-Kayed, Senior Database Administrator
- Dana Khader, Core Banking Development Head

From Oracle team were:

- Ersoy Bayraktar, MEA, CEE & CIS, ISV OEM Sales Director
- Salma Sharabi, Territory Manager - ISV OEM – MENA
- Emrah Uysal, Principle Sales Consultant - ISV OEM – EMEA
- Frederic Michiara, Master Principle Sales Consultant, EMEA Oracle Solution Center

Test Data:

For the benchmarking exercise, ICSFS generated ICS BANKS data representative of a bank with 630M accounts, 5,000 branches and around 60,000 concurrent users.

ICSFS team generated the following ICS BANKS data:

- 63M Customers
- 630M Accounts consisting of the following types:
    - Current Accounts (260M)
    - Saving Accounts (125M)
    - Lending Accounts
    - Trade Finance Accounts
    - Term Deposit
    - Expense & Revenue Accounts (P&L)
- 5,000 Branches
- 60,000 Teller Users

ICSFS team prepared the Oracle Application Testing Suite (OATS) scripts used for the injection.

Test Architecture Overview:

The Test infrastructure consists of the following tiers:
- Injection Tier:
  Oracle OATS Version (13.2.0.1 Build 203) on all injectors

- Application Tier:
    - Oracle WebLogic Server 12c version 12.2.1.3
    - Oracle Forms and Reports 12c version 12.2.1.3
    - ICS BANKS latest Update

- Database Tier:
  - Oracle Database Enterprise Edition 18c 18.2.0.0.0 with Oracle RAC option
  - Oracle Database Enterprise Edition 12cR2 12.2.0.1 with Oracle RAC option
  - Oracle Enterprise Manager Cloud Control 13c Release 3 13.3.0.0.0
  - ICS BANKS database

Test Methodology

- ICSFS was responsible for preparing and running each test. ICSFS validated test results from a functional point of view.
- Oracle was responsible for collecting information for each test to build both technical and summary white papers.
- Tests were considered valid if:
  - All components have a stable behavior (no CPU peaks, no peak in response time, stable throughput over a period of 30 minutes at minimum)
  - Rate of failed transactions lower than 2%
  - No transaction failure due to ICS BANKS application.

Test Metrology:

The metrics for each test were gathered using the following tools:

- TPS (Financial Transactions per Second) was be measured through Oracle Enterprise Manager.
- Oracle AWR & ADDM reports
- Average Transaction throughput was calculated over a period of 10 minutes of stable state using SQL query
- ICSFS checked to ensure that transactions are properly passed.
- Oracle checked and gathered the infrastructure readings during each test.

Test Results & Findings

Test 1: 60K Concurrent Users (High-Watermark) 12c Database

The purpose of this test is to achieve high watermark results with high number of connected users and massive injection of financial transactions.

We were able to simulate 60k (60000) concurrent ICS BANKS users during a ramp up time of around 60 minutes. The test lasted for 35 minutes and the infrastructure did not show any bottleneck in that period.

ICSFS successfully completed the test and surpassed their expectations by achieving 60k users and 32k TPS.

The following results and information were gathered during this period:

Test Begin time	17:00pm 07 August 2018
Test End Time	17:35pm 07 August 2018
Concurrent ICS BANKS users	**60k** (60000)
TPS (Financial Transactions)	An average throughput of **32k** (31,972) financial transactions per second is sustained during the test period of 35 minutes. TPS is gathered from Oracle Enterprise Manager and from the AWR reports from both nodes. Also Business Transaction Mix is shown in Table 1 below.

Transaction Mix	TPS
Total	31972
Cash Withdrawal	3923
POS Purchase	3923
Loan Disbursement	77
Open LC	74
Open Time Deposit	80
Outward Transfer	80
Cash Deposit	4156
Cheque Clearing	3864
IBS/PBS Transaction	3864
ATM Transaction	7993
Transfer between customers	3864
Open LG	74

Table 1: Transaction Mix

CPU usage on every server of the dedicated infrastructure – 55% CPU usage for the Database servers and around 40% CPU usage for the Application servers.

Oracle Enterprise Manager for Database Performance (top section) & TPS (bottom section)

Test 2: ATM & E-channels (High-Watermark) 12c Database

The purpose of this test is to achieve high watermark results for delivery channel transactions.
In this test, ICSFS E-Channels Injectors are used to inject the following financial transactions (FT) in a round robin way and the test lasted for 20 minutes taking into consideration that the injectors are posting the transactions directly to the database (no load on application servers):

- Internet Banking Fund Transfer
- POS Purchase
- ATM Cash Withdrawal

ICSFS successfully completed the test and surpassed their expectations by achieving 114k overall TPS.

The injector started multi threads and each thread worked on different branches and different set of accounts.

The following results and information were gathered during this period:

Test Begin time	17:19pm 08 August 2018
Test End Time	17:40pm 08 August 2018
Test Period	20 minutes
TPS	An overall throughput of **114k** (113,858) financial transactions per second was achieved during the 20 minutes test. TPS is gathered from Oracle Enterprise Manager and from the AWR reports from all nodes. Also Business Transaction Mix is shown in Table 2 below.

