The Economics of Cloud Computing

Addressing the Benefits of Infrastructure in the Cloud

June 2010

The Office of Management and Budget is embracing cloud computing as the preferred federal IT environment of the future

- Reduce expenditures for IT infrastructure and services
- Trade up-front investment for significant outyear savings
- Begin with pilot programs that lead to agency migrations

"Of the investments that will involve up-front costs to be recouped in outyear savings, Cloud-computing is a prime case in point. The federal government will transform its Information Technology Infrastructure by virtualizing data centers, consolidating data centers and operations, and ultimately adopting a Cloud computing business model. Initial pilots conducted in collaboration with federal agencies will serve as test beds … The pilots will evolve into migrations of major agency capabilities from agency computing platforms to base agency IT processes and data in the Cloud. Expected savings in the outyears, as more agencies reduce their costs of hosting systems in their own data centers, should be many times the original investment in this area."

President's Budget, FY10, Section 9

In the private sector, cloud computing is in a "hype cycle" and cost savings claims are often inflated

- Most ROI estimates are driven by reductions in hardware replacement costs
- "ROI Calculators" are provided by vendors who stand to profit from cloud adoption
- ROI was not based on a Life Cycle Cost Estimate, and excludes
  - Systems engineering and program management
  - Operations support
  - Transition costs and parallel operations during transition

It makes sense that cloud computing will lower IT costs, but what's the real story?

Booz Allen constructed detailed cost models and a framework for economic analysis that produces Life Cycle Cost Estimates for cloud computing

- Cost model built on government and commercial best practices
  - Tailored DoD Cost Element Structure (CES)
  - Industry best-practice Cost Estimating Relationships
  - SCEA-certified estimating and analysis methods
- Economic framework addresses
  - Net Present Value: present value of the net difference of all estimated savings minus total costs
  - Benefit-Cost Ratio: ratio of total savings to total costs
  - (Discounted) Payback Period: the time required to recover investments through future savings

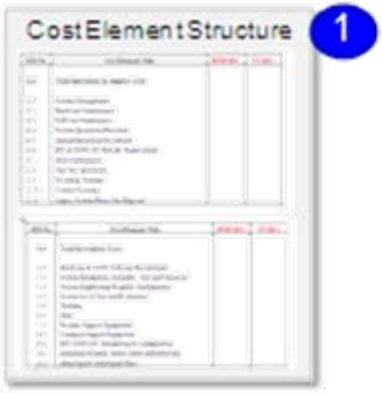
We applied our analysis to the three prevalent cloud computing deployment models

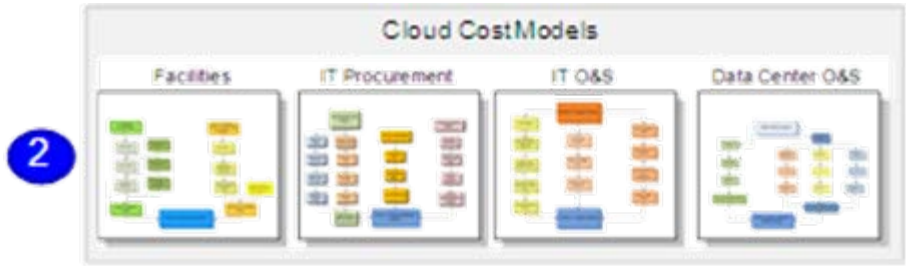
Cloud Computing Deployment Model	Definition	Characteristics	Assumptions
Public Cloud	Department or agency migrates its IT infrastructure to an existing public cloud.	Relatively low level of mission, bureau, or program-specific sensitivities; these agencies may be the most likely early adopters of cloud computing.	Transition to the new cloud environment will occur steadily over 3 years; workload remains constant (i.e., no increase in capacity demand)
Hybrid Cloud	Department or agency builds a private cloud solution to handle the majority of its IT workload but also uses a public cloud solution to provide "surge" support and/or support for low-sensitivity applications.	Bureau or program-specific payment and/or privacy sensitivities; because of the inherent complexity of this scenario, these agencies are more likely to be part of the "second wave" of cloud adopters.	Seventy-five percent of the IT server workload will migrate to a private cloud, and the remaining 25 percent will be transitioned to a public cloud; transition to the new cloud environments will occur steadily over 3 years; existing facilities will be used (i.e., no new investment is required in physical facilities) and workload remains constant (i.e., no increase in capacity demand)
Private Cloud	Department or agency builds its own private cloud solution or participates in an interagency cloud solution.	Broad mission sensitivity; given the perceived risk, these agencies may be more likely to be late adopters of cloud solutions.	Transition to the new cloud environment will occur steadily over 3 years; existing facilities will be used (i.e., no new investment is required in physical facilities); workload remains constant (i.e., no increase in capacity demand).

