Mainframe Capacity Usage: Chargeback Model

This paper focuses on a solution to identify the cost of the mainframe used by various business activities. This would facilitate understanding the Total Cost of Ownership (TCO) of the mainframe, and provide pointers to pro-actively manage mainframe capacity and cost; and identify opportunities for future investment in business applications.
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Abstract
The mainframe capacity usage needs to be seen in the context of the measures that drive the TCO of the mainframe. While there are a number of tools available to analyze application- or transaction-wise capacity usage, these tools are currently unable to analyze the activity within individual business applications. Like, for instance: Is the mainframe processing new or existing business or is the mainframe engaged in re-work on an existing application etc?

This paper will argue that enterprises need a solution that can identify the cost of mainframe computing power. It focuses on a solution to identify the cost of the mainframe used by various business products based on the use of the mainframe capacity. This would facilitate understanding the mainframe TCO, and provide pointers to pro-actively manage mainframe capacity and cost; and identify opportunities for future investment in business applications.

Abbreviations and Acronyms
The following table illustrates the list of various abbreviations used in this document.

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>CBU</td>
<td>ChargeBack Unit</td>
</tr>
<tr>
<td>COTS</td>
<td>Commercial Off-The-Shelf</td>
</tr>
<tr>
<td>CPU</td>
<td>Central Processing Unit</td>
</tr>
<tr>
<td>DR</td>
<td>Disaster Recovery</td>
</tr>
<tr>
<td>LPAR</td>
<td>Logical Partitions</td>
</tr>
<tr>
<td>MIPS</td>
<td>Million Instructions Per Second</td>
</tr>
<tr>
<td>MSU</td>
<td>Million Service Units</td>
</tr>
<tr>
<td>TCS</td>
<td>Tata Consultancy Services</td>
</tr>
</tbody>
</table>

Approach for Mainframe Chargeback
The approach followed for this feasibility study is given below:
- Identify 1 sample application for the feasibility study
- Understand the various business products and the business transactions that are associated with each of the business products
- Understand the mainframe environments, specifically with respect to the sample application
  - Resource utilization and performance metrics
  - Storage and memory capacity usage
  - Category of workloads etc.
- Identify sample online transactions (TRN1, TRN2, etc.) and 1 sample batch job (JOB#001) from the sample application for this feasibility study
- Extract workload class definitions for the identified sample transactions and the batch job
- Identify specific execution instances of each of the chosen transactions
- For each execution instance, determine
  - the business product pertaining to the instance execution
  - the amount of CPU resources consumed by the execution instance
- Identify specific instances of the execution of JOB#001 in the production environment
- For each batch execution instance, determine
  - the business product pertaining to the instance execution
  - the amount of CPU resources consumed by the execution instance
- Define a CBU (chargeback unit) metric, which is based on CPU resource utilization
- Finally, determine the number of CBUs consumed by each of the business products

**Mainframe Environment Overview**

**Mainframe Technology Stack**
The technology stack of the feasibility study (Prod) mainframe environment is given below:

<table>
<thead>
<tr>
<th>Operating System</th>
<th>z/OS V1R8</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transaction Manager</td>
<td>CICS TS V3.1, IMS/TM V10</td>
</tr>
<tr>
<td>Database</td>
<td>DB2 for z/OS V8.1, IMS/DB V10</td>
</tr>
<tr>
<td>System Monitors</td>
<td>Omegamon for z/OS</td>
</tr>
<tr>
<td>Performance Monitors</td>
<td>Tritune V4.0, CA-MICS</td>
</tr>
<tr>
<td>Programming Languages</td>
<td>IBM Enterprise COBOL, PL/I, CA/Easytrieve, Assembler</td>
</tr>
</tbody>
</table>

**Mainframe Server, Storage Portfolio**
The feasibility study mainframe (IBM z10-506) has got four logical partitions (LPAR) with a group capacity around 2400 MIPS.