Transaction Mix	TPS
Total	114k
Internet Banking- Fund Transfer	33%
POS	33%
ATM Cash Withdrawal	34%

Table 2: Transaction Mix

CPU usage on every server of the dedicated infrastructure – average 12% CPU usage for the Database servers.
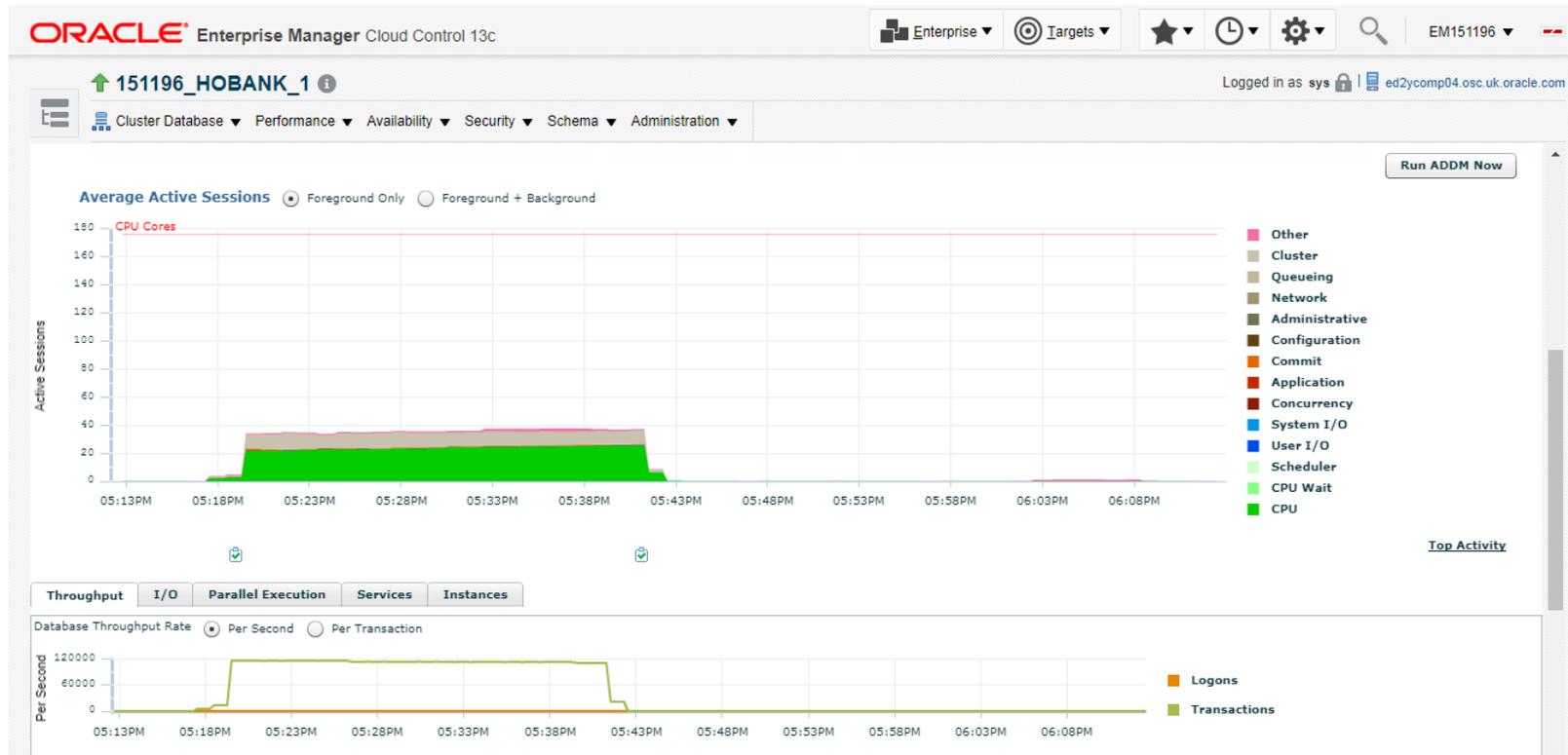
Oracle Enterprise Manager for Database Performance (top section) & TPS (bottom section)

Test 3: Capitalization Batch (12c Database)

The purpose of this test is to achieve high watermark results for End of Month Interest Capitalization Batch.

In this test, ICSFS launched the multithreaded capitalization batch to process 630M accounts (10% are interest accounts) and the elapsed time was measured to calculate number of accounts processed per second.

ICSFS successfully completed the test and surpassed their expectations by achieving 262k interest accounts processing per second.

Note: Batch is started on the database

The following results and information were gathered during this period:

Test Begin time	17:00pm 08 August 2018
Test End Time	17:04pm 08 August 2018
Test Period	4 minutes
TPS (Interest account per second)	63 million Interest Accounts processed in 4 minutes making the batch throughput **262k** (262,354) accounts per second if we consider only interest accounts. TPS is gathered from Oracle Enterprise Manager and from the AWR reports from all nodes.

