

# Mainframe Alternative Sizing using AMT

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## 1. Executive Summary

Back in 2012, HP conducted a series of performance benchmarks to compare performance of an IBM mainframe with a number of different x86 based platforms using a benchmark application called zRef (COBOL/CICS application designed for an IBM mainframe running z/OS). The results of that are described in a whitepaper: 4AA4-2452ENW, August 2013, REV. 1.

Running the exact same application using Asysco's AMT framework resulting in the following conclusions where AMT can provide (rounded USD numbers, IBM mainframe MIPS equivalent):

- ▶ **On premise, Single Server: 2210 MIPS @ \$3 per MIPS**, on a 20 core system, nearly an order of magnitude lower than previously conducted tests;
- ▶ **Scale Up SDX: 9004 MIPS @ \$45 per MIPS** using a fully loaded HP superdome-X (240 cores SD-X) non virtualized, virtualizing the same Superdome-X reduces performance to 7121 MIPS at a cost of roughly \$37 per MIPS;
- ▶ **Azure Virtual Machines: 5156 MIPS @ \$33 per MIPS**;
- ▶ **Azure Managed Database: 2161 MIPS @ \$105 per MIPS**, using a high end (4000 DTU) Azure managed database configuration. A mid tier (1750 DTU) managed database gives **1457 MIPS @ \$85 per MIPS**.;
- ▶ the combination of AMT and Azure can **safely scale up to over a 5000 MIPS** equivalent for a single application at a fraction of the cost making it both suitable and a cost attractive alternative for 99% of the mainframe applications in existence.

The tests have shown that, using the zRef benchmark application, AMT provides both the lowest cost as well as the highest performing mainframe alternative infrastructure. The test results also underline that the cost difference between on premise (where the end user is responsible for everything) and the cloud (where a lot of the operational tasks are provided by the cloud provider) are minimal to the degree that the cloud (Azure) is likely to be a more cost-effective option whilst providing at least the same quality of service. This is especially the case in the managed database configuration where all operational tasks (backup, fail over, ..) are included in the managed database Azure subscription.

## 2. AMT Systems Under Test (SUT) and benchmark results

### 2.1 | Introduction

Back in 2012, HP conducted a series of performance benchmarks to compare performance of an IBM mainframe with a number of different x86 based platforms (DL980, DL580, BL460) using a benchmark application designated zRef. The zRef application is a representative z/OS batch and CICS mainframe application, written in COBOL on the IBM mainframe.

This resulted in a whitepaper 4AA4-2452ENW, August 2013, REV. 1. As is stated in the report: *The data presented in this paper enables one to answer the question "How much HP x86 processor based system capacity, e.g., how many servers/CPUs, will I need to take on a given sized mainframe workload (size stated here in MIPS or MSUs)" or to take on the workload of an LPAR (Logical Partition) of a given size.*

