Cloud Migration Planning Toolkit

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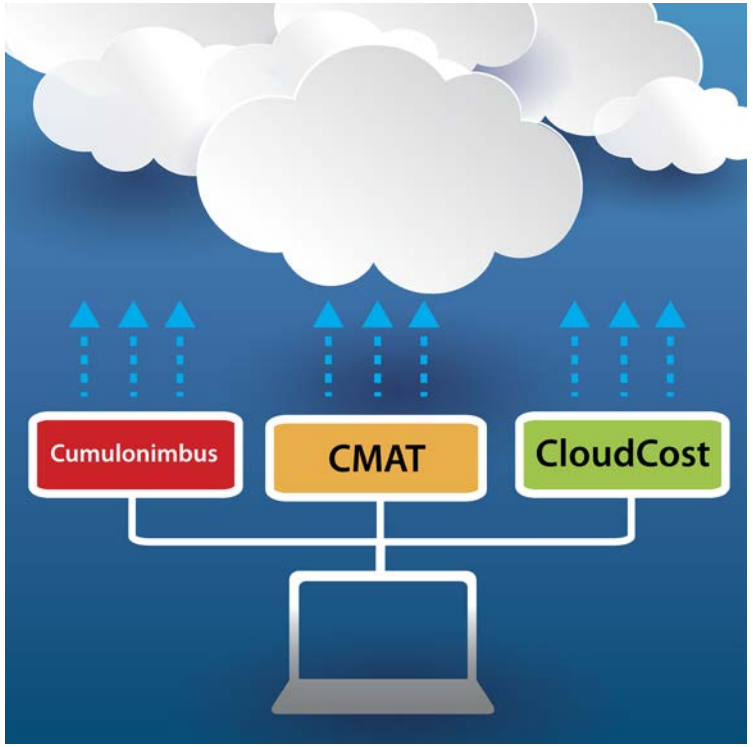

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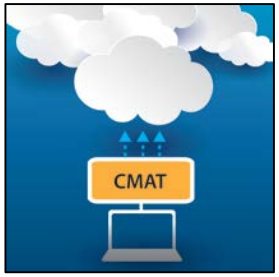
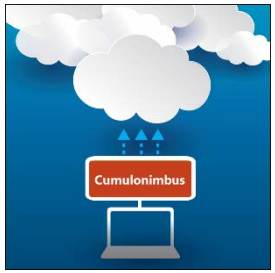
Background

- **Many persons have heard about cloud computing, but in general, their understanding is fuzzy**
- **Some organizations are being mandated to leverage cloud computing environments, but they need guidance in determining what applications to migrate to the cloud**
- **MITRE has developed several tools to support cloud migration**
  - Cloud Migration Analysis Tool (CMAT): Determines the relative suitability of an application for migration to the cloud
  - CloudCost (Regular and Lite versions): Assesses the economics of moving an application to the cloud
  - Cumulonimbus: Determines viable and preferred migration options





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Unfortunate secret –
Cloud migration is not as straightforward as advertised.

How is this migrated?

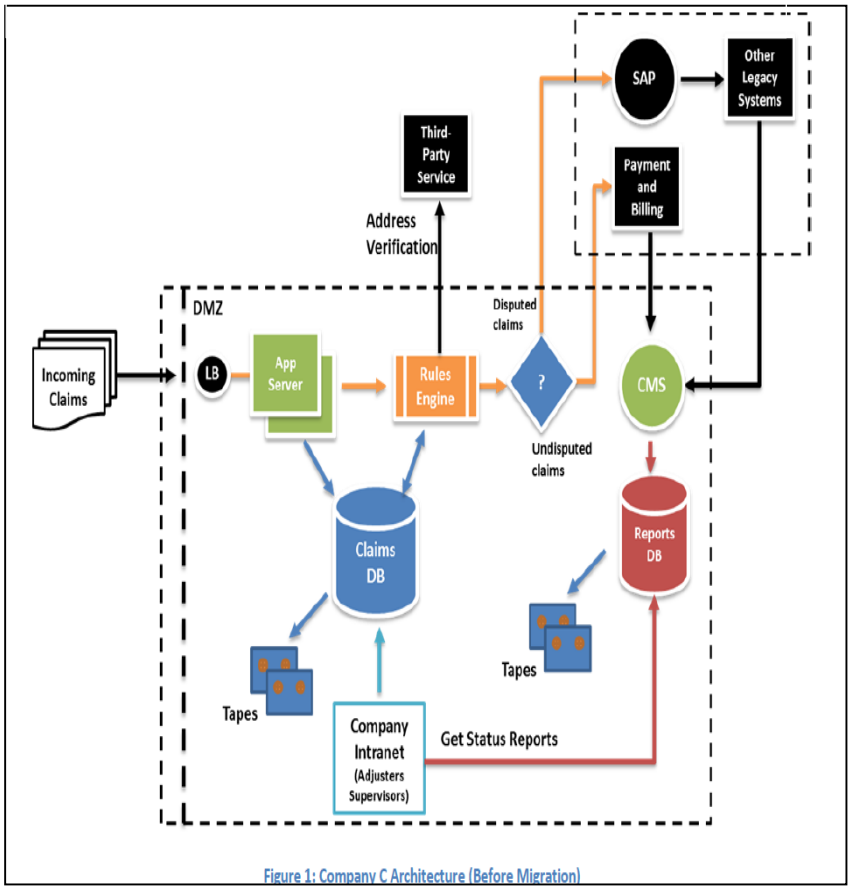

Figure 1: Company C Architecture (Before Migration)

Issues?

- Performance
- Security
  - Access, confidentiality, integrity
- Interfaces to other systems
- Interfaces to systems in the cloud
- Demand changes
- Failover and COOP
- Reliability, availability
- Refactoring
- ROI
- Payback
- Special hardware, other devices
- OS, languages
- Cloud provider services …

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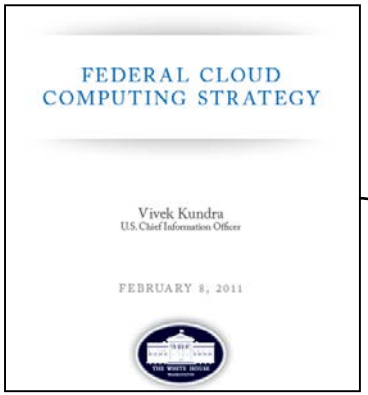
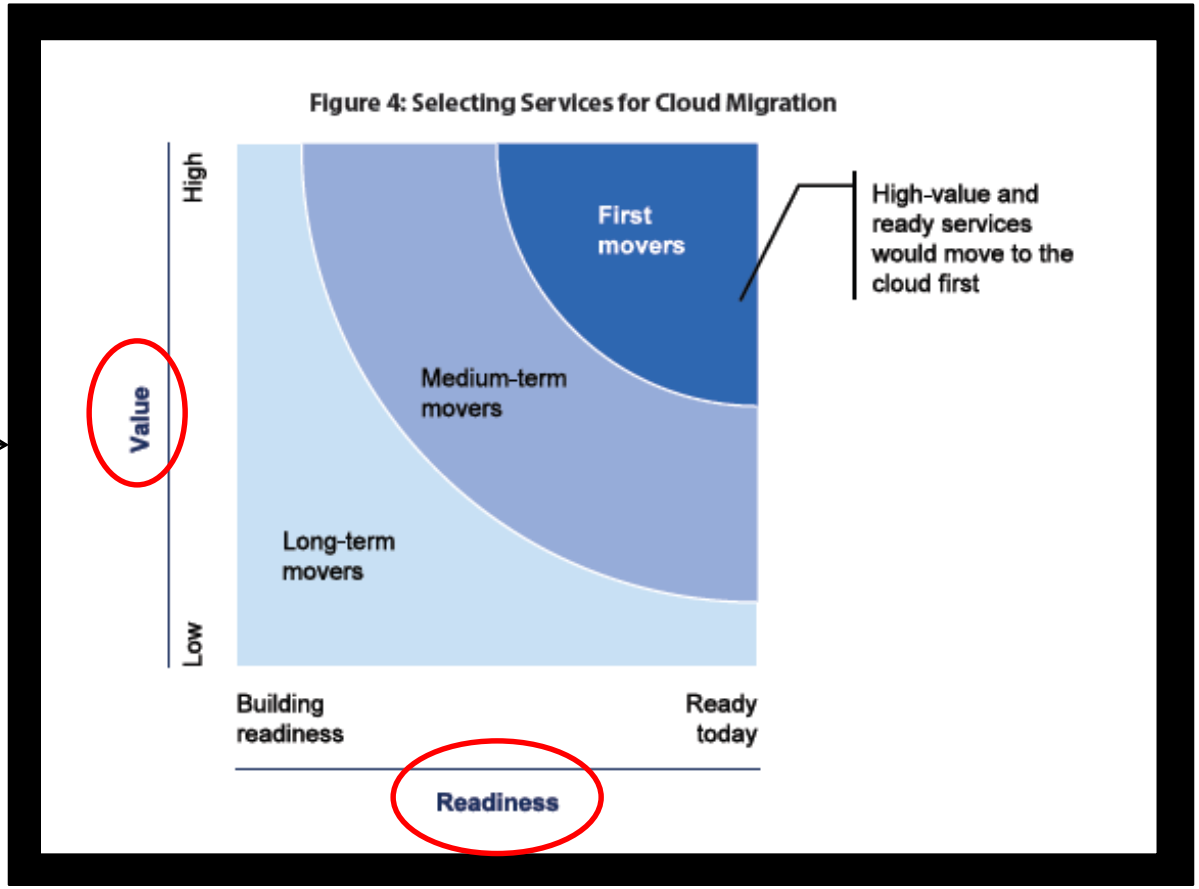
Cloud First Strategy

Which ones? How much does it cost? Return on investment?