**Business Products Overview**

**Business Products**
The mainframe capacity usage feasibility study department mainly comprises pensions and investment business:

<table>
<thead>
<tr>
<th>Business Products</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pensions</td>
<td>A regular payment of a stated allowance intended to allow the recipient to subsist in retirement</td>
</tr>
<tr>
<td>Bonds</td>
<td>Single premium life assurance policy Most bonds written as Whole life policies, with no specific maturity date and no payment of contributions for the duration of the plan</td>
</tr>
</tbody>
</table>
Application Selection
The following criteria are used to select the sample application for this feasibility study.

Filtering Criteria for Application Selection

- **CPU Intensive**
  The total CPU time consumed by a particular transaction on a given business day

- **Number of Transactions**
  The total number of transaction instances of a particular application.

- **Coverage across Workload Classes**
  The selected application should reasonably cover the various workload classes.

Description of the Sample Application
Based on the above selection criteria, Pension and Investments Business application has been chosen for this feasibility study. This application is considered to be a strategic system within the department. The application system is essentially a 2-tier client-server application, utilizing various technologies such as CICS, DB2, COBOL, MQ Series, Connect Direct etc. It supports the following business functions:

- Individual and Group Personal Pensions
- Investments
- With Profit and Portfolio Bonds.

Online Transaction Selection
The following criteria are used to select sample transactions for this feasibility study.

- **Coverage across Transaction Classes**
  The selected transactions should reasonably cover the following 4 broad classes:
  1. Business Transaction
  2. Technical Transaction
  3. Internal Transaction
  4. System Transaction

Criteria to Select Transaction Instances

- **Successful Execution**
  Instances of transactions where the transactions have executed successfully

- **Max CPU Time > Avg CPU Time**
  Transactions whose maximum CPU time is way higher than the average CPU time

- **Min CPU Time < Avg CPU Time**
  Transactions whose minimum CPU time is way lower than the average CPU time

- **Execution Failure**
  Instances of transactions where the transactions have ended in a failure
Description of Sample Transactions
Based on the above selection criteria, the following list of transactions have been identified for the feasibility study:

<table>
<thead>
<tr>
<th>Tran ID</th>
<th>Transaction Category</th>
<th>Transaction Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>TRN1</td>
<td>Business Transaction</td>
<td>Add/update policy benefits</td>
</tr>
<tr>
<td>TRN2</td>
<td>Business Transaction</td>
<td>Policy transactions insert/update</td>
</tr>
<tr>
<td>TRN3</td>
<td>Internal Transaction</td>
<td>Performs case impact object maintenance</td>
</tr>
<tr>
<td>TRN4</td>
<td>Business Transaction</td>
<td>Performs premium collection group functionality</td>
</tr>
<tr>
<td>TRN5</td>
<td>Business Transaction</td>
<td>DSS Scheme Maintenance</td>
</tr>
<tr>
<td>TRN6</td>
<td>Business Transaction</td>
<td>Computes projected annuity rates related to specific policies</td>
</tr>
<tr>
<td>TRN7</td>
<td>Business Transaction</td>
<td>Specifically computes claims related to a given set of policies</td>
</tr>
<tr>
<td>TRN8</td>
<td>Business Transaction</td>
<td>Processes stop claim events for a specific set of policies</td>
</tr>
</tbody>
</table>

Batch Job Selection
The following criteria are used to select the sample batch job for this feasibility study.

Filtering Criteria to Select Sample Batch Job
Coverage across different classes
The selected batch job should reasonably cover the following 4 broad classes:
1. Business
2. Technical
3. Internal
4. System
The exercise selected the instances of batch jobs where the jobs were executed successfully, using average and maximum CPU usage time as the criterion.

Description of the Sample Batch Job
Based on the above selection criteria, the batch job JOB#001 (Policy administration & wind-forward) has been identified for this feasibility study. The description of JOB#001 is given below:
- It performs scheduled policy administration processing and policy error correction
- This is a multi-streamed daily job which is part of the overnight batch

Performance Data Extraction Process
In order to arrive at the business product-wise resource consumption for both online and batch the following had been done:
- Performance data had been extracted using CA-MICS for the online transactions
- Appropriate instrumentation had been done to extract the resource consumption
This subsection briefly describes the steps that were followed for the extraction of the performance data which was later used in the detailed analysis.
Data Extraction for Online
In order to compute the business product-wise resource consumption for online transactions those were involved in inserts/update,
- Performance data had been extracted using CA-MICS for the specified online window
- DB2 records which were inserted/updated during the online window had been extracted
- The transaction-wise MICS data and the DB2 table data extracted above were matched to ascertain the CPU utilization by the business products.