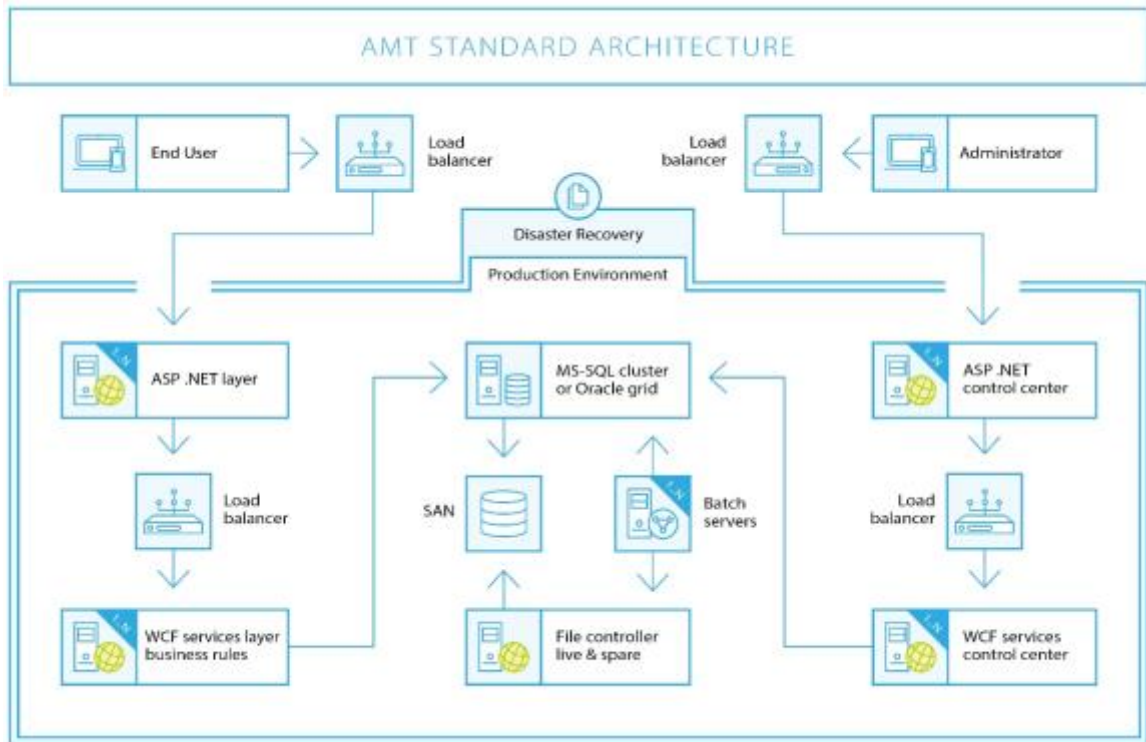
Back then, HP already found that an x86 based system could easily provide multiple 1000's of IBM MIPS equivalent whilst running this workload at a fraction of the cost using Micro Focus technologies (using COBOL, CICS, JCL and other emulators).

Asysco signed an agreement with HP to convert the zRef application and reran these tests using Asysco's migration technology (AMT) where, rather than emulating a mainframe environment, the converted system consists of native Microsoft Windows<sup>™</sup> technologies (.NET, C#, SQL Server).

Please refer to the HP report with ID 4AA4-2452ENW, August 2013, REV. 1 for a description of the zRef application as well as the HP/Micro Focus benchmark results. The HP report did establish a zRef vs IBM mainframe MIPS ratio of 8.158 MIPS per zRef transaction (124 TPS with 1015 IBM mainframe MIPS). This ratio is used throughout the document to convert zRef TPS into the IBM mainframe MIPS equivalent.

This report is limited to describing the AMT benchmark results in relation to running the exact same benchmark application in a number of different configurations including a number of on premise systems as well as a number of configurations using the Microsoft Azure cloud.

Asysco conducted the benchmark tests using a standard AMT GO configuration as follows:



Each system used the following software components:

- Microsoft Windows Server running the Microsoft .NET framework
- Microsoft SQL Server with a database 1 TB of test data

In each case, system load was increased (simulating end users) as much as possible whilst guaranteeing sub second response times under sustained load.

Load generation was achieved using a program called AMT SimulateLoad, using, on the input-side, HP's the Egen-loader DLL's for the creation of random input data.

PLATFORM	HARDWARE	DETAIL
On Premise	20 core x86 server	6 cores SQL Server database 2 cores load generation 12 cores transaction processing
SD-X non virtualised	240 core HP Superdome-X physical setup	120 core SQL Server physical partition 2x 60 core IIS transaction servers
SD-X Virtualised	240 core HP Superdome-X virtualized setup	60 core SQL Server database virtual partition 7 x 15 core IIS transaction servers
Azure VM (1-tier)	Azure G5	32 cores, 448 GB RAM, 6TB storage
Azure VM (2-tier)	Azure G5 database and 4xF16 transaction servers	32 cores, 448 GB RAM, 6TB storage; 4x16 cores, 32 GB RAM
Azure managed DB high	Azure P15 database	4000 DTU
Azure managed DB mid	Azure P11 database	1750 DTU

Notes:

- 1) each zRef transaction generates 4 calls from client to the server system so zRef transactions are in fact 4 actual transactions in real life.
- 2) All Azure costs mentioned are annual, rounded and at the time of report production. These costs continue to drop significantly.

## 2.2 | AMT On premise

### 2.2.1 | Setup

Singe, basic 20 core x86 server, 10K spinning hard drives of in total 12TB disk space.