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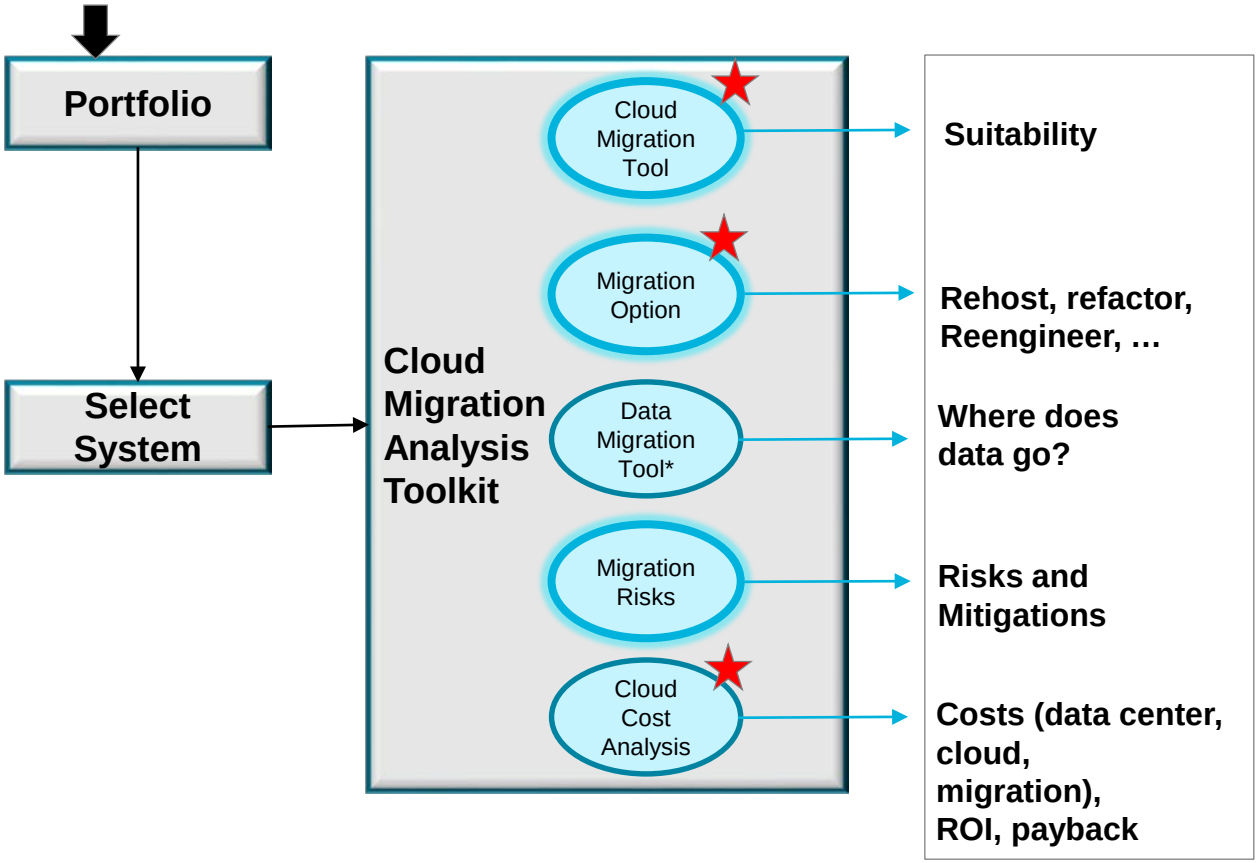
Cloud Migration Analysis –

Portfolio -> Architecture



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Suitability and Cost Work Together

Application Portfolio

1. Sharepoint app
2. Email as a service
3. Web app #1
4. GIMS
5. Web App #2
6. Business App
7. Mission App #2
8. Comms App

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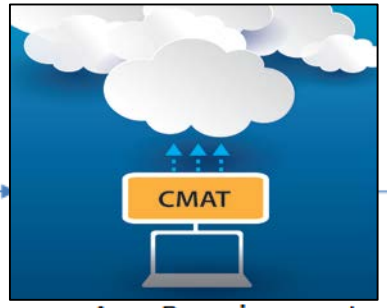


- App Requirements
- Architecture
- Business
- Migration Risk

Cost in Data Center
vs
Migration Cost +
Cost in Cloud

Cloud Migration Index

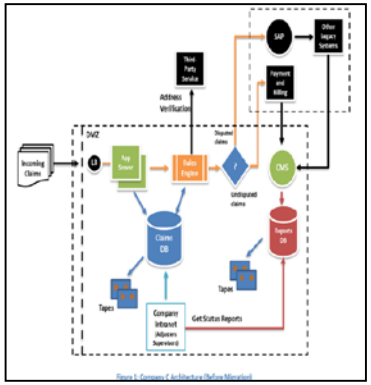
	CMI
Max score	.158
Web App #2	.133
Sharepoint app	.127
Email aaS	.123
Web App #1	.119
Bus App	.087
GIMS	.063
Mission App	.058
Communications	.052
Min score	.028

Migration Payback Period

Web App #2	18 months
Sharepoint app	24 months
Email aaS	27 months
Web App #1	5 years
Bus App	8 years
GIMS	negative return
Mission App	negative return
Communications	negative return

Cloud Migration Analysis Tool (CMAT)

- CMAT determines the relative suitability of moving a software application to the cloud
- For each application in a software portfolio, CMAT generates a suitability index based on a large number of factors
- CMAT leverages an expert system using the Analytic Hierarchical Process



Suitability?

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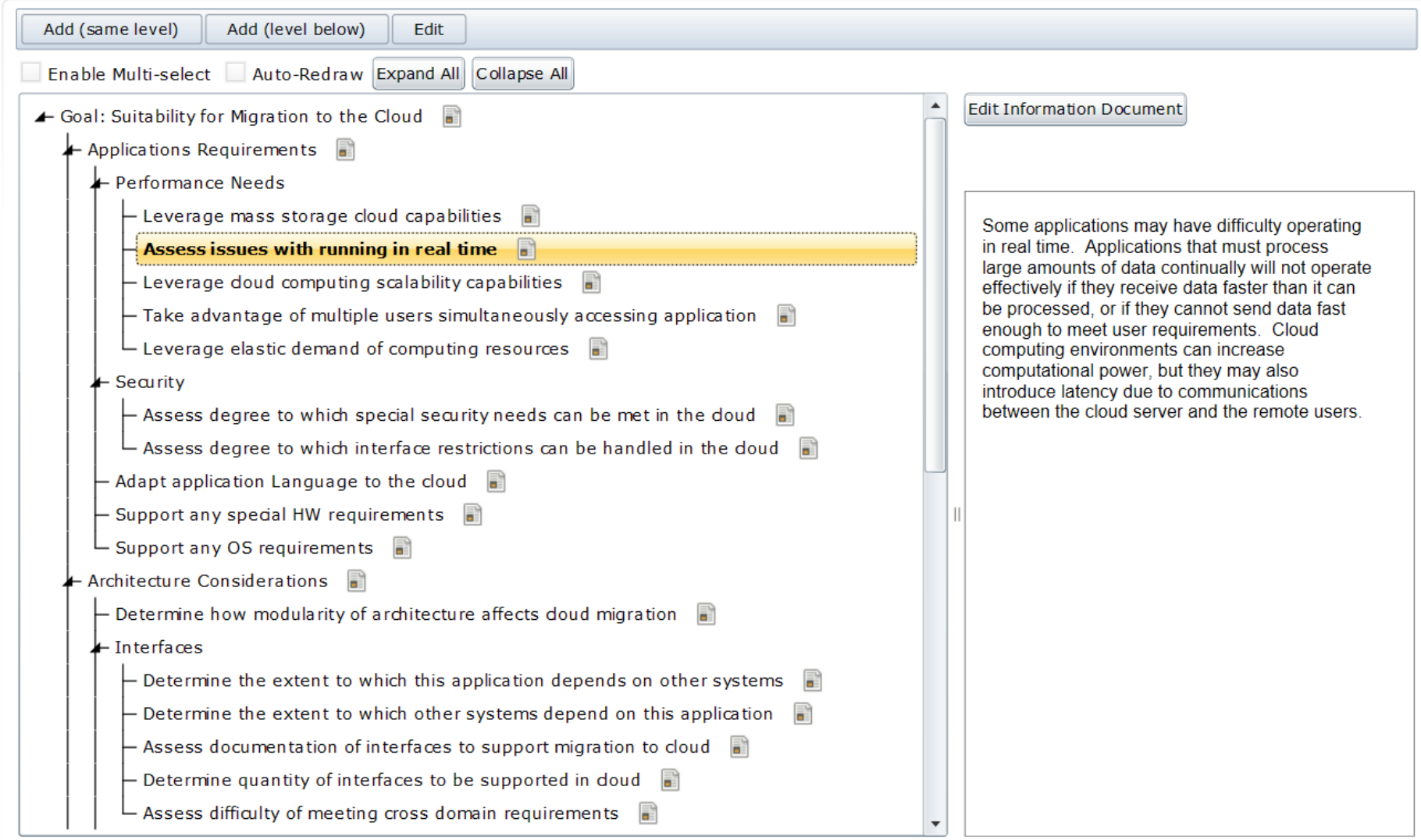
CMAT Hierarchical Structure of Decision Criteria