Our study focused on factors likely to be common to any cloud computing scenario

- The study considered
  - *Transition costs,*
  - *Life-cycle operations*, *and*
  - *Likely migration schedules* - which other studies usually ignore or treat incidentally
- Analysis framework consists of
  - Up-front investment costs
  - Transition schedules and costs
  - Steady-state Operations and Support costs over a 10-year life cycle
- Exclusions:
  - Costs that would be less likely to vary significantly between Cloud scenarios
  - Costs for physical facilities -- assume “wash” cost between the existing and new Cloud environments.

The cost estimating process produces low, high, and most probable cost estimates.





1. Begin with a tailored Cost Element Structure
2. Gather data and estimate costs, using Cost Estimating Relationships, historical data, vendor quotes, and engineering estimates
3. Refine assumptions for each cloud deployment model
4. Calculate the economic metrics

4

Costs/Economic Metrics	Status Quo: 1,000 Server (Non-Virtualized) Environment	Scenario 1: Public Cloud	Scenario 2: Hybrid Cloud	Scenario 3: Private Cloud
Investment Phase Costs FY10–12 (BY09 M$)	$0	$3.0	$6.1	$7.0
O&S Phase Costs FY10–22 (BY09 M$)	$77.3	$22.5	$28.9	$31.1
Total LCCs (BY09 M$)	$77.3	$25.5	$35.0	$38.1
Economic Metrics:				
NPV (BY09 M$)	N/A	$41.8	$33.7	$31.1
BCR	N/A	15.4	6.8	5.7
DPP (Years)	N/A	2.7	3.5	3.7

Our cost model allows precise descriptions of hardware procurement, reuse, power consumption, facilities*, and labor costs

* The cost model allows facility costs, but in this study we assumed the facility costs were $0

General Cloud Server & Facililty Characteristic Assumptions

	Green Cells	= Data to be provide
Facility Size		
Tier Level of Facility	4	
Exisitng Server Information		
No. of Existing Servers		Avg. Current Server Utilization Rate
Low-end Server	1,405	12%
Mid-range Server	60	12%
High-end Server	21	12%
Total Existing environment server Units	1,486	
Existing IT System Admin. Staff Requirements (24/7) i	25	
% Existing Servers to be Re-used in New Private Cloud		
Low-end Server		
Mid-range Server		
High-end Server		
No. of existing Servers to be Re-used in New Private Cloud		
Low-end Server	0	
Mid-range Server	0	
High-end Server	0	
Total existing Servers to be re-used	0	
No. Servers in New Cloud Environment		
Low-end Server		
Max Server Utilization in Cloud Environment	60%	
Total required servers	281	
Mid-range Server		
Max Server Utilization in Cloud Environment	60%	
Total required servers	12	
High-end Server		
Max Server Utilization in Cloud Environment	60%	
Total required servers	4	

Power Metrics	
IT (UPS load)	1
Cooling (chillers, fans, pumps) x UPS Load	1.0
Auxiliaries (UPS losses, lighting, other) x UPS Load	0.3
Land & Construction Costs	
Land (K$'s per acre)	
Number of acres of land needed	
Facilities Cost per Square Foot	$240
Power Related Facilities Cost	$24,772
Building Arch. & Engring (% of IT & Non-IT constr. costs)	5.0%
Power Usage	
Average hours per year	8766
Load factor (power, not computation)	98%
Electricity Cost ($/KWH)	$0.10

$'s per KW By Tier Level		
TIER Level	FY05*	FY09*
Tier III	$20,000	$22,520
Tier IV	$22,000	$24,772

* FY05 Cost Data from Uptime Institute 2006 White Paper by Pitt Turner & John Seader on $'s per K

Our cost model allows precise descriptions of hardware procurement, reuse, power consumption, facilities*, and labor costs (con't)