CPU usage on every server of the dedicated infrastructure – average 12% CPU usage for the Database servers.
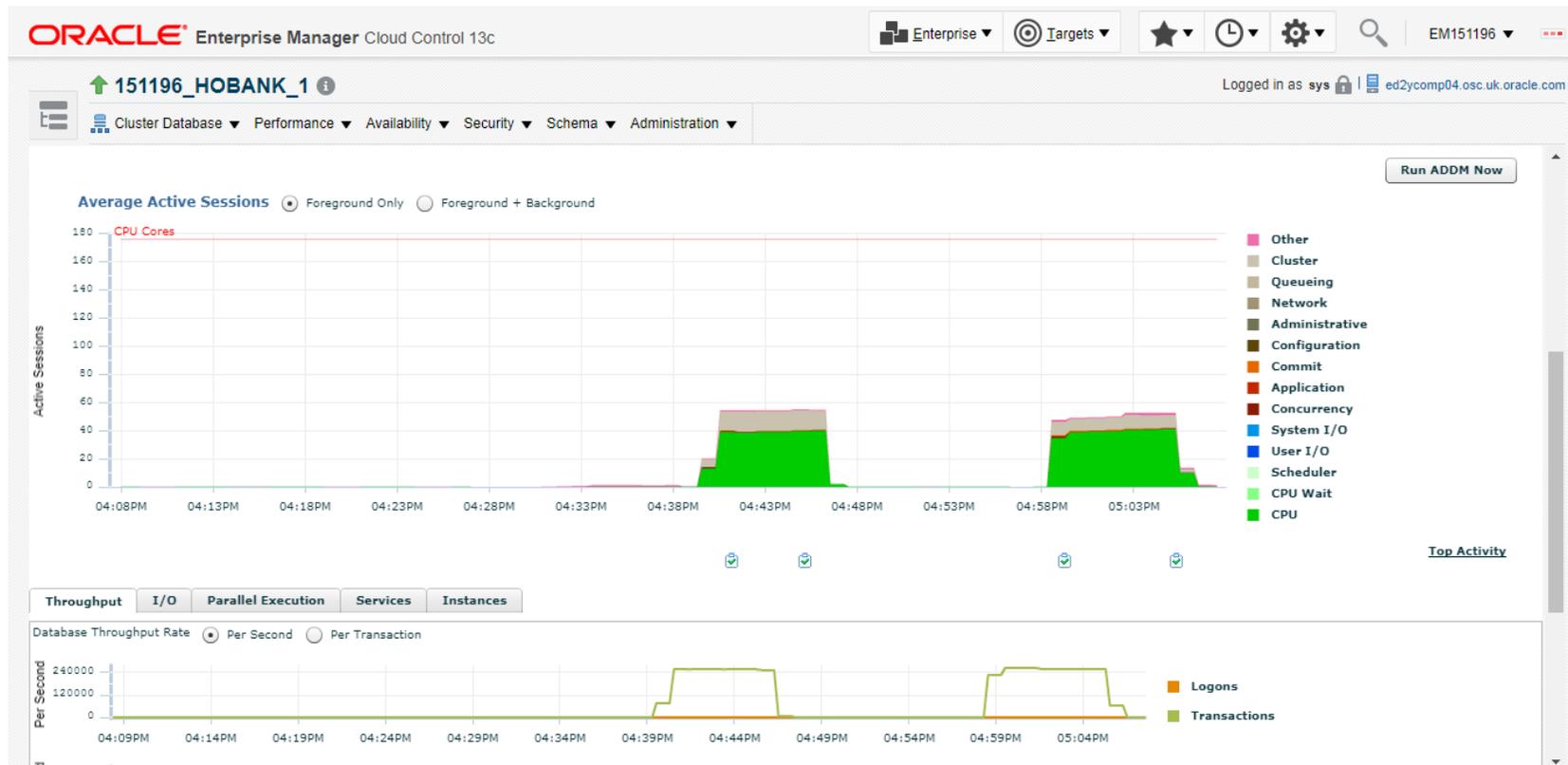
Oracle Enterprise Manager for Database Performance (above section) & TPS (below section)

Test 4 : Digital Banking – (High-Watermark) 12c Database

The purpose of these tests is to achieve high watermark results for ICS BANKS Digital Banking Platform with high number of online users, huge number of online financial transactions and numerous web page visits. This test will measure the scalability and sustainability of ICS BANKS Digital Banking platform to serve massive clients over 30 minutes while still ensuring efficient service delivery without any loss of speed or quality of service.

ICSFS achieved results that exceeded their expectations and success criteria. ICSFS managed to simulate **63 million** online IBS registered users; whilst **200k** concurrent users were working at the same time making a throughput of **128K tps**; resulting in **231.5 million** transactions within **30 minutes**. During this test the system supported **1.25 million** users log on within a 30-minute window.

The following results and information were gathered during this period:

Test Begin time	14:35pm 10 August 2018
Test End Time	15:05pm 10 August 2018
Test Duration	30 minutes
Concurrent ICS BANKS IBS users	**200k** (20000)
Number of Internet Banking registered users	**63 million**
Total Users log on over 30 minutes	**1.25 million** (1250000)
TPS (Financial Transactions)	An average throughput of **128k** (128583) online financial transactions per second is sustained resulting in 231.5 million online transactions within a 30-minute window. TPS is gathered from Oracle Enterprise Manager and from the AWR reports from all nodes. Business Transaction Mix is shown in Table 3 below.