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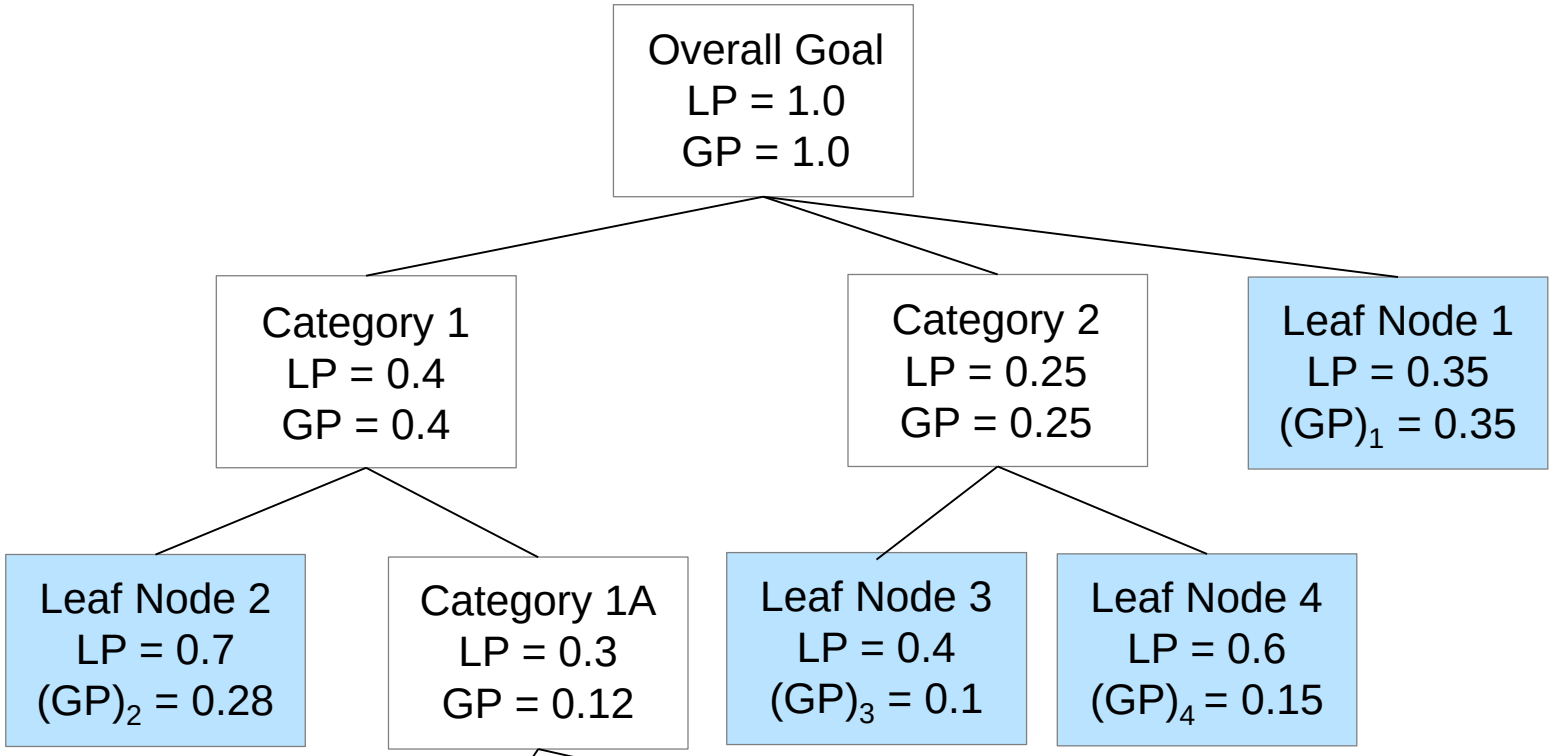
Determination of Cloud Migration Value for Each Application, using the Analytic Hierarchy Process

- **CMAT assigns local priorities at each hierarchical level of the decision criteria tree**
  - Local priorities are determined by pairwise comparisons of the relative importance of different tree nodes
  - Local priorities ranges from 0.0 to 1.0, and the local priorities sum to 1.0
- **Global priorities are calculated for each leaf of the tree**
  - The global priority of each leaf node is determined by multiplying all the local priorities in the tree branch
  - Global priorities of all leaf nodes sum to 1.0
- **The questions are associated with the leaf nodes**
- **Each question response is assigned a value between 0.0 and 1.0**
- **The total score is a summation of each question's global priority multiplied by the response value**

Example of Weighting Methodology



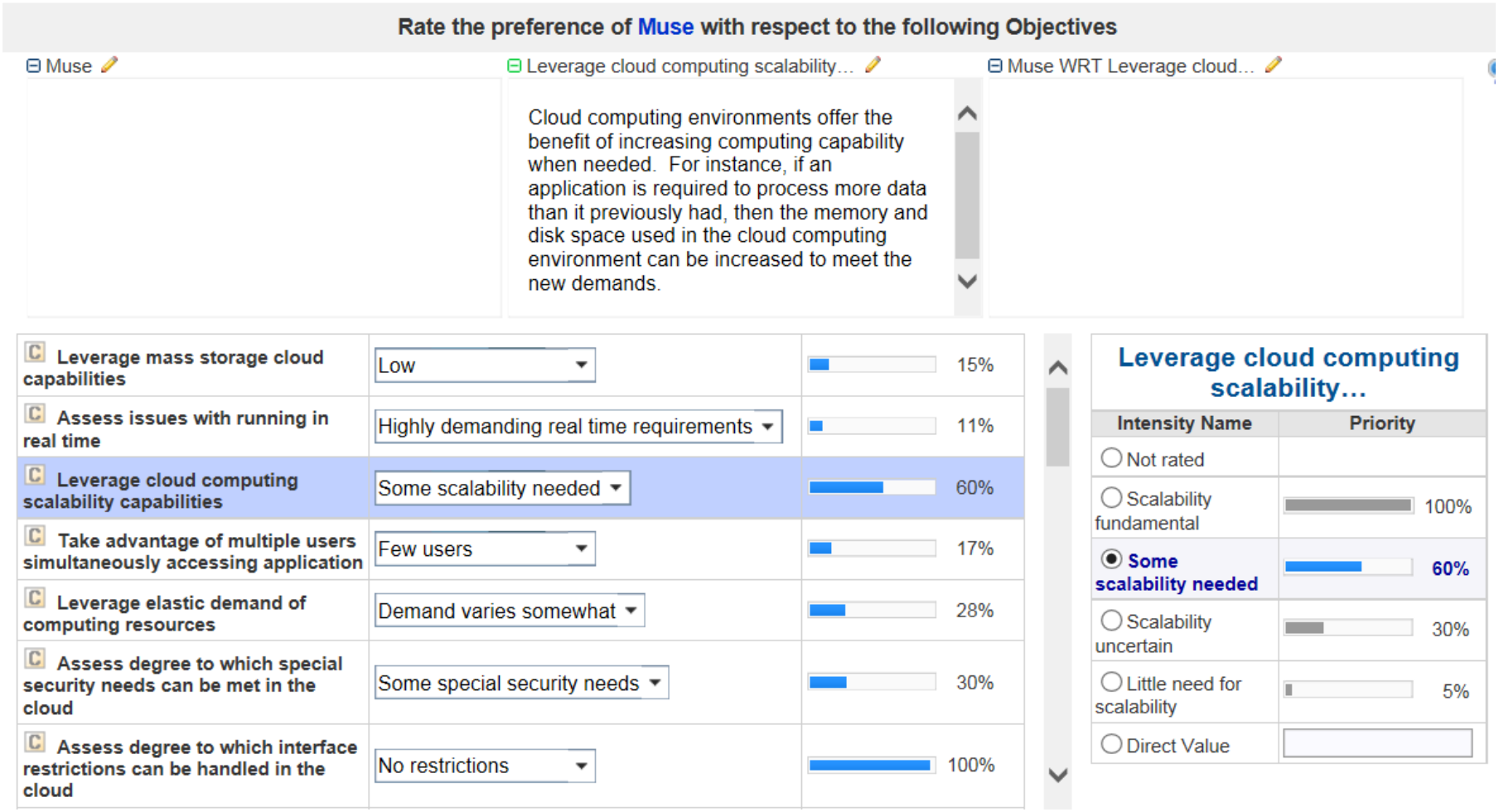
LP = Local Priority

GP = Global Priority

Score = $(GP)_1*A_1 + (GP)_2*A_2 + (GP)_3*A_3 + (GP)_4*A_4 + (GP)_5*A_5 + (GP)_6*A_6$

where A_X is the value of the response to the question for Leaf Node X, and $(GP)_x$ is its global priority

CMAT Users Answer a Series of Questions to Determine Suitability on Numerous Criteria



