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Cloud migration decisions II

To lease storage from cloud OR buy storage?

Introduction

- A key principle in economic finance is the time value of money
- This principle states that an investor always prefers to receive some fixed amount of money today rather than in the future
- Hence, when making buy-or-lease decisions, investors often compare future cash flows in an investment over time, discounted to their present value by some interest rate

Preliminaries

- In equation form, the simplified standard capital budgeting format for calculating a purchased asset's net present value (NPV) is as follows:

$$\mathrm{NPV}_P = \sum_{T=0}^{N} \frac{P_T - C_T^P}{(1+I_K)^T} + \frac{S}{(1+I_K)^N} - E$$

where

P_T is the annual profit resulting from the purchased asset in year T

C_T P is the asset's expected annual operating cost at year T

I_K is the firm's cost of capital, defined as the interest rate of its outstanding debt used to finance the purchase

N is the asset's productive life in years

S is the asset's salvage value after N years

E is the asset's purchase (capital) cost

Preliminaries

- Similarly, the equation for calculating a leased asset's NPV is as follows:

$$\text{NPV}_L = \sum_{T=0}^{N} \frac{P_T - C_T^L}{\left(1 + I_K\right)^T} - \sum_{T=0}^{N} \frac{L_T}{\left(1 + I_R\right)^T}$$

where

C_T^L is the leased asset's expected annual operating cost at year T

L_T is the lease payment at year T

I_R is the interest rate for financing the lease payments

In this formulation, the lease's financing rate is generally regarded as smaller than the cost of capital, I_K, because of the involved payment structure's predictability

The decision model

- With this NPV formulation for asset purchase and lease, investors can make the buy-or-lease decision using the following criteria: If the incremental NPV (ΔNPV) ≥ 0 ⇒ buy; if Δ NPV < 0 ⇒ lease, where ΔNPV = NPVP – NPVL.

$$\Delta \mathrm{NPV} = \sum_{T=0}^{N} \frac{C_T - E_T + L_T}{\left(1+I_F\right)^T} + \frac{S}{\left(1+I_F\right)^N} - C$$

$$S = \gamma * \Omega * \lceil V_T \rceil_\Omega * K * e^{-0.438T}$$

$$C_T = -\rho * H_T - (365*24) * \delta * \left(P_C + P_D * \lceil V_T \rceil_\Omega\right)$$

$$E_T = \left(1.03 * \lceil V_T \rceil_\Omega - \lceil V_{T-1} \rceil_\Omega\right) * \Omega * K * e^{-0.438T}$$

S: expected end-of-life disk salvage value

CT: the operating cost in year T

ET: capital cost in year T

Term	Description
δ	Cost of electric utility ($/kilowatt hour)
Ω	Size of purchased disk drives (Gbytes)
ρ	Proportional difference between human effort in maintaining a purchased versus a leased storage infrastructure
Υ	Used disk depreciation factor on salvage ([0.0, 1.0])
C	Disk controller unit cost ($)
H_T	Annual human operator salary ($)
I_F	Risk-free interest rate (percent)
K	Current per-Gbyte storage price ($/Gbyte)
L_T	Expected annual per-Gbyte lease payment ($/Gbyte/year)
P_c	Disk controller power consumption (kW)
P_D	Disk drive power consumption (kW)
V_T	Expected storage requirement in year T (Gbytes)

Derivation of the decision model

- Assuming that profit from storage is equal in both the buy and lease cases—that is, using 1 Tbyte of storage from a purchased disk or from a storage cloud results in the same level of productivity—the above simplification results in the removal of the profit term P_T

$$\Delta NPV = NPV_P - NPV_L$$

$$\Rightarrow \sum_{T=0}^{N} \frac{P_T - C_T^P}{(1+I_K)^T} + \frac{S}{(1+I_K)^T} - E - \sum_{T=0}^{N} \frac{P_T - C_T^L}{(1+I_K)^T} + \sum_{T=0}^{N} \frac{L_T}{(1+I_R)^T}$$

$$\Rightarrow \sum_{T=0}^{N} \frac{C_T^L - C_T^P}{(1+I_K)^T} + \frac{S}{(1+I_K)^N} + \sum_{T=0}^{N} \frac{L_T}{(1+I_R)^T} - E.$$