- 6 core SQL Server Database server
- 2 cores for load generation
- 12 cores for transaction processing (ISS)
- Memory: 256GB

- › Microsoft Windows Server 2012R2
- › Microsoft SQL Server 2012
- › Microsoft .Net 4.5

Three instances of the AMT SimulateLoad were run. Each with 600 users, simulating 1800 users in total.

### 2.2.2 | Results

A sustained level of 270 zRef TPS was achieved. 270 zRef TPS converts to 2210 IBM mainframe MIPS equivalent.

### 2.2.3 | Costs

Server: Dell PowerEdge T430, 256MB mem, 0.5TB SSD, 2 10 core CPUs, Microsoft Windows incl. 3 years maintenance and support.

Total cost: \$9428

SQL Server 6 core license incl. 3 years maintenance and support: \$11,505

Total 3 years: \$20,933.-

Annual depreciation (assuming zero residual value): \$6978

Cost per MIPS: \$3.16

## 2.3 | AMT on HP Superdome-X non virtualized

### 2.3.1 | Setup

Superdome was split up in 3 machines:

- 1 DB server, 4 blades, 120 cores, 512 Gb
- 2 IIS servers, 2 blades, 60 cores each, 256 Gb
- nPar physical partitioning

- › Microsoft Windows Server 2012R2
- › Microsoft SQL Server 2012
- › Microsoft .Net 4.5

ISS with 1 worker / numa node (config set to 0) worked ok but with 16 workers better performance was reached.

Expensive .Net garbage collecting on 1 worker.

Fourteen instances of the AMT SimulateLoad were run. Each with 200 users simulating a total of 2800 end users.

### 2.3.2 | Results

With IIS cores at 100% utilization and the database at 75%, a sustained level of 1100 zRef TPS was achieved. 1100 zRef TPS converts to 9004 MIPS equivalent.

### 2.3.3 | Costs

HP Superdome-X with 240 cores, 512GB mem: \$260,339.-

Microsoft Windows Server DC 2016: 6,155 per 16 cores, total: \$92,325.-

SQL Server Enterprise: \$14,256 per 2 cores, total \$855,360.-

Total 3 year system cost: \$1,208,324.-

Annual cost assuming zero residual value: \$402,775.-

Cost per MIPS: \$44.73



## 2.4 | AMT on HP Superdome-X virtualized

### 2.4.1 | Setup

Network handling was using 1 CPU on DB machine due to the number of packets. Best results were achieved with: (Virtual) RSS enabled, CPU affinity set, multiple (virtual) network adapters (each IIS its own adapter).

Superdome was split up in the following virtual machines:

- 1 DB 1 DB 60 cores, 512 Gb  
7 IIS, 15 cores each. 256 Gb
- Hyper-V virtualisation

- › Microsoft Windows Server 2012R2
- › Microsoft SQL Server 2012
- › Microsoft .Net 4.5

Fourteen instances of the AMT SimulateLoad were run. Each with 200 users simulating a total of 2800 end users.

### 2.4.2 | Results

Result: 870 zRef-TPS.

With IIS cores at 100% utilization and the database at 60%, a sustained level of 870 zRef TPS was achieved. 870 zRef TPS converts to 7121 MIPS equivalent.

### 2.4.3 | Costs

HP Superdome-X with 240 cores, 512GB mem: \$ 260,339.-

Microsoft Windows Server DC 2016: 6,155 per 16 cores, total: \$ 92,325

SQL Server Enterprise: \$ 14,256 per 2 cores, total \$ 427,680

Total system cost: \$ 780,344.-

Annual cost assuming zero residual value: \$ 260,111.-

Cost per MIPS: \$ 36.53

## 2.5 | AMT Azure Virtual Machines (1-tier setup)

### 2.5.1 | Setup

The largest available virtual machine (at the time of the report in West Europe) is a standard G5 with 32 cores and 448 GB ram supporting premium Azure storage.

- › Microsoft Windows Server 2016
- › Microsoft SQL Server 2016
- › Microsoft .Net 4.62

10 \* 600 GB premium storage disk, striped into 2 3600 GB disk were created. Each 600 GB Azure disk has 5000 IOPS. Each Windows striped disk has 25000 IOPS. The database files are split over the 2 windows striped disks.