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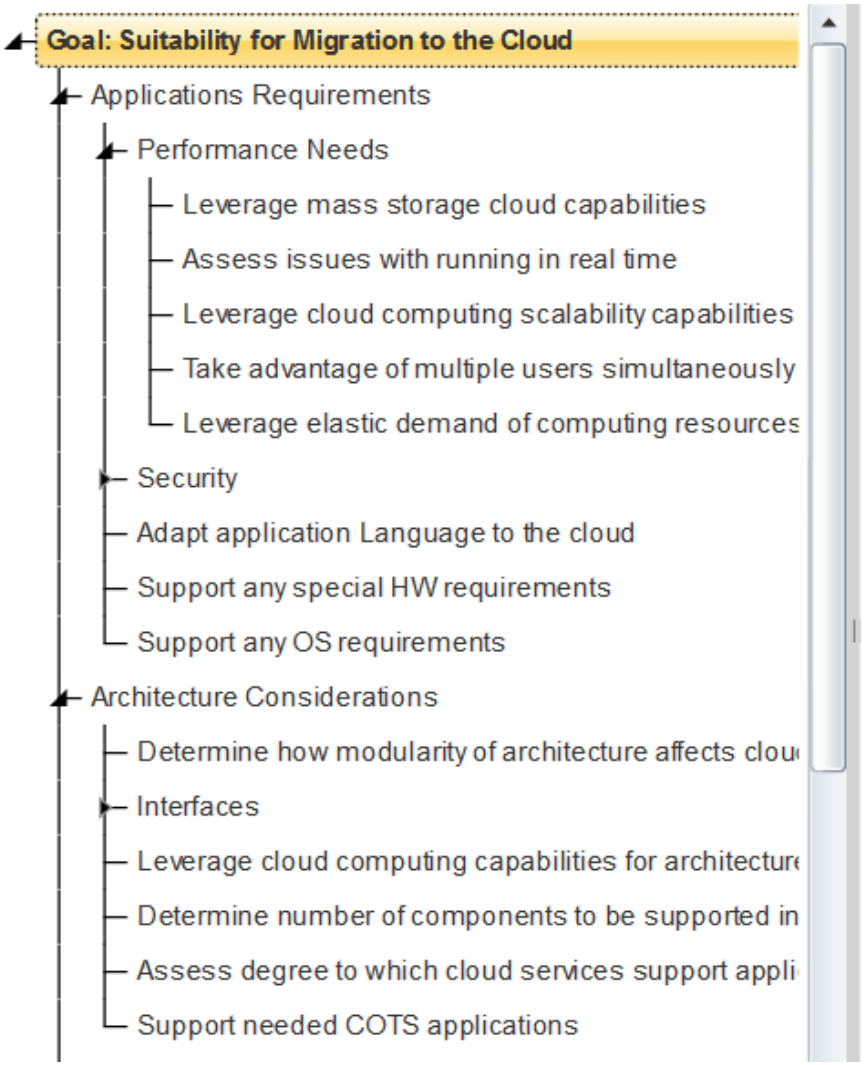
CMAT Ranks the Applications for Suitability for Migration



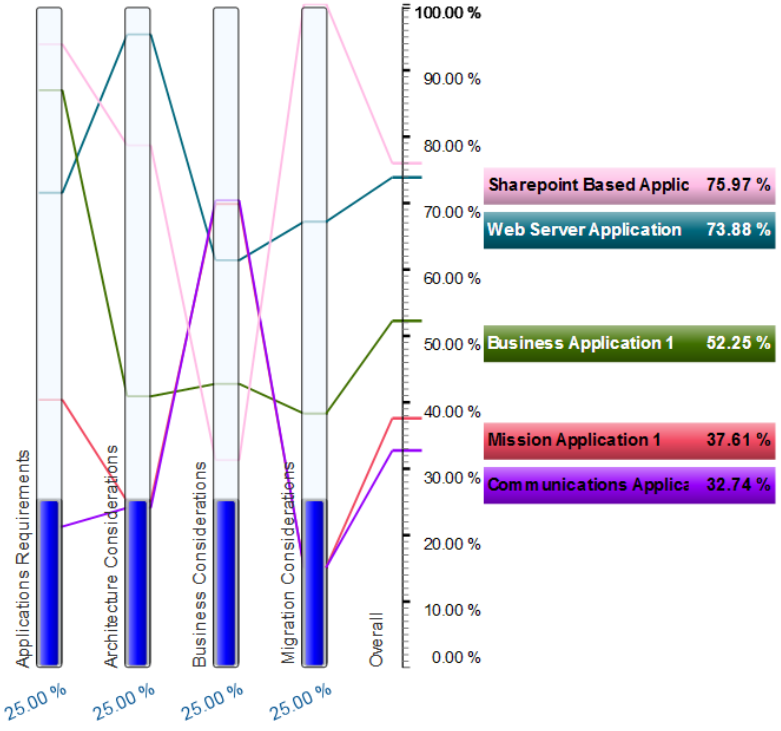
Ideal mode WRT Goal

Alternatives

	Alternative Name	All Participants
1	Web Server Application	73.88 %
2	Business Application 1	52.25 %
3	Mission Application 1	37.61 %
4	Communications Application	32.74 %
5	Sharepoint Based Application	75.97 %
6	Email as a Service	78.37 %
7	GIMS	37.24 %
8	Perfect Migration Candidate	100.00 %
9	Terrible migration candidate	13.91 %
10	Application with unknown characteristics	28.26 %
11	AWS web application example	71.68 %
12	Muse	56.21 %

CMAT Data Analysis

- **In addition to generating the comparison of application suitability for the cloud, perhaps more importantly, CMAT identifies the most challenging aspects of an application's migration to the cloud**



	1	2	3	4	5	6	7	
	Ratings	Ratings	Ratings	Ratings	Ratings	Ratings	Ratings	Ra
	Total	Leverage mass storage cloud capabilities	Assess issues with running in real time	Leverage cloud computing scalability capabilities	Take advantage of multiple users simultaneously accessing application	Leverage elastic demand of computing resources	Assess degree to which special security needs can be met in the cloud	Assess degree to which interface restrictions can be handled in the cloud	A app Lar t c
Web Server Application	0.7388	0.5769	0.6893	1.0000	0.7379	0.6420	0.5429	0.5459	
Business Application 1	0.5225	0.3546	0.3785	0.3036	0.1688	1.0000	1.0000	1.0000	
Mission Application 1	0.3761	1.0000	0.1115	1.0000	0.4757	0.1047	0.2980	0.2581	
Communications Application	0.3274	0.1539	0.1115	0.0518	1.0000	0.1047	0.2980	0.0919	
Sharepoint Based Application	0.7597	0.2723	1.0000	0.6035	0.4757	1.0000	1.0000	1.0000	

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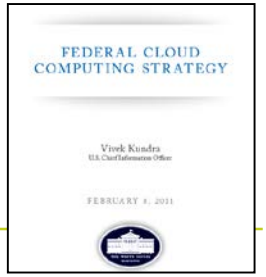
CMAT: Business value vs. Migration Risk (Readiness)



All Participants | Ideal mode | WRT Goal

Risky

High Value.
Lower risk

Business reason

106.27 %
96.27 %
86.27 %
76.27 %
66.27 %
56.27 %
46.27 %
36.27 %
26.27 %
16.27 %
6.27 %

5.82 % 15.82 % 25.82 % 35.82 % 45.82 % 55.82 % 65.82 % 75.82 % 85.82 % 95.82 % 105.82 %

Migration

Applicationw ith... AWSw eb... Payroll-... Communications... GIMS-Mission Perfect... SharepointBased... Terrible... WebServer... S2S-Mission Unstructured...

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Cloud Cost

Costs for running
the application
in your data center

1) Costs for hosting and running the application in the cloud

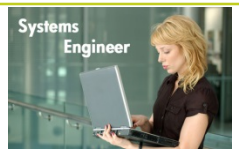
2) Costs for migrating the application to the cloud

CloudCost

- **CloudCost is a tool to determine how much an application would cost to run in a cloud**
  - Includes migration costs and operating costs (servers, storage, bandwidth)
- **It compares that cloud cost with the costs of running the application in the local data center**
- **CloudCost support the planning and budgeting for application migration to the cloud**

- ***Why is this important?***
  - Applications can be difficult (and costly) to migrate
  - Savings from cloud may be wiped out by the costs of migration

CloudCost Compares Costs in the Data Center With Costs to Migrate to the Cloud



- SW development effort model (COCOMO)
- Monte Carlo Simulation (cost distributions)
- Displays

Existing Application

New Arch #1

New Arch #2

New Arch #3

1. Current operating budget
2. SLOC to refactor
3. Other transition effort and cost
4. # Servers
5. Server size
6. Storage (GB)