Preliminaries

Three components make up the cost of purchasing storage E:

- The consumer needs a disk controller to house the purchased disks
- The consumer purchases disk drives in blocks based on increasing storage needs
- The consumer must periodically replace disks due to failure

These components contribute to the future cash flow E as follows:

$$E = \frac{\left(\left(\lceil V_T \rceil_\Omega - \lceil V_{T-1} \rceil_\Omega\right) * \Omega + R_T\right) * G_T}{\left(1 + I_K\right)^T} + C$$

$$\Rightarrow E = \frac{E_T}{\left(1 + I_K\right)^T} + C$$

$$E_T = \left(\left(\lceil V_T \rceil_\Omega - \lceil V_{T-1} \rceil_\Omega\right) * \Omega + R_T\right) * G_T,$$

where

Ω represents the hard disk drive size in Gbytes

V_T is the storage requirement in Gbytes at year T; $ceil(V_T)_\Omega$ is an operator that returns the minimum number of Ω-sized disk drives needed to store V_T

G_T is the predicted cost per Gbyte of disk storage at year T

R_T is the disk replacement in Gbytes at year T

C is the disk controller cost

A more accurate model

- The important insight in this formulation is that the capital cost isn't all incurred at the start of the project
- Rather, it's a time-varying formula in which users can grow their storage systems as their requirements evolve
- We modify ΔNPV to reflect this growth in capital cost:

$$\Delta NPV = \sum_{T=0}^{N} \frac{C_T^L - C_T^P - E_T}{\left(1+I_K\right)^T} - C + \frac{S}{\left(1+I_K\right)^N} + \sum_{T=0}^{N} \frac{L_T}{\left(1+I_R\right)^T}$$

Operating cost of purchased storage

- We estimate the operating cost of purchased storage, C_T^P, by calculating the electric utility cost associated with running the disk controller and the disk units, plus the cost of a human operator to manage the system/data
- These cost components contribute to C_T^P as follows:

$$C_T^P = (365 \cdot 24) * \delta * \left(P_C + P_D * \lceil V_T \rceil_{\Omega} \right) + \alpha * H_T$$

where

- δ is the utility cost ($/kilowatt per hour)
- P_C is the controller's power requirement in kWs
- P_D is the power requirement in kWs per disk drive
- α is the proportion of the human operator cost, H_T, required to maintain the system/data at year T

Operating cost of leased storage

- The operating cost for leased storage, C_T^L , only includes the cost of a human operator to manage the data. Thus, we calculate C_T^L as $C_T^L = \beta * H_T$, where β is the proportion of the human operator cost required to maintain the data on the leased storage at year T
- Substituting ρ for (α – β), we can modify ΔNPV to reflect the operating costs as follows:

$$\Delta \mathrm{NPV} = \sum_{T=0}^{N} \frac{-\rho * H_T - (365 \cdot 24) * \delta * \left(P_C + P_D * [V_T]_{\Omega}\right) - E_T}{(1 + I_K)^T} - C + \frac{S}{(1 + I_K)^N} + \sum_{T=0}^{N} \frac{L_T}{(1 + I_R)^T}.$$