Two instances of the AMT SimulateLoad were run. Each with 250 users simulating a total of 500 users.

### 2.5.2 | Results

With a CPU utilization of around 80-90%, a total of 200 zRef TPS was achieved. Adding more generated end users did not increase the TPS. 200 zRef TPS converts to a 1637 MIPS equivalent.

### 2.5.3 | Costs

Virtual machine G5:	\$ 7,965,- per month
Premium storage:	\$ 1,475,- per month
Total:	\$ 9,440.- per month

Total annual cost: \$ 113,280.-

Cost per MIPS: \$ 69.20

## 2.6 | AMT Azure Virtual Machines (2-tier setup)

### 2.6.1 | Setup

The largest available virtual machine (at the time of the report in West Europe) was a standard G5 with 32 cores and 448 GB ram supporting premium Azure storage.

10 \* 600 GB premium storage disk, striped into 2 3600 GB disk were created. Each 600 GB Azure disk has 5000 IOPS. Each Windows striped disk has 25000 IOPS. The database files are split over the 2 windows striped disks.

- › Microsoft Windows Server 2016
- › Microsoft SQL Server 2016
- › Microsoft .Net 4.62

4 Client VMs were run. Each client pointed to a different NIC by configuring the specific ip-addresses in the local HOST file. Each client ran 3 instances of the SimulateLoadTool with 200 users each.

In total 2400 users were simulated. For the clients a Standard F16s was used with 16 cores, 32 GB ram.

During testing the processing of the network traffic on the database machine became a bottleneck. Therefore, the database vm was configured with 4 NICs, each with its own ip-address. Receive Side Scaling configured to use 'Closest processor', 8 processors and 8 queues per NIC. Processors starting at 0, 8, 16, 24 so the load of the NICs is evenly divided over the CPU cores. See screenshots below for configuration details:

### 2.6.2 | Results

With a CPU utilization of around 80-90%, a sustained (2+ hours of test) of 631 zRef TPS was achieved. 631 zRef TPS converts to 5165 MIPS equivalent.

### 2.6.3 | Costs

Virtual machine G5:	\$ 7,965,- per month
Premium storage:	\$ 1,475,- per month
Clients: 4 * VM's F16S:	\$ 4,720,- per month (€1000 each)
Total:	\$ 14,160 per month
Total annual cost:	\$ 169,920.-
Cost per MIPS:	<u>\$ 32.90</u>

## 2.7 | AMT Azure, Managed database (4000 DTU)

### 2.7.1 | Setup

The database for ZREF was loaded into a Premium P15 Azure database, which is the largest available at the time writing. It supports up to 4 TB of data and 4000 DTU (<https://docs.microsoft.com/en-us/azure/sql-database/sql-database-what-is-a-dtu>) SQL Azure provides high availability out of the box.

- › Microsoft Windows Server 2016
- › Microsoft SQL Server (latest according to P15 specs)
- › Microsoft .Net 4.62

3 Client VMs were run. 2 clients ran 3 instances of the SimulateLoadTool, 1 client ran 2 instances, with 200 users each. In total 1600 users were simulated.

### 2.7.2 | Results

With this setup, a sustained load of 264 zRef TPS was achieved. 264 zRef TPS converts to a 2161 MIPS equivalent.

### 2.7.3 | Costs

SQL Azure 4000 DTU (P15):	\$ 15,340.- per month
Clients: 3 * VM's F16S:	\$ 3,540,- per month
Total:	\$ 18,880.- per month
Annual cost: \$ 226,560.-	
<u>Cost per MIPS of \$ 104.84</u>	

## 2.8 | AMT Azure, Managed database (1750 DTU)

### 2.8.1 | Setup

Same setup as the previous test but using a P11 database (1750 DTU) engine instead of a P15 (4000 DTU).

- › Microsoft Windows Server 2016
- › Microsoft SQL Server (latest according to P11 specs)
- › Microsoft .Net 4.62

### 2.8.2 | Results

With this setup, a sustained load of 178 zRef TPS was achieved. 178 zRef TPS converts to a 1457 MIPS equivalent.