IT Labor: Server Installation & Hookup	Hrs./Server
Low-end Server	20
Mid-range Server	20
High-end Server	20
IT fully loaded labor $'s per Hour (FY09 $'s)	$100

IT Labor: COTS SW Install. & Config.	% Cost Mark up
COTS SW Installation Labor	36%
COTS SW Intial Configuration Labor	33%

Rack Information

Low-end Server	
Units Per Rack	33
Assumed area per Rack (SF)	9
% of Rack Filled	100%
Number of Racks	12
Number of IT facilities SF Required	216

Mid-range Server	
Units Per Rack	16
Assumed area per Rack (SF)	9
% of Rack Filled	100%
Number of Racks	7
Number of IT facilities SF Required	126

High-end Server	
Units Per Rack	8
Assumed area per Rack (SF)	9
% of Rack Filled	100%
Number of Racks	4
Number of IT facilities SF Required	72

New Facility Size	
IT area (SF)	414
Non - IT Power/Cooling support area (SF)	646
Total Size of Facility (SF)	1,060

Our cost model allows precise descriptions of hardware procurement, reuse, power consumption, facilities*, and labor costs (con't)

Misc. Hardware Cost Information	
Low-end Server	**KS's/Rack**
Rack costs	$3.5
External hardwired connections	$5.0
Internal routers and switches	$5.0
Rack management hardware	$2.0
Mid-range Server	**KS's/Rack**
Rack costs	$3.5
External hardwired connections	$5.0
Internal routers and switches	$5.0
Rack management hardware	$2.0
High-end Server	**KS's/Rack**
Rack costs	$3.5
External hardwired connections	$5.0
Internal routers and switches	$5.0
Rack management hardware	$2.0
Cabling Costs (% of other HW Costs)	**5.0%**

ew Cloud Environment	No. Servers	Avg Power Consumption (Watts)	Server cost (K $'s)
Low-end Server	0	217	$1.8
Mid-range Server	0	641	$3.3
High-end Server	0	1,000	$12.6
Procure New Servers			
Low-end Server	281	217	$1.8
Mid-range Server	12	641	$3.3
High-end Server	4	1,000	$12.6
Total Servers	**297**		

The model allows detailed specification of implementation schedules, to include reuse of existing infrastructure

Implementation Schedule

				Total	FY2009	FY2010	FY2011	FY2012	FY2013	FY2014	FY2015	FY2016	FY2017	FY2018
	Facilities Construction Schedule			0%										

Server Implementation		Required		Total	FY2009	FY2010	FY2011	FY2012	FY2013	FY2014	FY2015	FY2016	FY2017	FY2018
Low-end Server	Re-use	0		0										
Mid-range Server	Re-use	0		0										
High-end Server	Re-use	0		0										
Low-end Server	New	281		350		210	140							
Mid-range Server	New	12		93		56	37							
High-end Server	New	4		23		14	9							
Total		297		466	0	280	186	0	0	0	0	0	0	0
Total Implementation years				2		1	1	0	0	0				

Other Hardware Implementation		Required		Total	FY2009	FY2010	FY2011	FY2012	FY2013	FY2014	FY2015	FY2016	FY2017	FY2018
Other Hardware Item A		0		0										
Other Hardware Item B		0		0										
Other Hardware Item C		0		0										
		0		0	0	0	0	0	0	0	0	0	0	0

Misc. HW (Routers, Switches, Racks, Cables)				Total	FY2009	FY2010	FY2011	FY2012	FY2013	FY2014	FY2015	FY2016	FY2017	FY2018
Low-end Server		= Racks		12	0	7	5	0	0	0	0	0	0	0
Mid-range Server		= Racks		7	0	4	3	0	0	0	0	0	0	0
High-end Server		= Racks		4	0	2	2	0	0	0	0	0	0	0
Total				23	0	13	10	0	0	0	0	0	0	0

The cloud computing cost model calculates costs over a program life cycle and estimates the economic benefit of the proposed program

Summary Financial Economic Measures

Net Present Value (NPV) in FY09 K$'s	$30,281
Benefit-Cost Ratio (BCR)	3.6
Discounted Payback Period (DPP)*	4.0
Real Discount Rate =	2.60%