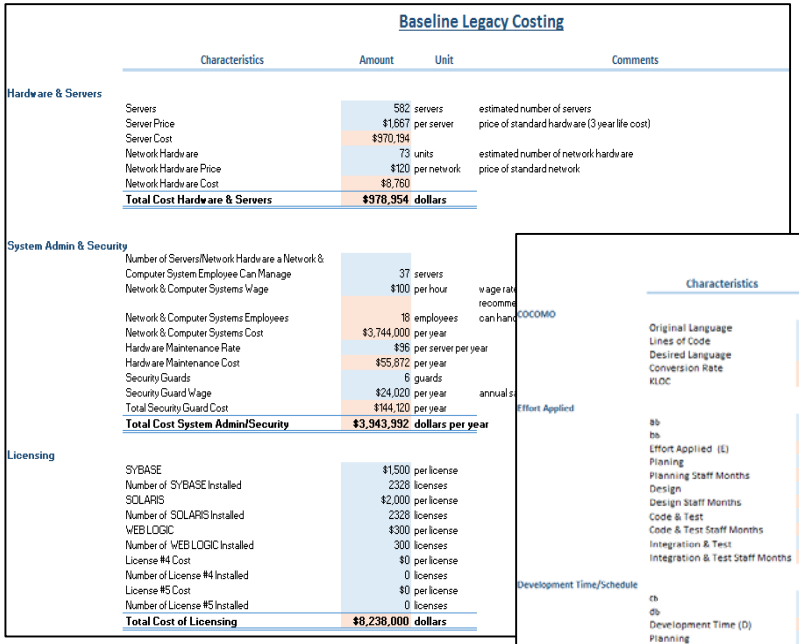
Cloud prices
Servers
Storage
Other

Per year

1. Cost to operate in data center
2. Cost to transition to cloud
3. Cost to operate in the cloud
4. Cloud vs data center each year
5. Cumulative difference
6. Payback = when cumulative cost of transition and cloud is less than data center

CloudCost Inputs

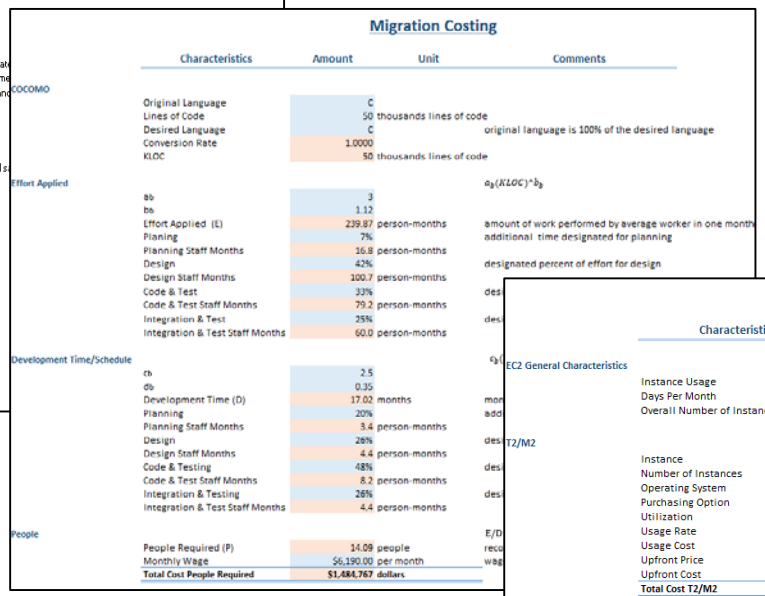
Baseline Legacy Costs



Baseline Legacy Costing

	Characteristics	Amount	Unit	Comments
Hardware & Servers				
	Servers	582	servers	estimated number of servers
	Server Price	$1,667	per server	price of standard hardware (3 year life cost)
	Server Cost	$970,194		
	Network Hardware	73	units	estimated number of network hardware
	Network Hardware Price	$120	per network	price of standard network
	Network Hardware Cost	$8,760		
	Total Cost Hardware & Servers	**$978,954**	**dollars**	
System Admin & Security				
	Number of Servers/Network Hardware a Network &			
	Computer System Employee Can Manage	37	servers	
	Network & Computer Systems Wage	$100	per hour	wage rat… recomme…
	Network & Computer Systems Employees	18	employees	can hand…
	Network & Computer Systems Cost	$3,744,000	per year	
	Hardware Maintenance Rate	$96	per server per year	
	Hardware Maintenance Cost	$55,872	per year	
	Security Guards	6	guards	
	Security Guard Wage	$24,020	per year	annual s…
	Total Security Guard Cost	$144,120	per year	
	Total Cost System Admin/Security	**$3,943,992**	**dollars per year**	
Licensing				
	SYBASE	$1,500	per license	
	Number of SYBASE Installed	2328	licenses	
	SOLARIS	$2,000	per license	
	Number of SOLARIS Installed	2328	licenses	
	WEB LOGIC	$300	per license	
	Number of WEB LOGIC Installed	300	licenses	
	License #4 Cost	$0	per license	
	Number of License #4 Installed	0	licenses	
	License #5 Cost	$0	per license	
	Number of License #5 Installed	0	licenses	
	Total Cost of Licensing	**$8,238,000**	**dollars**	

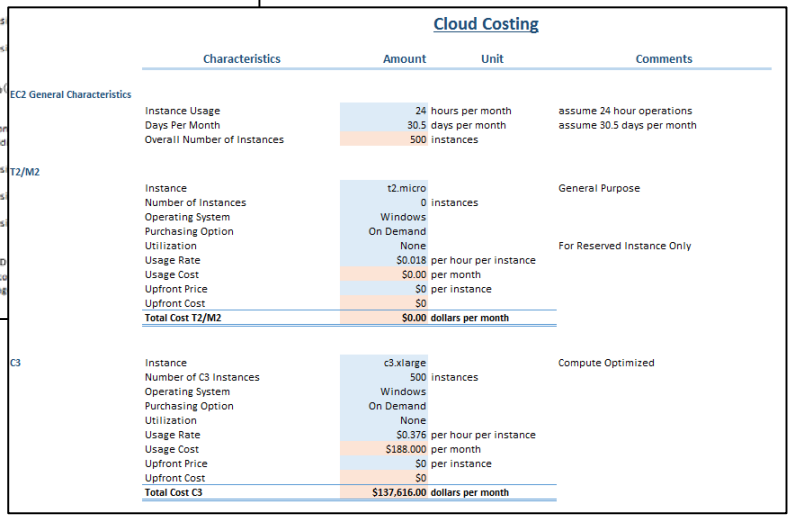
Migration Costs



Migration Costing

	Characteristics	Amount	Unit	Comments
COCOMO				
	Original Language	C		
	Lines of Code	50	thousands lines of code	
	Desired Language	C		original language is 100% of the desired language
	Conversion Rate	1.0000		
	KLOC	50	thousands lines of code	
Effort Applied				$a_b(KLOC)^{b_b}$
	ab	3		
	bb	1.12		
	Effort Applied (E)	239.87	person-months	amount of work performed by average worker in one month
	Planing	7%		additional time designated for planning
	Planning Staff Months	16.8	person-months	
	Design	42%		designated percent of effort for design
	Design Staff Months	100.7	person-months	
	Code & Test	33%		des…
	Code & Test Staff Months	79.2	person-months	
	Integration & Test	25%		des…
	Integration & Test Staff Months	60.0	person-months	
Development Time/Schedule				$t_b($
	cb	2.5		
	db	0.35		
	Development Time (D)	17.02	months	mon…
	Planning	20%		add…
	Planning Staff Months	3.4	person-months	
	Design	26%		des…
	Design Staff Months	4.4	person-months	
	Code & Testing	48%		des…
	Code & Test Staff Months	8.2	person-months	
	Integration & Testing	26%		des…
	Integration & Test Staff Months	4.4	person-months	
People				E/D…
	People Required (P)	14.09	people	reco…
	Monthly Wage	$6,190.00	per month	wag…
	Total Cost People Required	**$1,484,767**	**dollars**	

Cloud Costs



Cloud Costing

	Characteristics	Amount	Unit	Comments
EC2 General Characteristics				
	Instance Usage	24	hours per month	assume 24 hour operations
	Days Per Month	30.5	days per month	assume 30.5 days per month
	Overall Number of Instances	500	instances	
T2/M2				
	Instance	t2.micro		General Purpose
	Number of Instances	0	instances	
	Operating System	Windows		
	Purchasing Option	On Demand		
	Utilization	None		For Reserved Instance Only
	Usage Rate	$0.018	per hour per instance	
	Usage Cost	$0.00	per month	
	Upfront Price	$0	per instance	
	Upfront Cost	$0		
	Total Cost T2/M2	**$0.00**	**dollars per month**	
C3				
	Instance	c3.xlarge		Compute Optimized
	Number of C3 Instances	500	instances	
	Operating System	Windows		
	Purchasing Option	On Demand		
	Utilization	None		
	Usage Rate	$0.376	per hour per instance	
	Usage Cost	$188.000	per month	
	Upfront Price	$0	per instance	
	Upfront Cost	$0		
	Total Cost C3	**$137,616.00**	**dollars per month**	