Transaction Mix	TPS
Total	128583
Balance Inquiry	3%
E-statement request	3%
Currency rates inquiry	1%
Transfer between customers' accounts	28%
Outward Transfer	12%
Open LC	1%
Payment Orders	25%
Transfer to another customers inside the bank	12%
Bills payment	6%
Cheque Book Request	3%
Salary Payments	1%
Standing Instructions	1%
Stop ATM card	1%
Stop CC card	1%
Credit Card Settlement	2%

Table 3: Transaction Mix

CPU usage on every server of the dedicated infrastructure – 15% CPU usage for the Database servers and around 20% CPU usage for the Application servers.
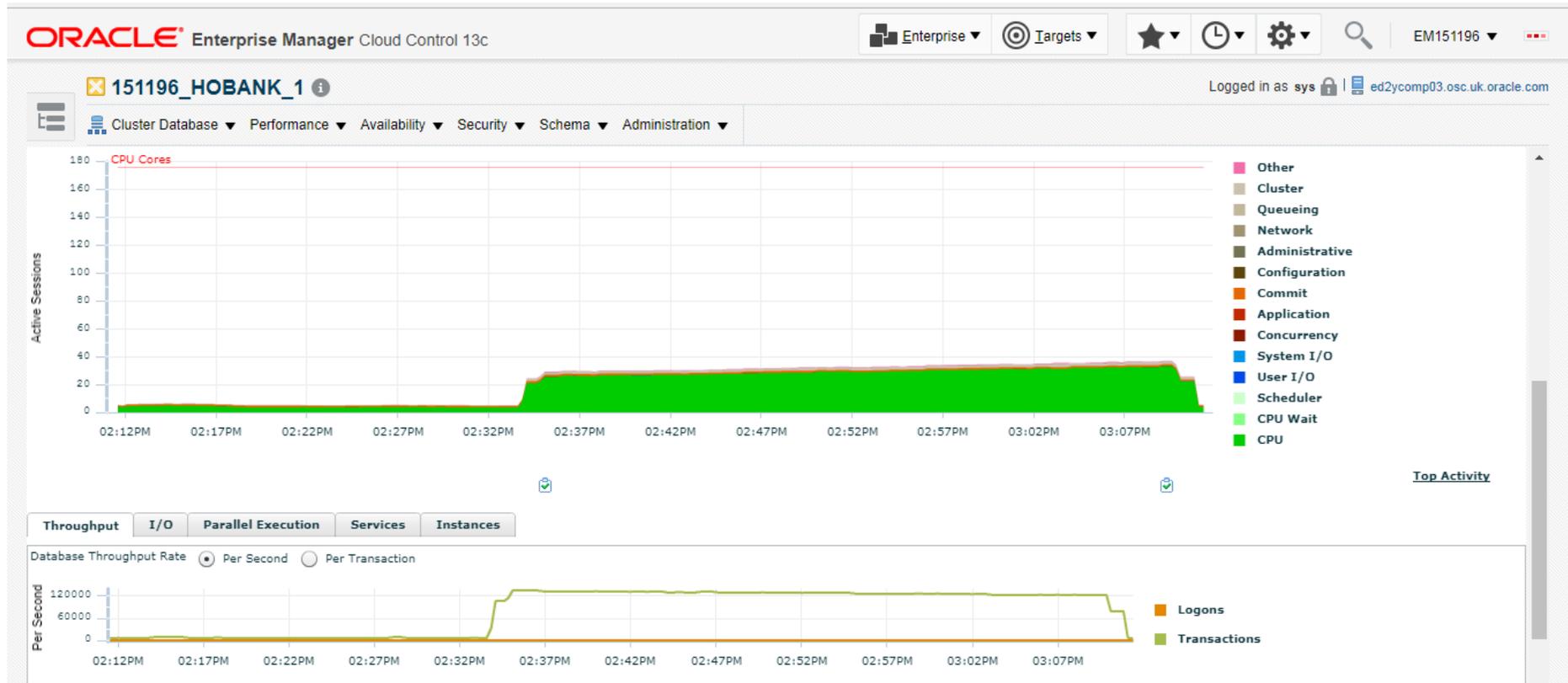
Oracle Enterprise Manager for Database Performance (top section) & TPS (bottom section)

Test 5: 60K Concurrent Users (High-Watermark) 18c Database

The purpose of this test is to achieve high watermark results with high number of connected users and massive injection of financial transactions.

We were able to simulate 60k (60200) concurrent ICS BANKS users during a ramp up time of around 60 minutes. The test lasted for 35 minutes and the infrastructure did not show any bottleneck in that period.

ICSFS successfully completed the test and surpassed their expectations by achieving 60k users and 35.5k TPS.

The following results and information were gathered during this period:

Test Begin time	12:10pm 15 August 2018
Test End Time	12:40pm 15 August 2018
Concurrent ICS BANKS users	**60k** (60200)
TPS (Financial Transactions)	An average throughput of **35.5k** (35,577) financial transactions per second is sustained during the test period of 35 minutes. TPS is gathered from Oracle Enterprise Manager and from the AWR reports from both nodes. Also Business Transaction Mix is shown in Table 4 below.