Data Extraction for Batch
In order to compute the business product-wise resource consumption for the batch job, instrumentation had been done at appropriate points to capture the resource consumption. For example, if there is a batch job that processes policies, the main program that is executed as part of the job, could be instrumented to display CPU utilization after each policy is processed.

Summary of Online Transaction Analysis
Based on the analysis of a select set of 8 online transactions that ran during the online window (from 8.00 AM to 5.00 PM), the MIPS used by the various business products (associated with these select transactions) was computed. Given below is a summary of the MIPS consumed by the business products. (The “percentage of total” column represents the percentage consumption of a specific business product over the total MIPS consumed by all the products). The total MIPS consumed by all the products (specific to the 8 select transactions) totals to 5.8 MIPS.

<table>
<thead>
<tr>
<th>Business Products</th>
<th>MIPS Consumed</th>
<th>% of Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pension Product 1</td>
<td>2.265</td>
<td>38.90%</td>
</tr>
<tr>
<td>Pension Product 2</td>
<td>1.509</td>
<td>25.91%</td>
</tr>
<tr>
<td>Pension Product 3</td>
<td>0.556</td>
<td>9.55%</td>
</tr>
<tr>
<td>Bond Product 1</td>
<td>0.263</td>
<td>4.53%</td>
</tr>
<tr>
<td>Bond Product 2</td>
<td>0.224</td>
<td>3.85%</td>
</tr>
<tr>
<td>Pension Product 4</td>
<td>0.203</td>
<td>3.48%</td>
</tr>
<tr>
<td>Bond Product 3</td>
<td>0.193</td>
<td>3.32%</td>
</tr>
<tr>
<td>Pension Product 5</td>
<td>0.183</td>
<td>3.14%</td>
</tr>
<tr>
<td>Bond Product 4</td>
<td>0.151</td>
<td>2.59%</td>
</tr>
<tr>
<td>Pension Product 6</td>
<td>0.053</td>
<td>0.90%</td>
</tr>
<tr>
<td>Bond Product 5</td>
<td>0.048</td>
<td>0.82%</td>
</tr>
<tr>
<td>Bond Product 6</td>
<td>0.028</td>
<td>0.49%</td>
</tr>
<tr>
<td>Bond Product 7</td>
<td>0.027</td>
<td>0.46%</td>
</tr>
<tr>
<td>Pension Product 7</td>
<td>0.025</td>
<td>0.42%</td>
</tr>
<tr>
<td>Pension Product 8</td>
<td>0.013</td>
<td>0.22%</td>
</tr>
<tr>
<td>Bond Product 8</td>
<td>0.012</td>
<td>0.21%</td>
</tr>
<tr>
<td>Bond Product 9</td>
<td>0.012</td>
<td>0.20%</td>
</tr>
<tr>
<td>Others</td>
<td>0.059</td>
<td>1.01%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>5.822</strong></td>
<td><strong>100.00%</strong></td>
</tr>
</tbody>
</table>
Following are the key inferences made based on the gathered performance metrics of the select transactions/jobs.

**MIPS Usage by Current & New Business Products**

The bar chart below identifies the total MIPS consumed by business products, with one axis showing the total number of execution instances and the other axis showing the total MIPS consumed by the transaction execution instances during the online window.

It is clear that more than 90% of MIPS consumption by the products is contributed by “new” activities rather than “current” activities (with respect to the select 8 pilot transactions). The legend “New” denotes the number of instances where a new DB2 record had been inserted into the DB2 table. And, the legend “Current” denotes the number of instances where a DB2 record had been updated by the transaction.

![MIPS usage by Products](image)

**Transaction-wise MIPS Consumption**

The following bar chart identifies the total MIPS consumed by each of the online transactions with one axis showing the total number of execution instances and the other axis showing the total MIPS consumed by the transaction execution instances during the online window.

Based on the chart, we conclude that the transactions TRN5 and TRN6 contribute to high MIPS utilization, predominantly from “new” business activities.