*Years from the beginning of the Cloud investment phase

CES #	Labor	# FTEs
2.0	Test	1.0
3.1	PM	1.8
3.2	SE	3.4
12.4.2	IT O&S	5.0

Year No. =	0	1	2	3	4	5	6	7	8	9	10	11	12	13
	FY09	FY10	FY11	FY12	FY13	FY14	FY15	FY16	FY17	FY18	FY19	FY20	FY21	FY22
Discount Factors =	1.0000	0.9747	0.9500	0.9259	0.9024	0.8796	0.8573	0.8355	0.8144	0.7937	0.7736	0.7540	0.7349	0.7163

Internal Cloud Alternative Constant Dollars Costs

	Total	FY09	FY10	FY11	FY12	FY13	FY14	FY15	FY16	FY17	FY18	FY19	FY20	FY21	FY22
Investment Costs (BY09 K$'s)	$12,015	$0	$7,407	$4,608	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Recurring Costs (BY09 K$'s)	$46,003	$0	$8,050	$4,636	$2,087	$2,087	$2,087	$5,192	$4,162	$2,087	$2,087	$2,087	$5,192	$4,162	$2,087

Status Quo Alternative Constant Dollars

	Total	FY09	FY10	FY11	FY12	FY13	FY14	FY15	FY16	FY17	FY18	FY19	FY20	FY21	FY22
Investment Costs (BY09 K$'s)	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Recurring Costs (BY09 K$'s)	$96,672	$0	$7,436	$7,436	$7,436	$7,436	$7,436	$7,436	$7,436	$7,436	$7,436	$7,436	$7,436	$7,436	$7,436

Undiscounted BY09 K$'s Costs & Benefits	Total	FY09	FY10	FY11	FY12	FY13	FY14	FY15	FY16	FY17	FY18	FY19	FY20	FY21	FY22
Net Investment Costs (Cloud Alt. - SQ Alt.)	$12,015	$0	$7,407	$4,608	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Net System Benefits (SQ Alt. - Cloud Alt.)	$50,669	$0	-$614	$2,800	$5,349	$5,349	$5,349	$2,245	$3,275	$5,349	$5,349	$5,349	$2,245	$3,275	$5,349

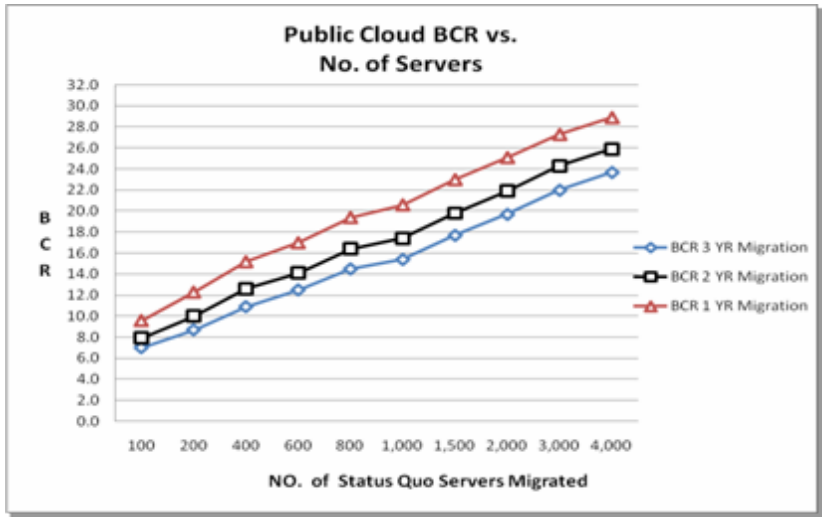
Discounted Costs & Benefits (K$'s)	Total	FY09	FY10	FY11	FY12	FY13	FY14	FY15	FY16	FY17	FY18	FY19	FY20	FY21	FY22
Discounted Net Investment Costs	$11,596	$0	$7,219	$4,377	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Discounted Net Cloud Benefits	$41,878	$0	-$598	$2,660	$4,953	$4,827	$4,705	$1,924	$2,736	$4,356	$4,246	$4,138	$1,692	$2,407	$3,832
Cumulative Net Cloud Benefits		-$11,596	-$12,194	-$9,535	-$4,582	$245	$4,950	$6,874	$9,611	$13,967	$18,213	$22,351	$24,043	$26,450	$30,281
DPP Calculation			0.0	0.0	0.0	4.0	4.1	7.6	8.5	9.2	11.3	13.4	23.2	21.0	18.9