Transaction Mix	TPS
Total	35577
Cash Withdrawal	4365
POS Purchase	4365
Loan Disbursement	85
Open LC	82
Open Time Deposit	87
Outward Transfer	87
Cash Deposit	4625
Cheque Clearing	4306
IBS/PBS Transaction	4306
ATM Transaction	8881
Transfer between customers	4306
Open LG	82

Table 4: Transaction Mix

CPU usage on every server of the dedicated infrastructure – around 50% CPU usage for the Database servers and around 45% CPU usage for the Application servers.
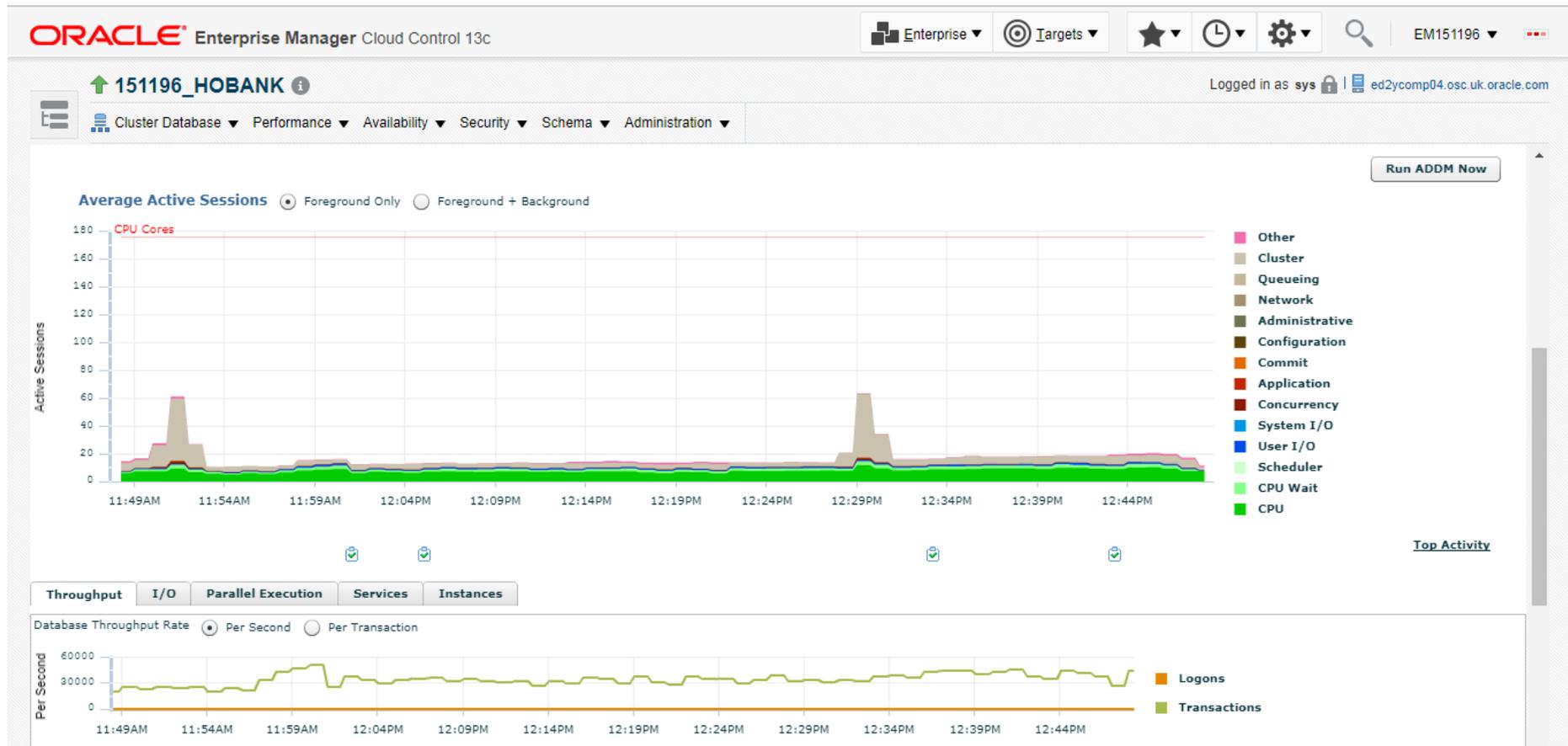
Oracle Enterprise Manager for Database Performance (top section) & TPS (bottom section)

Test 6: ATM & E-channels (High-Watermark) 18c Database

The purpose of this test is to achieve high watermark results for delivery channel transactions.
In this test, ICSFS E-Channels Injectors are used to inject the following financial transactions (FT) in a round robin way and the test lasted for 20 minutes taking into consideration that the injectors are posting the transactions directly to the database (no load on application servers):

- Internet Banking Fund Transfer
- POS Purchase
- ATM Cash Withdrawal

ICSFS successfully completed the test and surpassed their expectations by achieving 128k overall TPS.

The injector started multi threads and each thread worked on different branches and different set of accounts.