![Transaction Vs Instances Vs MIPS usage](image)

In the above chart, the legend “New” denotes the number of instances where a new DB2 record had been inserted into the DB2 table; the “Current” denotes the number of instances where a DB2 record had been updated by the transaction.
Business Product-wise MIPS Consumption

The following bar chart identifies the top MIPS consuming business products with one axis showing the number of execution instances and the other axis showing the total MIPS consumed by the transaction execution instances for each product during the online window.

Based on the chart, we conclude that the “Pension Product 1” and “Pension Product 2” top the list of top MIPS consumers with respect to the select 8 pilot transactions.

In the below chart, the legend “New” denotes the number of instances where a new DB2 record had been inserted into the DB2 table; the legend “Current” denotes the number of instances where a DB2 record had been updated by the transaction.

Summary of Batch Job Analysis

JOB#001 (belonging to the sample application) that ran on the Pre-Production environment for a select set of policies which are downloaded from the Production environment for this feasibility study, the MIPS used by the various business products was computed. Following is a summary of the MIPS consumed by the business products. (The “percentage of total” column represents the percentage consumption of a specific business product over the total MIPS consumed by all the products). The total MIPS consumed by the products (specific to the selective set of policies) totals to 0.128 MIPS.
Following are the key inferences made based on the performance metrics of the selected job.

**MIPS Consumption based on Execution Instances**

The following bar chart indicates the total MIPS consumed by each of the business products with one axis showing the total number of execution instances and the other axis showing the total MIPS consumed by the execution instances. Based on the chart, we conclude that the business products “Pension Product 3” and “Pension Product 9” contribute to high MIPS utilization.
MIPS Usage by Business Products
The chart identifies the total MIPS consumed by various business products during the execution of the batch job for the selective set of policies.

- We conclude that “Pension Product 3” and “Pension Product 9” top the list of top MIPS consumers with 0.064 MIPS (50% to total) and 0.052 MIPS (41% to total) respectively.
- Also, there is a high correlation between the transaction volumes and the MIPS consumed by these two products.

For JOB#001, following are the performance overhead results that were obtained:

<table>
<thead>
<tr>
<th>Job Name / Stream</th>
<th>Total CPU Minutes Before Instrumentation</th>
<th>Total CPU Minutes After Instrumentation</th>
<th>Overhead</th>
</tr>
</thead>
<tbody>
<tr>
<td>STREAM1</td>
<td>0.14</td>
<td>0.14</td>
<td>0%</td>
</tr>
<tr>
<td>STREAM2</td>
<td>0.05</td>
<td>0.05</td>
<td>0%</td>
</tr>
<tr>
<td>STREAM3</td>
<td>0.04</td>
<td>0.04</td>
<td>0%</td>
</tr>
<tr>
<td>STREAM4</td>
<td>0.04</td>
<td>0.04</td>
<td>0%</td>
</tr>
<tr>
<td>STREAM5</td>
<td>0.03</td>
<td>0.03</td>
<td>0%</td>
</tr>
<tr>
<td>STREAM6</td>
<td>0.24</td>
<td>0.25</td>
<td>4%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>0.54</strong></td>
<td><strong>0.55</strong></td>
<td><strong>2%</strong></td>
</tr>
</tbody>
</table>

- Out of the 6 streams, the stream which takes the maximum CPU time, shows the highest CPU overhead of 4%.
- For the other streams the CPU overhead involved is 0%.
- The total CPU overhead across all streams is only 2%.
**Allocation of MIPS to Business Products**

The key reasons for having MIPS as the measure are:

- All mainframe hardware and software costs are linked to the MIPS metric
- Upgrades to mainframe infrastructure in future (through addition of CPUs etc.) will be clearly accounted for, if MIPS is considered as the measurement metric
- Benchmarking with general industry measures becomes easier if MIPS is used as a metric (given that MIPS is widely used across the industry)

Given that the mainframe resource utilization by transactions/jobs is expressed in terms of CPU seconds (in performance monitors and other system tools), it is necessary to convert the CPU seconds consumed into the corresponding MIPS metric. A couple of alternatives were evaluated to do this conversion and based on the correctness/appropriateness, it was decided to convert the CPU seconds based on the 24-hour window for the processing day. Based on the conversion, the appropriate MIPS was allocated to the business products involved.