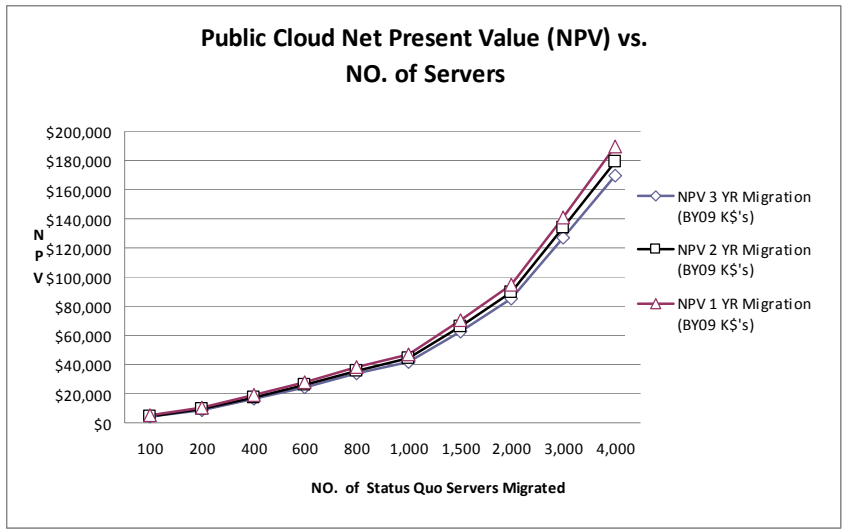
Our LCCE approach calculates investment costs, Benefit-Cost Ratio, and Discounted Payback Period on a Life Cycle basis

Costs/Economic Metrics	Status Quo: 1,000 Server (Non-Virtualized) Environment	Scenario 1: Public Cloud	Scenario 2: Hybrid Cloud	Scenario 3: Private Cloud
Investment Phase Costs FY10–12 (BY09 M$)	$0	$3.0	$6.1	$7.0
O&S Phase Costs FY10–22 (BY09 M$)	$77.3	$22.5	$28.9	$31.1
Total LCCs (BY09 M$)	$77.3	$25.5	$35.0	$38.1
Economic Metrics:				
NPV (BY09 M$)	N/A	$41.8	$33.7	$31.1
BCR	N/A	15.4	6.8	5.7
DPP (Years)	N/A	2.7	3.5	3.7

Public Cloud deployments offer the greatest economic benefit, at the expense of ownership and control of resources and data

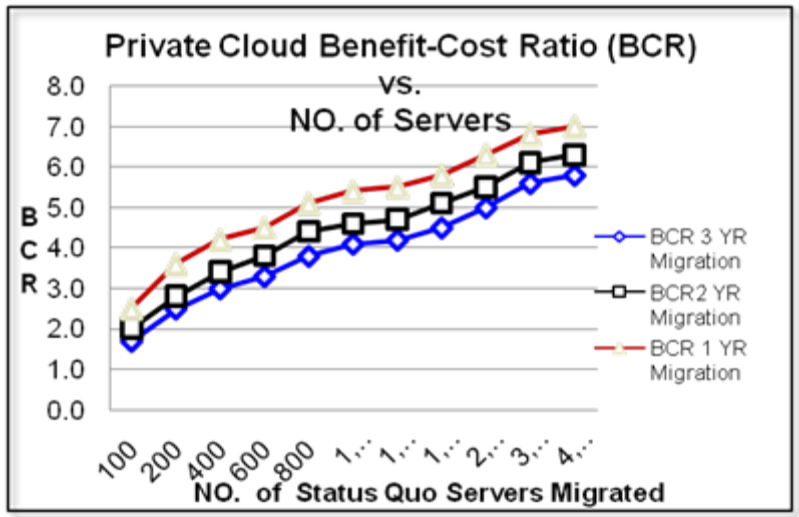
- O&S costs are
  - Unit costs of services procured from the Cloud provider *and*
  - Small amount of IT support labor to respond to service changes or problems
- Assuming public clouds are the primary IT source
  - Additional costs to the agency are minimized
  - Overall BCR is heavily influenced by the overall migration timeline – i.e., the faster the migration, the better the BCR (lower costs)