The following results and information were gathered during this period:

Test Begin time	14:14pm 14 August 2018
Test End Time	14:34pm 14 August 2018
Test Period	20 minutes
TPS	An overall throughput of **128k** (128,448) financial transactions per second was achieved during the 20 minutes test. TPS is gathered from Oracle Enterprise Manager and from the AWR reports from all nodes. Also Business Transaction Mix is shown in Table 5 below.

Transaction Mix	TPS
Total	128k
Internet Banking- Fund Transfer	33%
POS	33%
ATM Cash Withdrawal	34%

Table 5: Transaction Mix

CPU usage on every server of the dedicated infrastructure – average 12% CPU usage for the Database servers.
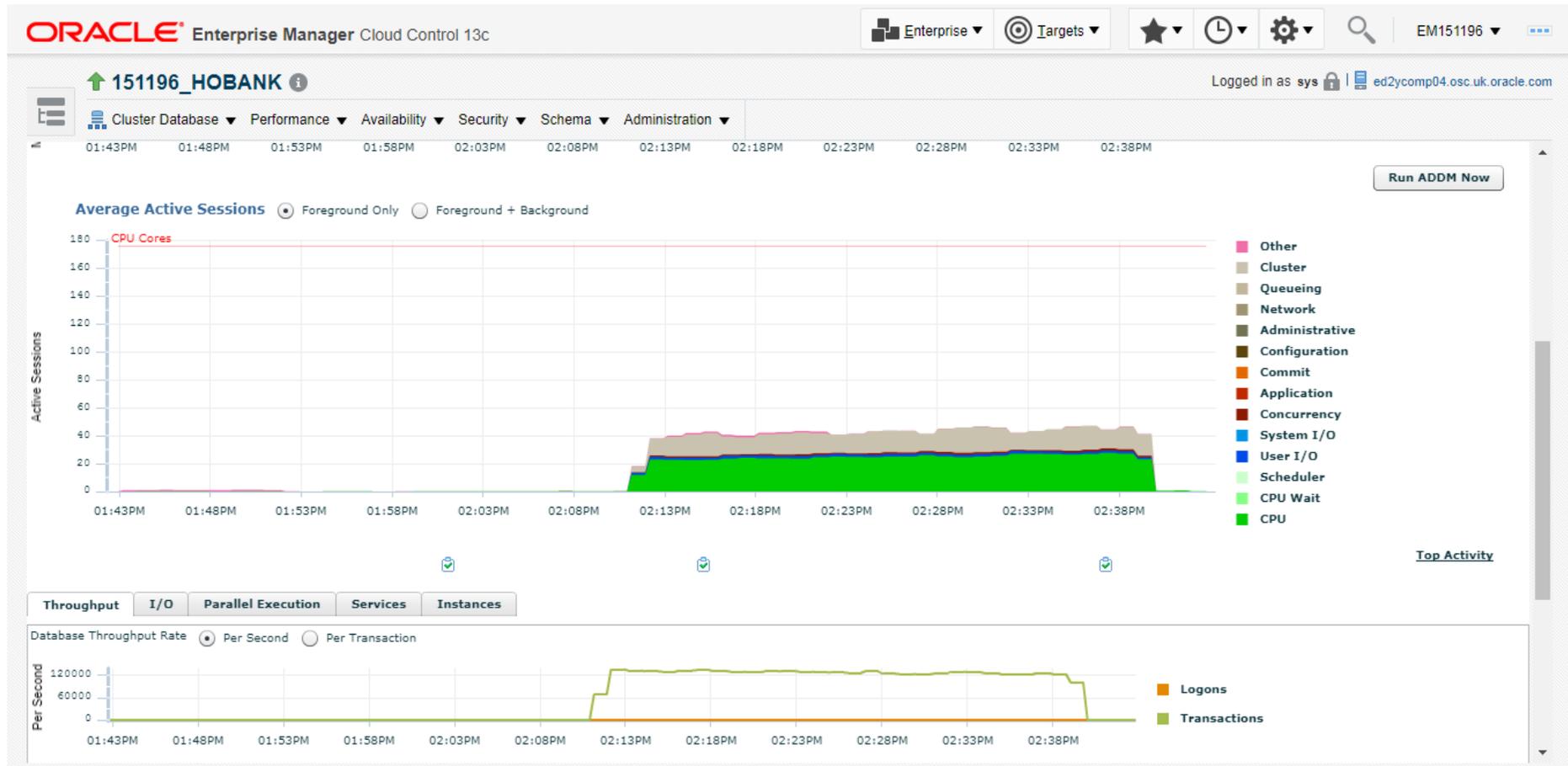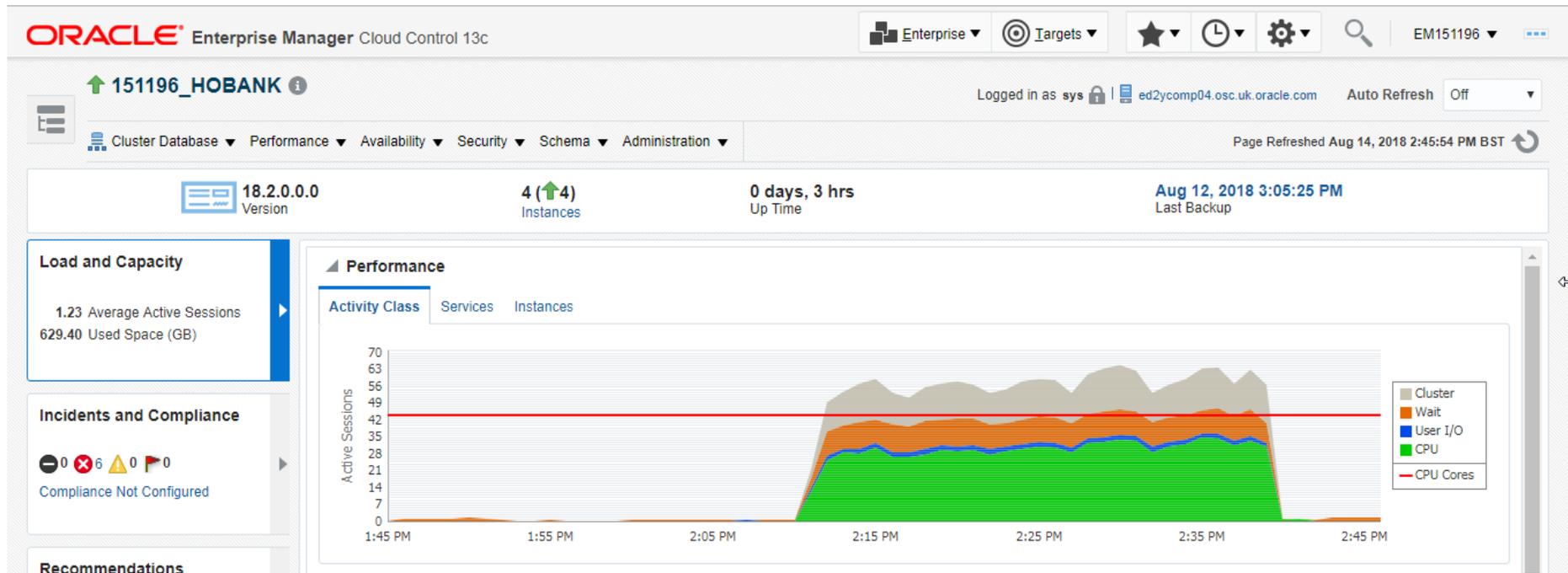
Oracle Enterprise Manager for Database Performance (top section) & TPS (bottom section)