**Recommendations for Full Scale Chargeback Implementation**

This section describes some of the key recommendations to implement a robust process track mainframe usage and the approach to be followed for the same.

**Capacity Usage Cost Assignment Process**

The mainframe capacity usage cost assignment process involves identifying and mapping the various business products with the underlying IT applications, determining the resource utilization costs by these IT applications and finally, assigning these costs to the business products associated with these IT applications. The process flow includes the following four steps:

- Extract business product details
- Extract IT application details and map to business products
- Select subset of applications, transactions/jobs and extract their performance data
- Define chargeback unit (CBU), rules and assign IT costs to business products

The below picture depicts the suggested process flow to apportion the mainframe capacity usage costs by various business products:
## 1 Extract Business Product Details

<table>
<thead>
<tr>
<th>Extract Business Product Details</th>
<th>Extract details of various business products that fetch revenue and consume IT costs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extract Business Growth Projections (Product-wise)</td>
<td>Extract growth projection details of the various business products. This data could be used in future to predict costs (by building a business to IT correlation model)</td>
</tr>
</tbody>
</table>

## 2 Extract IT Application Details and Map to Business Products

<table>
<thead>
<tr>
<th>Extract custom-built application details related to mainframe</th>
<th>Extract details of the various custom-built applications (processing windows, business products, architecture, consumption patterns etc.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extract list of Vendor package &amp; COTS applications used in mainframe environment</td>
<td>Extract details of the various vendor package applications (processing windows, business products covered, overall architecture, IT consumption patterns etc.)</td>
</tr>
<tr>
<td>Map these applications to the appropriate business products</td>
<td>Map each application to one or more of the business products</td>
</tr>
</tbody>
</table>

## 3 Select Specific Applications, Transactions/Jobs and Extract their Performance Data

<table>
<thead>
<tr>
<th>Select specific applications and their transactions &amp; jobs</th>
<th>Select specific applications and their transactions/jobs for further detailed analysis of their resource consumption patterns</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extract CPU capacity utilization data pertaining to these transactions/jobs</td>
<td>Extract CPU utilization data for each of the selected transactions/jobs across a set time period. The CPU time taken by these will have to be converted to MIPS/MSU</td>
</tr>
</tbody>
</table>

## 4 Define Chargeback Unit (CBU), Rules and Assign IT Costs to Business Products

<table>
<thead>
<tr>
<th>Define &amp; assign CBU based on mainframe CPU utilization</th>
<th>Define a unit for chargeback say CBU. For now, 1 CBU will be equivalent to 1 MIPS. However, in future, the CBU may be extended to include other appropriate metrics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Define rules to chargeback CPU utilization to business products</td>
<td>Define chargeback rules. Business transaction costs will be charged back to the various business products and other technical / internal / system transaction costs will be apportioned equally across all business products</td>
</tr>
<tr>
<td>Apply chargeback rules and allocate CBUs to business products</td>
<td>Based on the defined chargeback rules, allocate costs (in terms of CBUs) which were obtained in Step 3, to the various business products</td>
</tr>
</tbody>
</table>
Conclusion and the way forward

Based on our feasibility study, we conclude that the business product-wise chargeback is doable in the mainframe environment by appropriately identifying the business products, and determining the resource utilization costs by the associated transactions/jobs.

Following are the key recommendations to implement a robust chargeback process in the mainframe environment:

- Instrument online programs for retrieval online transactions and all batch jobs to aid in trace-back to business product usage
- Define an integrated and automated process for monitoring, matching and cost assignment
- Explore usage of tool for business product chargeback accounting and analysis
- Ensure coverage of chargeback process for all environments (inclusive of development, test and DR environments)
- Define process to handle inclusions/exclusions to IT/business metrics
- Define process to handle exceptions (due to incorrect data inputs)
- Define policy rules for cost assignment to business products
- Validate and finalize approach to compute MIPS used, based on CPU time taken by transactions/jobs
- Ensure that the trace process involved (in code instrumentation) does not contribute to high overheads
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