### 2.8.3 | Costs

SQL Azure 1750 DTU (P11):	\$ 6,726.- per month
Clients: 3 * VM's F16S:	\$ 3,540.- per month
Total:	\$ 10,266.- per month
Total annual cost: \$ 123,192.-	
<u>Cost per MIPS of \$ 85.55.</u>	

### 3. Consolidated results table

		zRef TPS	IBM MIPS	Annual cost	Cost/MIPS
IBM MF	IBM z10 EC 2097-604 1088 MIPS	124	1015	\$ 1,066,666.67	\$ 1,050.90
DL980 Mi-Fo	8CPU Xeon E7-4870, 80 cores	816	6679	\$ 766,666.67	\$ 114.78
DL980/DL580 Mi-Fo	80 cores app and 40 cores DB	936	7662	\$ 666,666.67	\$ 87.01
BL460/DL580 Mi-Fo	12 cores load, 40 cores DB	700	5730	\$ 142,000.00	\$ 24.78
Asysco AMT on-premise	20 core in house 2015	270	2210	\$ 6,978.00	\$ 3.16
AMT SD-X single system	120 core DB, 2 60 core IIS	1100	9004	\$ 402,775.00	\$ 44.73
AMT SD-X virtualised	60 core DB, 7x 16 core IIS	870	7121	\$ 260,111.00	\$ 36.53
AMT Azure 1-tier	GS5, 32 cores, 448GB RAM	200	1637	\$ 113,280.00	\$ 69.20
AMT Azure 2-tier	GS5, 32 cores, 448GB RAM, 64 clients	631	5165	\$ 169,920.00	\$ 32.90
AMT Azure P15 DB	4000 DTU, 4TB storage, managed DB	264	2161	\$ 226,560.00	\$ 104.84
AMT Azure P11 DB	1750 DTU, 4TB storage, managed DB	178	1457	\$ 123,192.00	\$ 84.55

Table 1: systems, transactions and cost overview. Grey and yellow lines from the HP report, blue lines represent the new AMT benchmarks

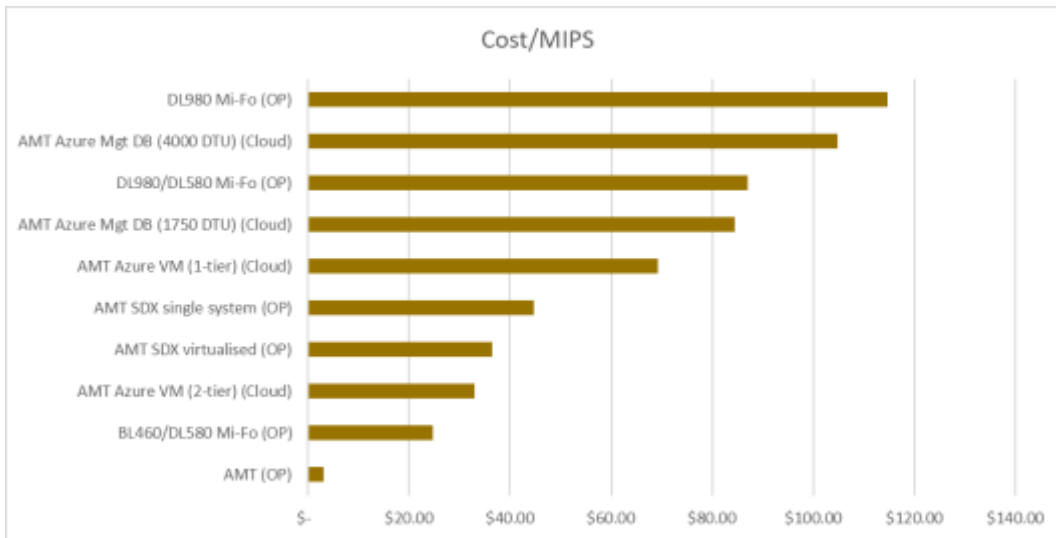
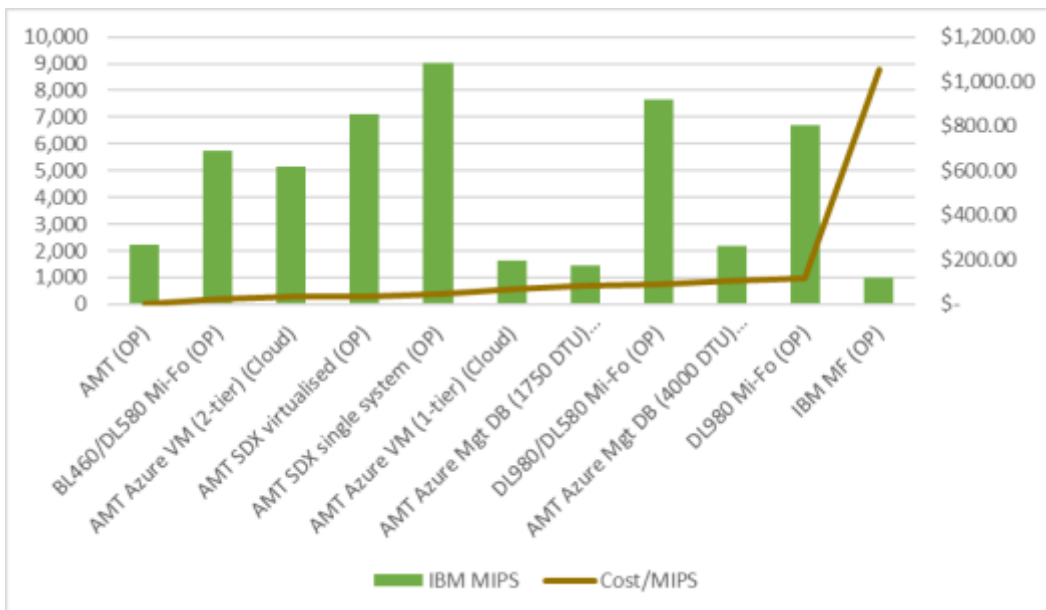