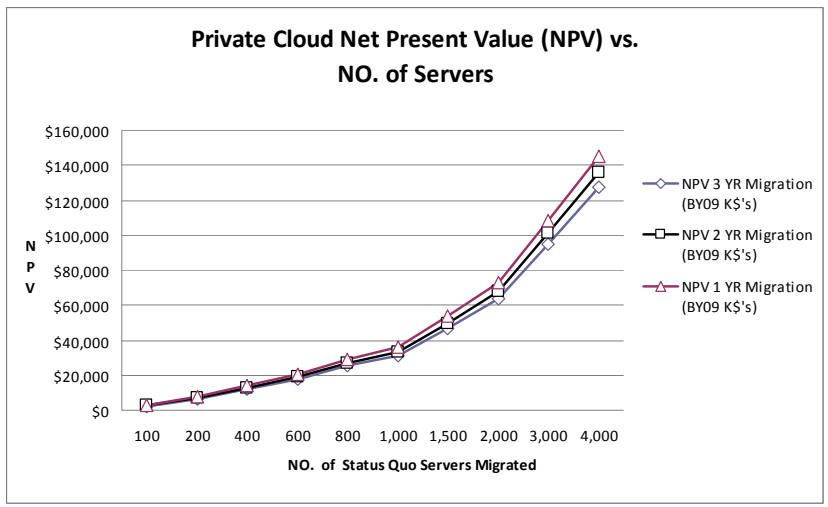




Private Cloud deployments offer substantial savings (although significantly less than public clouds) while preserving resource and data ownership and control

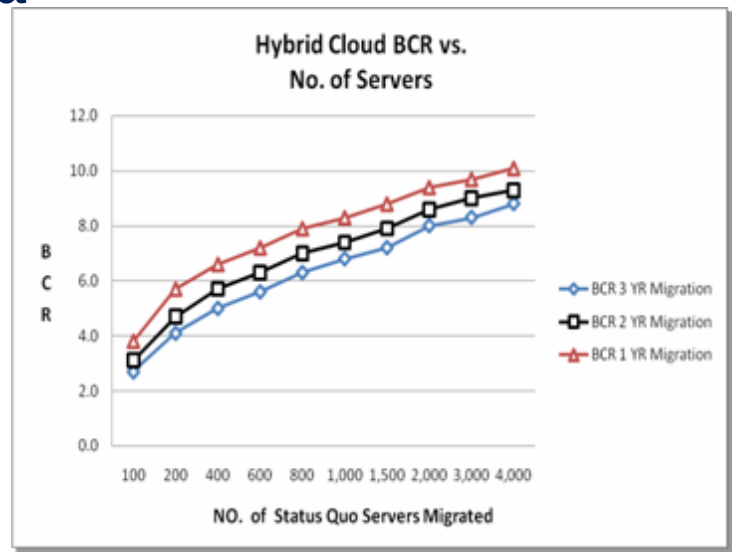
- O&S costs remain high in a Private Cloud model
- Benefits are derived mostly from operating efficiency in infrastructure
- If Migration is prolonged
  - Increased costs are incurred
  - The BCR ultimately achieved will be lower
  - Lesser incremental benefits still do accrue but not of magnitude intended

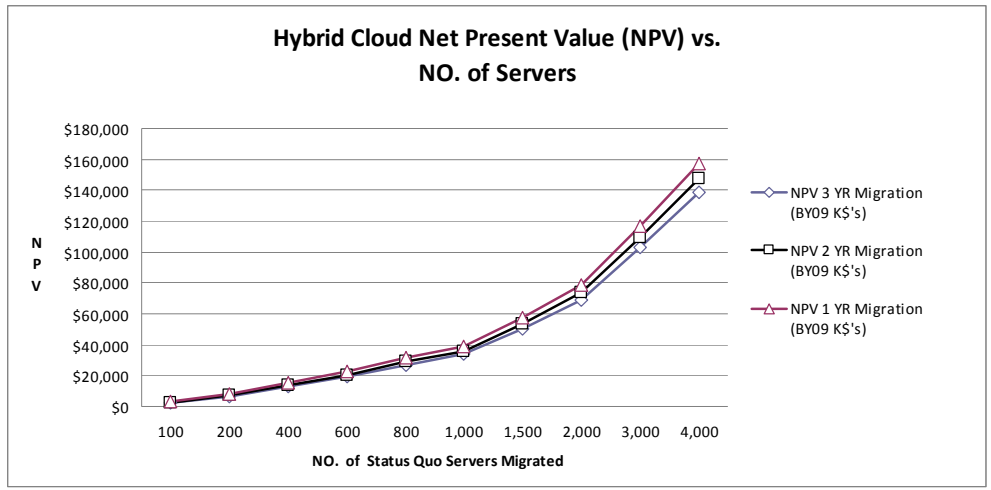




Hybrid Cloud deployments offer both cost savings and ownership and control of resources and data