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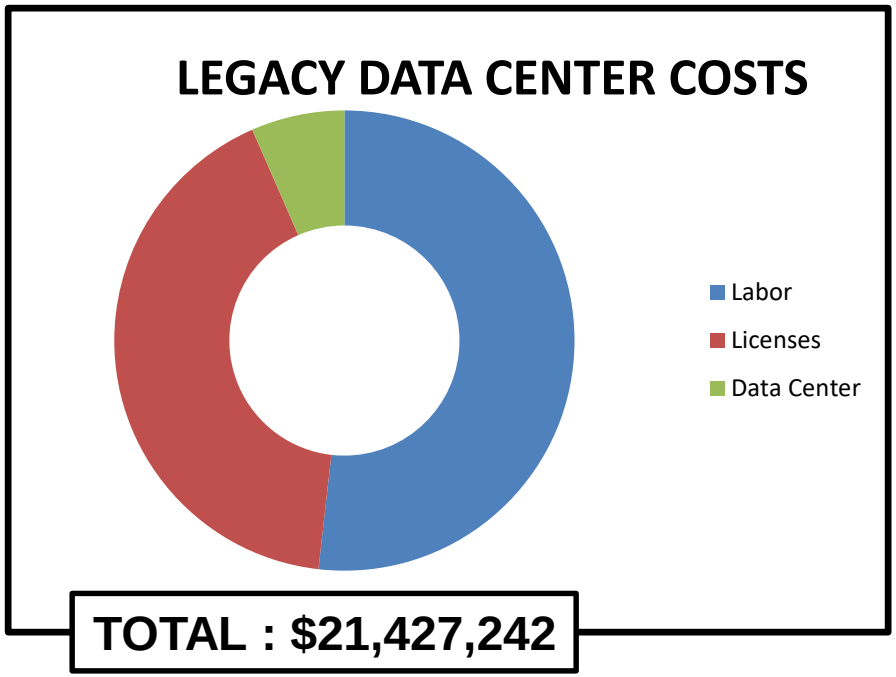
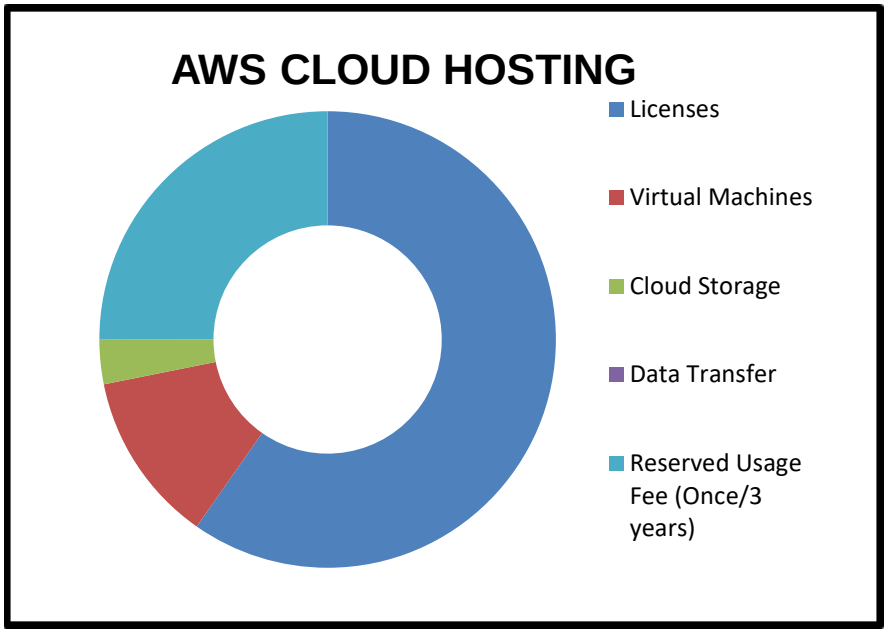
1) Legacy Data Center Costs

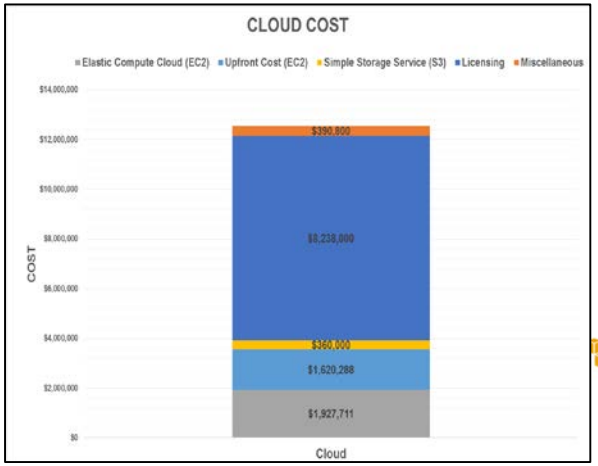
- **Model Parameters**
  - Labor
    - System Admins
  - Other Direct Costs
    - Licenses
  - Data Center
    - Hardware (HW) Servers
    - Network Servers
    - HW Maintenance
    - Power & Cooling
    - Data Center Space



2) Cloud Costs – AWS (C2S)

- **Model Parameters**
  - Virtual Machines
    - Instances
    - Usage (% or hr/month)
    - Operating System
    - Billing Option
      - On-demand or reserved instances
      - Level of usage
    - Data Transfers (GB/mo)
      - In, Out
    - Elastic Load Balancing
  - Storage
    - Storage (GB,TB, TB)
    - Data Transfer
      - In, Out (GB/mo)
  - Other Direct Costs
    - Licenses





TOTAL : $14,945,397

amazon.com web services

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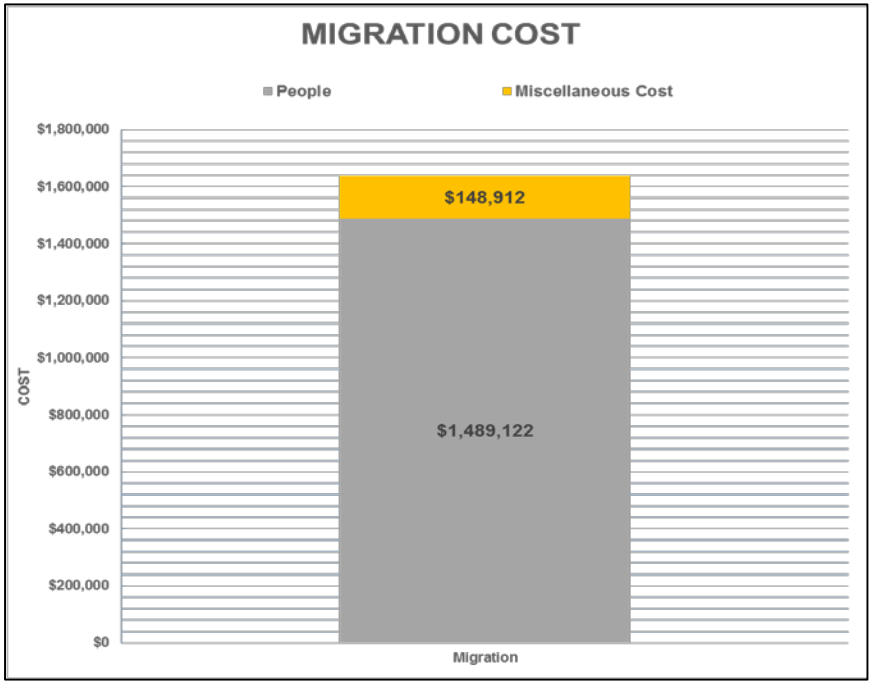
CloudCost Migration

- Migration costs may be significant
- Assumption = migration is a software project
- COCOMO with added costs built in
- Computes
  - Effort
  - Cost
  - Schedule



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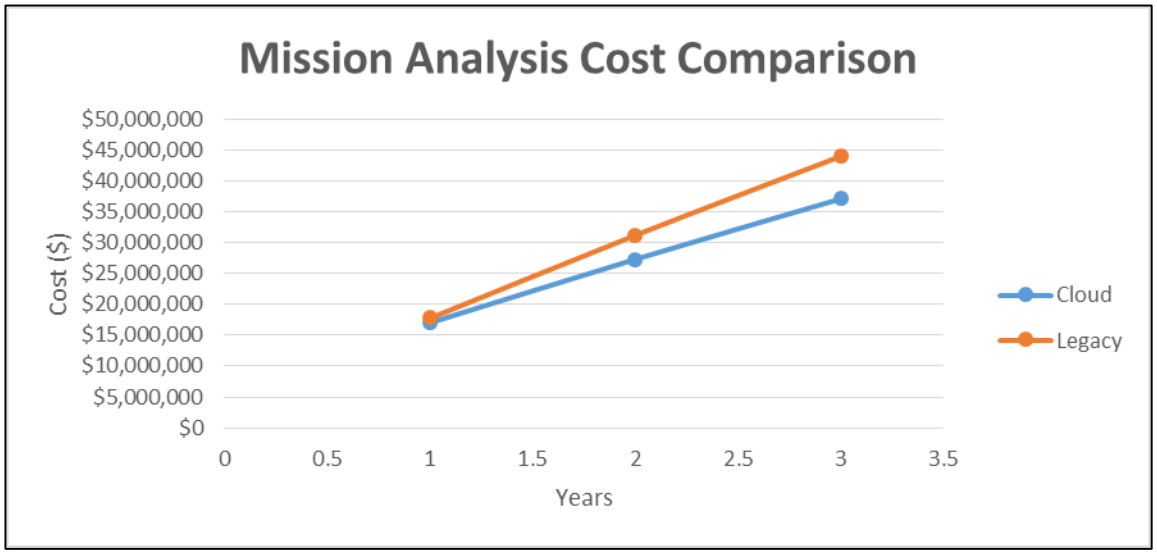
Results Legacy vs Cloud Cumulative Cost Comparison



Year	Legacy Cost	Legacy Cost NPV	Cloud Cost	Cloud Cost NPV	Percentage	Saving/Expenditure
0	$3,595,626	$3,595,626	$6,116,443	$6,116,443	-70%	Expenditure
1	$17,762,547	$17,762,547	$16,642,155	$16,642,155	6%	Savings
2	$31,929,468	$31,184,434	$27,167,866	$26,533,938	15%	Savings
3	$46,096,389	$43,970,286	$37,693,577	$35,955,037	18%	Savings