Fig 2: Cost/MIPS comparisons. (OP) represents On Premise



## 4. Conclusions

AMT can provide (using rounded USD numbers):

- **On premise, Single Server:** the equivalent of **2210 MIPS** on a 20 core system at a cost of nearly **\$3** per MIPS, nearly an order of magnitude lower than previously conducted tests;
- **Scale Up SDX:** the equivalent of **9004 MIPS** at a cost of less than **\$45 per MIPS** using a fully loaded HP superdome-X (240 cores SD-X) non virtualized, virtualizing the same Superdome-X reduces performance to 7121 MIPS at a cost of roughly \$37 per MIPS;
- **Azure Virtual Machines:** the equivalent of 5156 MIPS at a cost of **\$33** per MIPS;
- **Azure Managed Database:** the equivalent of 2161 MIPS at a cost of **\$105** per MIPS using a high end (4000 DTU) Azure managed database configuration. A mid tier (1750 DTU) managed database gives 1457 MIPS at a cost of **\$85** per MIPS.;
- the combination of AMT and Azure can **safely scale** up to over a **5000 MIPS** equivalent for a single application at a fraction of the cost making it both suitable and a cost attractive alternative for 99% of the mainframe applications in existence.

Comparing costs for a 1000 MIPS environment based on the above \$ per MIPS:

- IBM mainframe would cost \$1,050,904
- On-premise AMT: \$3,160
- Azure Virtual Machines: \$32,900
- Azure Managed Database: \$84,550

Not only is AMT multiple orders of magnitude cheaper than the mainframe but the Azure based pricing is of such a magnitude that organisations will struggle to meet these efficiency levels using in house based resources.

## 5. Performance Graph Examples





-  Tools
-  Copy
-  Restore
-  Export
-  Set server firewall
-  Delete

Essentials 

Resource group  
ZREF-Resource

Status  
Online

Location  
West Europe

Subscription name  
Asysco AMT-Azure

Subscription ID  
4f401403-177f-4c10-a6cc-105214177490

Server name  
zref.database.windows.net

Connection strings  
Show database connection strings

Pricing tier  
P15 Premium (4000 DTUs)

Geo-Replication role  
Not configured

Monitoring