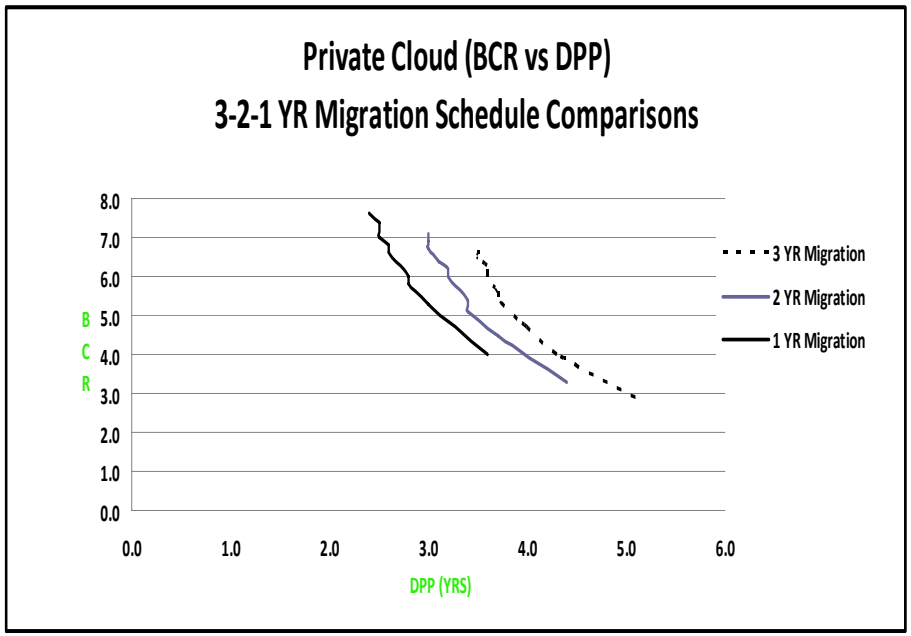
- Results Reflect Assumptions:
  - 75% of the current server workload migrate to a private Cloud, only 25% would transition to the public Cloud.
  - *BUT* if use is reversed (25% private Cloud and 75% public Cloud), hybrid scenario results are closer to the public Cloud results
- Actual results will be a function of speed and scope of transition

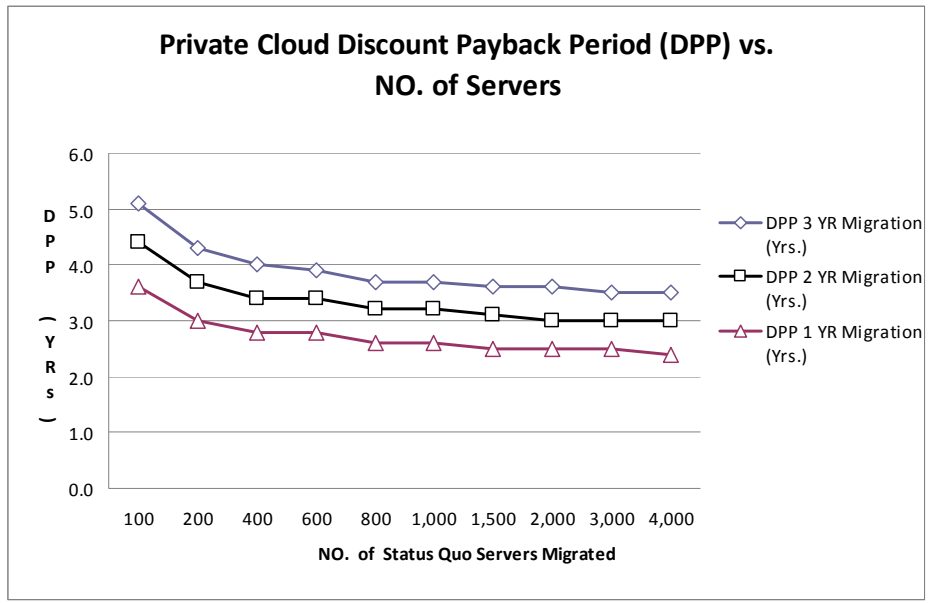




Longer migration schedules reduce the BCR, highlighting the importance of proper planning