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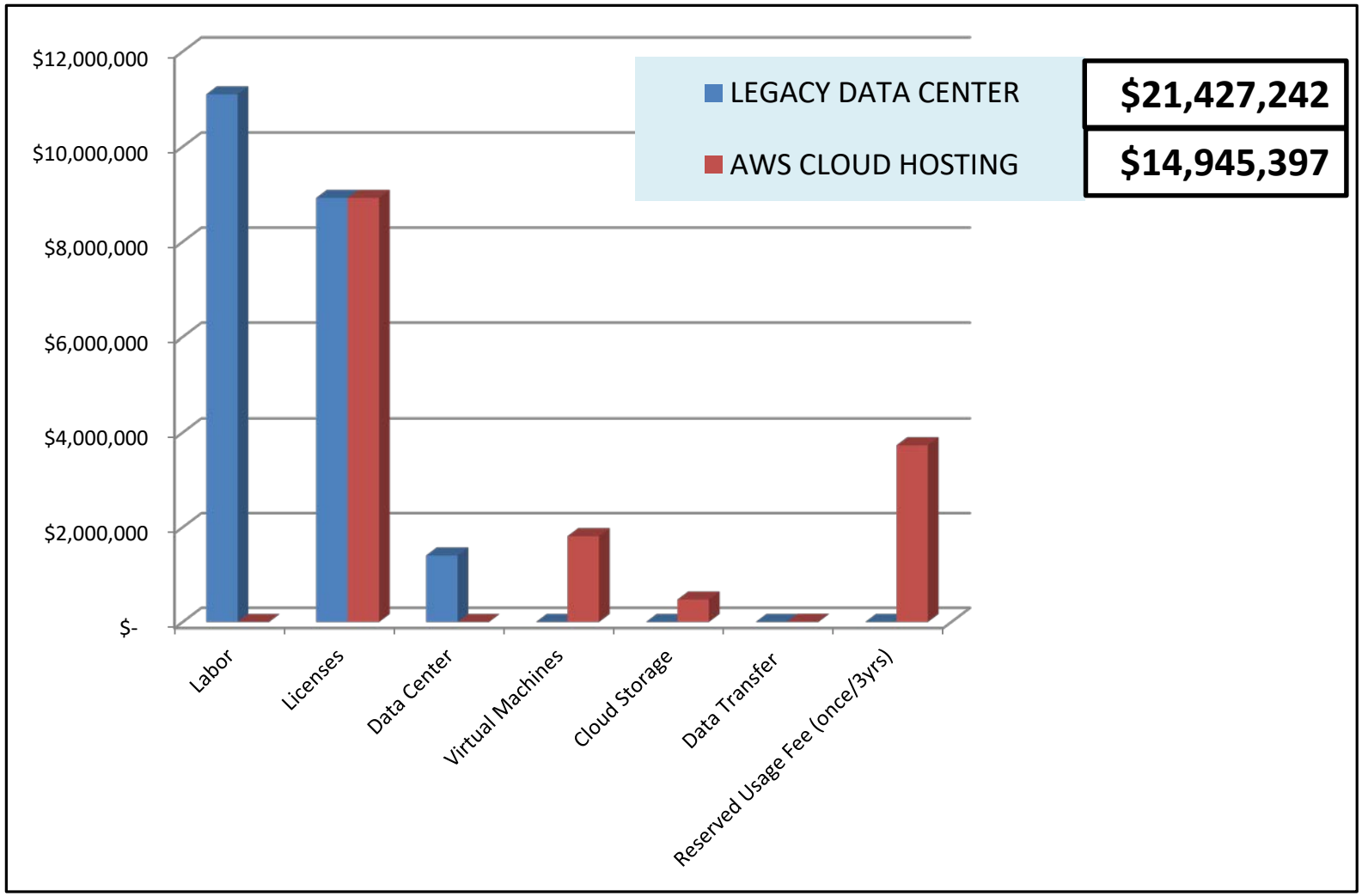
Data Center vs Cloud Price Comparison



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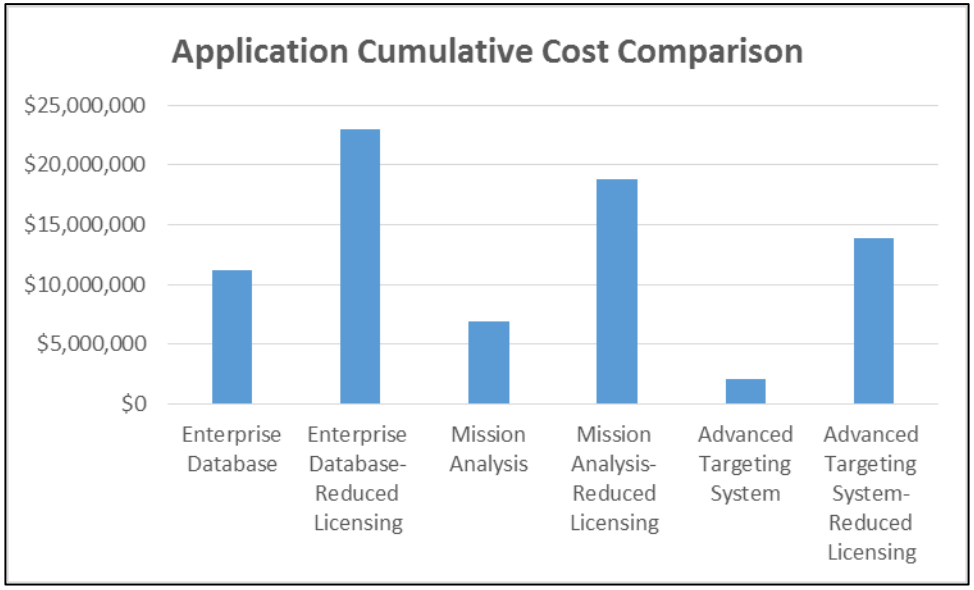
CloudCost Portfolio Output

Name	Total	2015	2016	2017
Enterprise Database	$11,185,703	$5,225,748	$3,174,565	$3,100,491
Enterprise Database- Reduced Licensing	$22,972,761	$9,344,748	$7,197,454	$7,029,510
Mission Analysis	$6,896,924	$729,593	$3,174,565	$3,100,491
Mission Analysis- Reduced Licensing	$18,778,055	$4,947,215	$7,197,454	$7,029,510
Advanced Targeting System	$2,068,637	-$4,332,157	$3,174,565	$3,100,491
Advanced Targeting System- Reduced Licensing	$13,855,695	-$213,157	$7,197,454	$7,029,510



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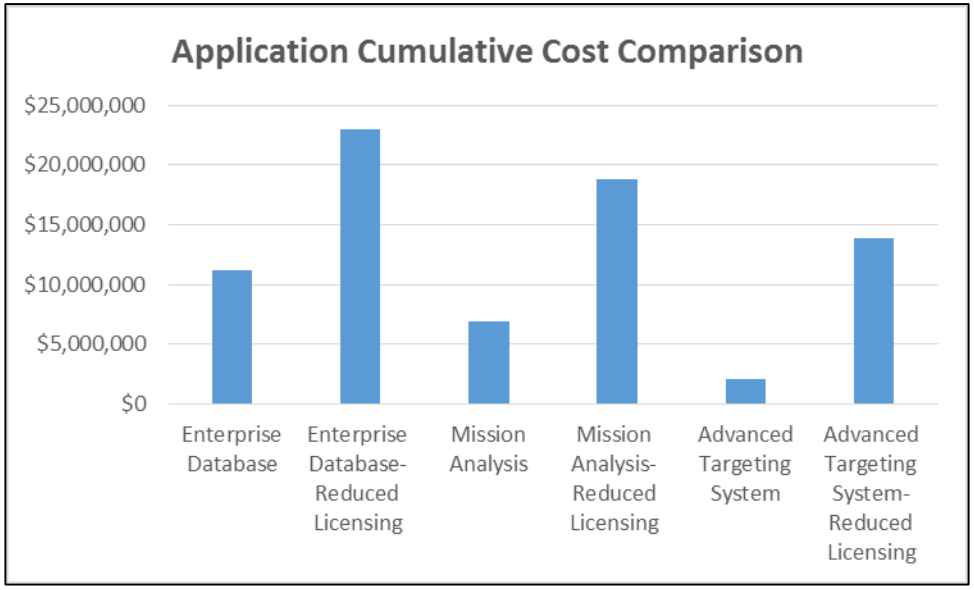
Name	Total	2015	2016	2017
Enterprise Database	$11,185,703	$5,225,748	$3,174,565	$3,100,491
Enterprise Database- Reduced Licensing	$22,972,761	$9,344,748	$7,197,454	$7,029,510
Mission Analysis	$6,896,924	$729,593	$3,174,565	$3,100,491
Mission Analysis- Reduced Licensing	$18,778,055	$4,947,215	$7,197,454	$7,029,510
Advanced Targeting System	$2,068,637	-$4,332,157	$3,174,565	$3,100,491
Advanced Targeting System- Reduced Licensing	$13,855,695	-$213,157	$7,197,454	$7,029,510