Test 7: Digital Banking – (High-Watermark) 18c Database

The purpose of these tests is to achieve high watermark results for ICS BANKS Digital Banking Platform with high number of online users, huge number of online financial transactions and numerous web page visits. This test will measure the scalability and sustainability of ICS BANKS Digital Banking platform to serve massive clients over 30 minutes while still ensuring efficient service delivery without any loss of speed or quality of service.

ICSFS achieved results that exceeded their expectations and success criteria. ICSFS managed to simulate **63 million** online IBS registered users; whilst **200k** concurrent users were working at the same time making a throughput of **143K tps**; resulting in **257.5 million** transactions within **30 minutes**. During this test the system supported **1.25 million** users log on within a 30-minute window.

The following results and information were gathered during this period:

Test Begin time	17:45pm 17 August 2018
Test End Time	18:15pm 10 August 2018
Test Duration	30 minutes
Concurrent ICS BANKS IBS users	**200k** (20000)
Number of Internet Banking registered users	**63 million**
Total Users log on over 30 minutes	**1.25 million** (1250000)
TPS (Financial Transactions)	An average throughput of **143k** (143137) online financial transactions per second is sustained resulting in 257.6 million online transactions within a 30-minute window. TPS is gathered from Oracle Enterprise Manager and from the AWR reports from all nodes. Business Transaction Mix is shown in Table 6 below.

Transaction Mix	TPS
Total	128583
Balance Inquiry	3%
E-statement request	3%
Currency rates inquiry	1%
Transfer between customers' accounts	28%
Outward Transfer	12%
Open LC	1%
Payment Orders	25%
Transfer to another customers inside the bank	12%
Bills payment	6%
Cheque Book Request	3%
Salary Payments	1%
Standing Instructions	1%
Stop ATM card	1%
Stop CC card	1%
Credit Card Settlement	2%