- Lengthy parallel operation of status quo and Cloud environments reduces economic benefit
  - BCR goes down rapidly as the migration schedule lengthens, *AND*
  - The discounted payback period (DPP) increases as the transition time





Booz Allen's economic analysis supports the government's expectations of significant cost savings

- Over a 13-year life cycle (3 year transition plus 10 years of O&S)
  - 66% Savings in Life Cycle over conventional IT environments
  - Benefit-to-Cost Ratios (BCR) for mid-sized data centers range from 5.7 to 15.4, while BCRs for larger data centers range as high as 25
  - Payback is not immediate, likely occurring in 4-5 years
- Additional insights were gained into optimal cloud adoption strategies
  - **Scale is important**: Economic benefits increase as larger numbers of non-virtualized servers are migrated into a cloud environment
  - **Time is money**: economic benefits increase as the migration schedule shortened
  - **Budget cycles impact migration**: most agencies will required 18-24 months to plan and implement a migration to a cloud environment

Agencies can implement policy changes and modify business practices to increase the potential benefits of cloud computing

POLICY

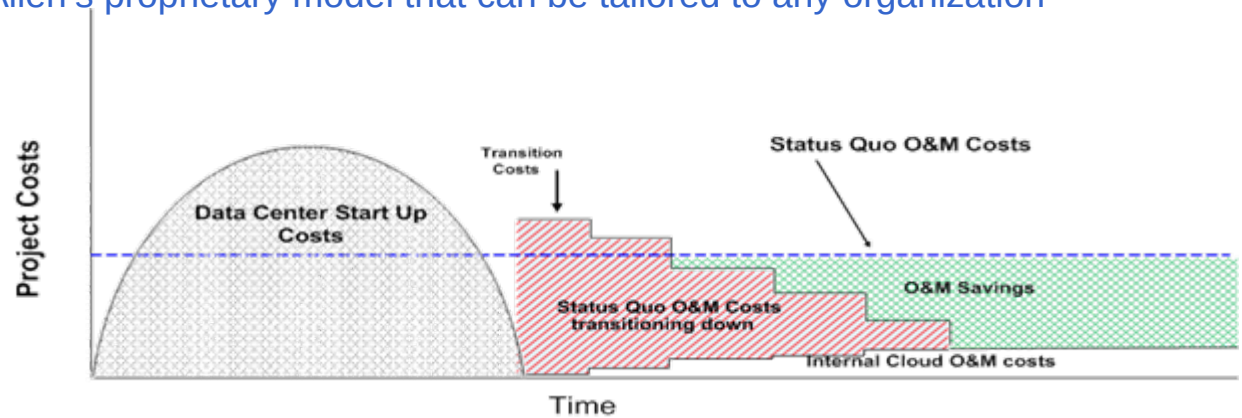
- When selecting a private cloud, seek efficiencies through inter-departmental and interagency collaboration
- Establish incentives, with effective monitoring, for departments and agencies

PRACTICE

- Provide timely, well-coordinated support to ensure agencies have the necessary tools to efficiently plan and carry out migrations to cloud environments
- Identify agencies with highest near-term IT costs and expedite their migration to cloud environments
- Identify specific IT functions that can be transitioned to cloud computing in the near-term
- Promote early wins to help build momentum

Now is the time to develop the economic framework and business case for moving towards operating in the Cloud…

- Decision makers are faced with many of the following questions
  - What services if any should I acquire from the Cloud?
  - What is the total cost and ROI to me?
  - What are the transition cost to the cloud?
  - When can I expect a payback on my investment?
  - How do I monitor my costs during the business cycle?
  - What is the reduction in the operating costs?
  - How do I ensure security and at what cost?
- Organizations need to establish the economic benefits of Cloud Computing
  - Booz Allen's proprietary model that can be tailored to any organization



The government's fiscal planning process shows that organizations need to answer the questions 'When' and 'How Soon', not 'If'

- The federal planning process has an imbedded delay in the realization of the benefits that can be attain from moving to a cloud environment
  - Planning for Cloud today will begin to show initial result in FY 11-FY12 during a transition period