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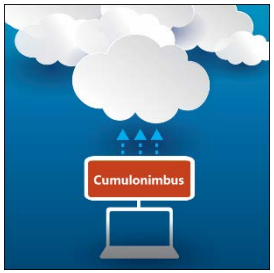
Cumulonimbus

- **Cumulonimbus is a tool for choosing viable and preferred mechanisms for migrating applications to the cloud, among the following options:**
  - Rehost: Redeployment of an application to a different environment; application would run on a virtual machine or operating system in the cloud
  - Refactor: Execution of an application on a cloud provider's infrastructure by making code or configuration changes to connect to the new infrastructure services
  - Reengineer: Modification or extension of existing code to optimize its operation in the cloud
  - Replace: Use of commercial software that has the desired functionality and is delivered as a cloud service; existing application would be discarded



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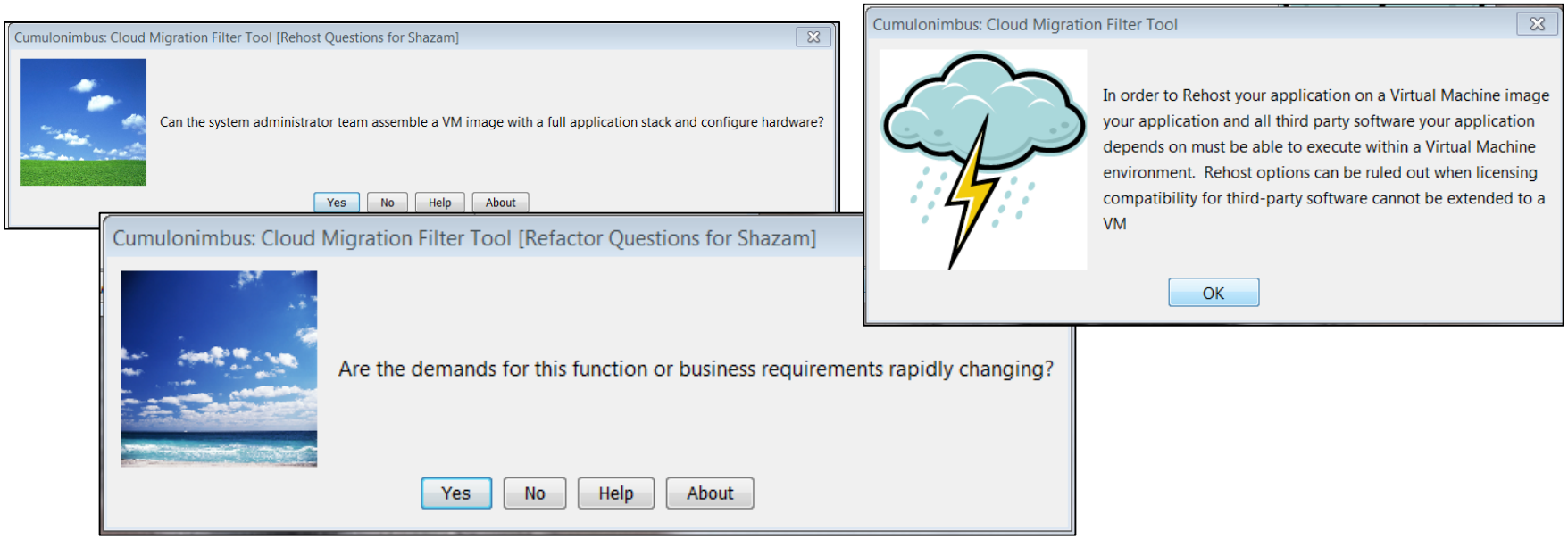
Cumulonimbus Mode of Operation

- **Cumulonimbus guides the user through a series of questions to determine what cloud migration options are viable for an application**
  - Once an option is ruled out, the user is not asked any more questions on the option
  - Help is available for each question



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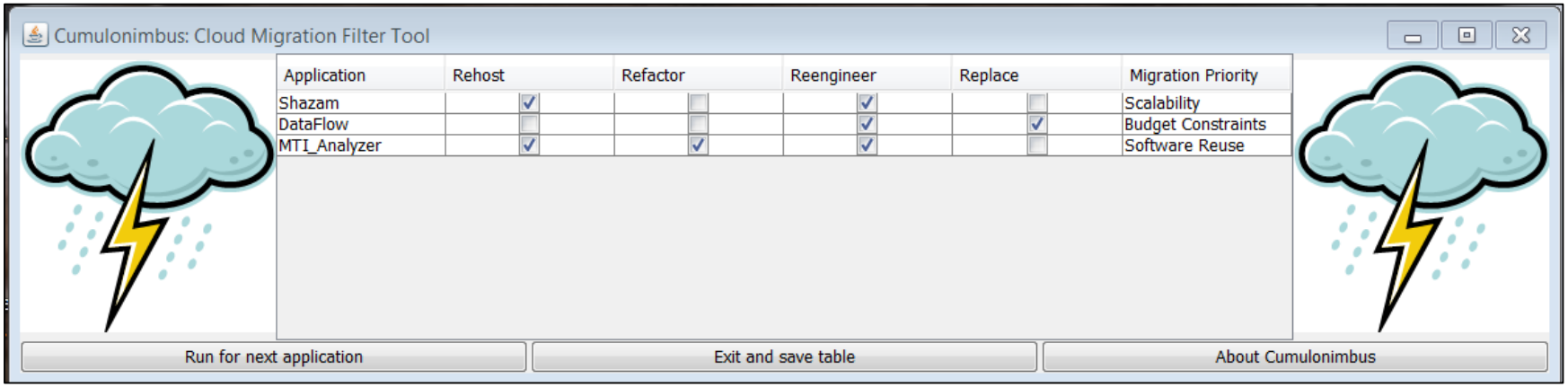
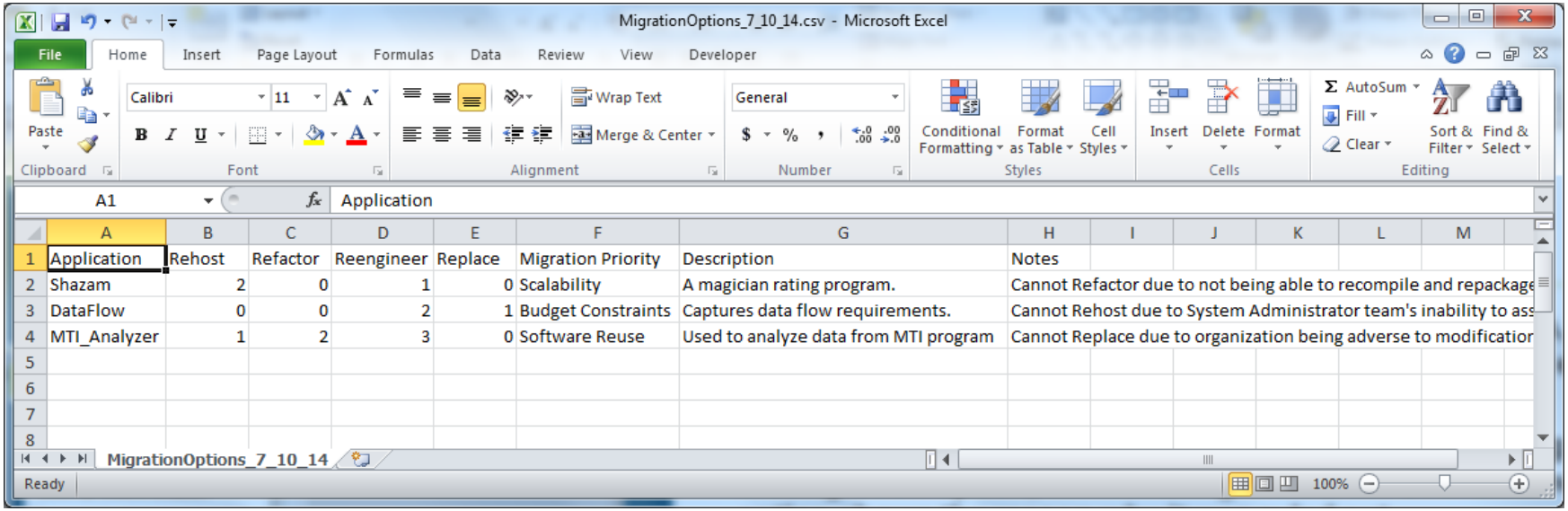
Cumulonimbus Output

- As Cumulonimbus collects data for different applications, it builds a table containing the viable migration options for each application
- Moving the cursor over a viable option shows the ranking of the migration option, while moving the cursor over an unviable option shows the reason why it was ruled out



Cumulonimbus Output

- **At the end of execution, output is saved to a Comma-Separated Value (CSV) file that can be easily loaded into a spreadsheet**



	A	B	C	D	E	F	G	H
1	Application	Rehost	Refactor	Reengineer	Replace	Migration Priority	Description	Notes
2	Shazam	2	0	1	0	Scalability	A magician rating program.	Cannot Refactor due to not being able to recompile and repackage
3	DataFlow	0	0	2	1	Budget Constraints	Captures data flow requirements.	Cannot Rehost due to System Administrator team's inability to ass
4	MTI_Analyzer	1	2	3	0	Software Reuse	Used to analyze data from MTI program	Cannot Replace due to organization being adverse to modification
5								
6								
7								
8								

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Demos

- **Cloud Migration Index**
- **Cloud Cost**
- **Cumulonimbus**