Table 6: Transaction Mix

CPU usage on every server of the dedicated infrastructure – 15% CPU usage for the Database servers and around 20% CPU usage for the Application servers.
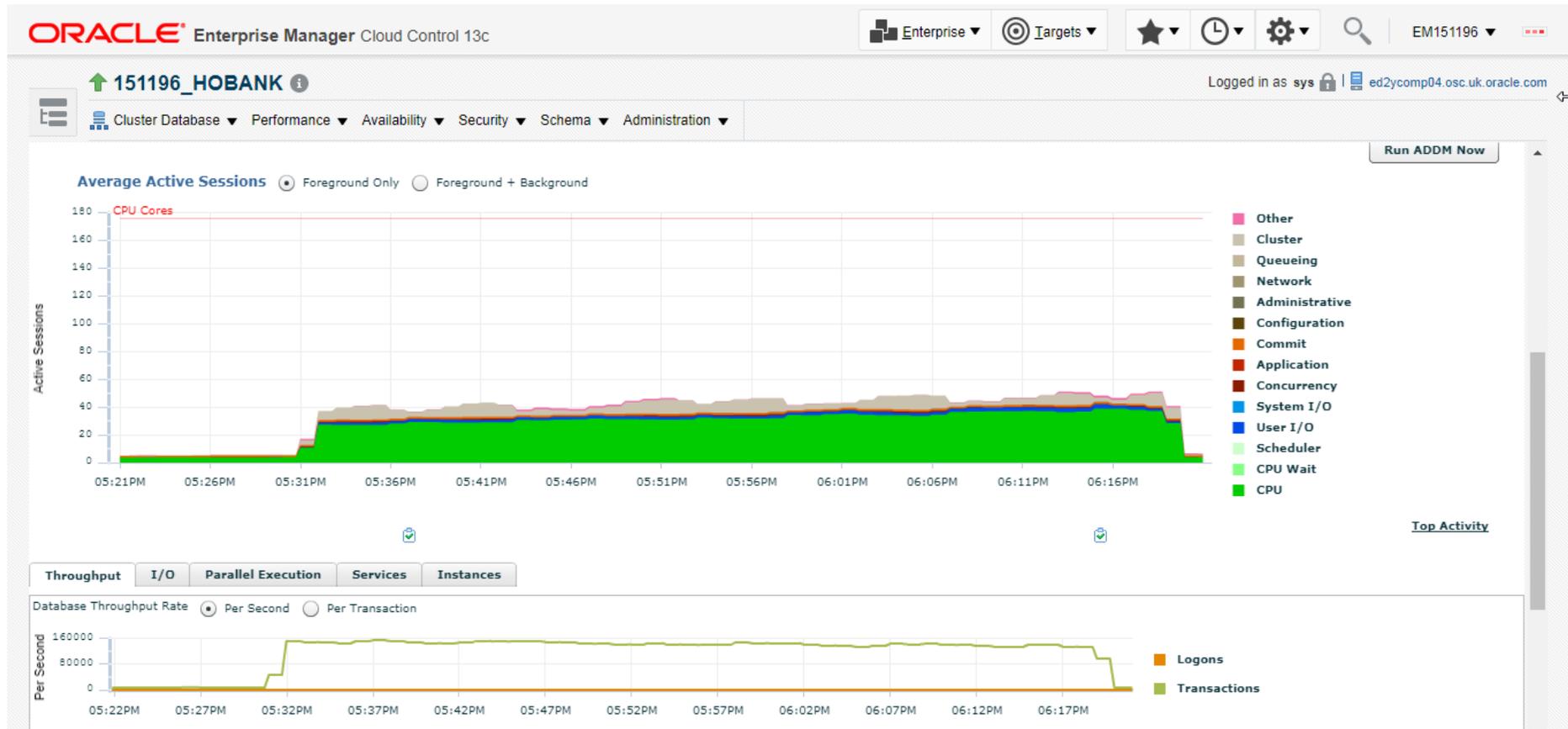
System Statistics - Per Second

I#	Logical Reads/s	Physical Reads/s	Physical Writes/s	Redo Size (k)/s	Block Changes/s	User Calls/s	Execs/s	Parses/s	Logons/s	Txns/s
1	661,618.22	1,210.82	1,253.72	26,547.90	140,708.11	1,004.43	43,940.05	47,538.63	4.38	33,423.94
2	672,152.71	1,221.44	1,280.42	27,344.31	146,358.99	6,723.35	47,527.13	50,280.90	4.22	34,739.22
3	774,918.65	1,300.59	1,409.41	30,412.36	166,761.21	18,012.87	57,283.17	58,956.54	4.49	39,492.35
4	673,086.99	1,244.07	1,307.35	27,842.85	149,512.13	8,386.91	48,852.33	51,319.91	4.24	35,481.32
Sum	2,781,776.58	4,976.92	5,250.90	112,147.42	603,340.44	34,127.56	197,602.68	208,095.98	17.33	143,136.84
Avg	695,444.15	1,244.23	1,312.73	28,036.86	150,835.11	8,531.89	49,400.67	52,023.99	4.33	35,784.21
Std	53,237.59	40.05	68.07	1,671.06	11,224.71	7,067.38	5,649.87	4,889.20	0.13	2,614.38

Oracle Enterprise Manager for Database Performance (top section) & TPS (bottom section)

Conclusion

With no room for doubt, this benchmark demonstrates how ICS BANKS high performance benefited from its own unique design and architecture for on-line, end of day and digital channels. As demonstrated by the workload testing described in this paper, ICS BANKS universal banking solution running on Oracle Exadata servers, sets a new standard of scalability and proofs viable solutions for the largest banks.

Running ICS BANKS from ICSFS on Oracle hardware is packaged as one complete solution with best-of-breed technologies, to provide banking solutions that address today's industry challenges and demands in the most cost-effective way, while offering the agility to respond to the business and technology opportunities of tomorrow. ICSFS and Oracle provide a complete integrated end-to-end solution that is easy to deploy, with ongoing maintenance and address scalability without complexity. The results of this benchmark are the highest achieved up-to-date, as no public available benchmark of this kind is known to provide higher performance.