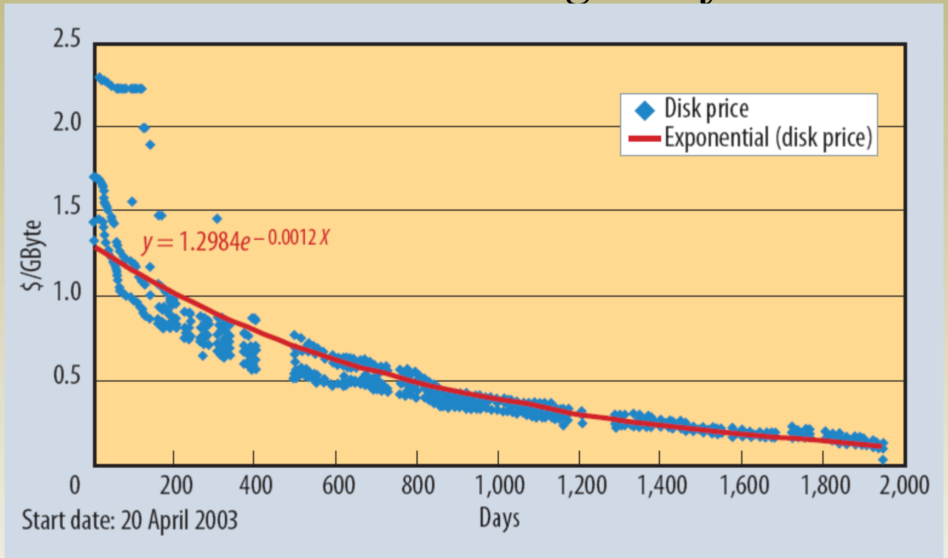
Approximating the best outcomes

- From the economic Law of One Price, we can derive the upper bounds for NPV_P and NPV_L by substituting I_K and I_R with the risk-free interest rate I_F.
- In turn, we can estimate the risk-free interest rate, I_F, from the published return on an instrument such as government treasury bills.
- We can therefore derive an approximation of the decision criteria using these best NPVs, letting us further simplify the currently derived version of ΔNPV to:

$$\Delta NPV = \sum_{T=0}^{N} \frac{-\rho * H_T - (365 * 24) * \delta * \left(P_C + P_D * \lceil V_T \rceil_{\Omega}\right) - E_T + L_T}{\left(1 + I_F\right)^T} - C + \frac{S}{\left(1 + I_F\right)^N}.$$

Disk price trends

- We need a function for the term G_T, which we need to calculate E_T and to estimate the cost of disk storage at year T



Weekly SATA disk price data collected from Pricewatch.com from 20 April 2003 to 19 August 2008

- Approximating the observed exponential trend line using regression analysis, we obtain the formula $G_X = 1.2984\, e^{-0.0012\, X}$
- We approximate G_T by assuming that the future disk price trend conforms to the equation $K * e^{C * T}$, where K represents the lowest storage price per Gbyte available to the consumer at T = 0; and T represents the number of years in the future
- Therefore: $G_T = K * e^{-0.0012 * 365 * T} \Rightarrow G_T = K * e^{-0.438 * T}$

Disk replacement rates

- A recent large-scale study of disk failures measured the annualized replacement rate (ARR) of disk drives in real data centers

B. Schroeder and G. Gibson, "Disk Failures in the Real World: What Does an MTTF of 1,000,000 Hours Mean to You?" *Proc. 5th Usenix Conf. File and Storage Technologies* (FAST 07), Usenix Assoc., 2007, pp. 1-16.

- The study observed ARRs in the range of 0.5 to 13.5 percent, with the most commonly observed ARRs in the 3 percent range
- In this model, we approximate R_T with this empirical approximation of the disk replacement rate by using the formula $R_T=0.03*\Omega*ceil(V_T)_\Omega$
- In this formula, the constant 0.03 represents the observed 3 percent disk replacement rate
- Thus, we can simplify E_T to:

$$E_T = ((\lceil V_T \rceil_\Omega - \lceil V_{T-1} \rceil_\Omega) * \Omega + 0.03 * \Omega * \lceil V_T \rceil_\Omega) * K * e^{-0.438 * T}$$

$$\Rightarrow E_T = (1.03 * \lceil V_T \rceil_\Omega - \lceil V_{T-1} \rceil_\Omega) * \Omega * K \cdot e^{-0.438 * T}.$$

Disk salvage value

- We assume a hard disk drive can be sold in the used market for some salvage value at the end of its life
- To predict this salvage value, we leverage the future disk price prediction formula, discounting the predicted price by some depreciation factor, γ, in the range [0, 1]
- In equation form, this gives us the salvage value

$$S = \gamma * \Omega * \lceil V_T \rceil_\Omega * K * e^{-0.438 * T},$$

Medium-size enterprises

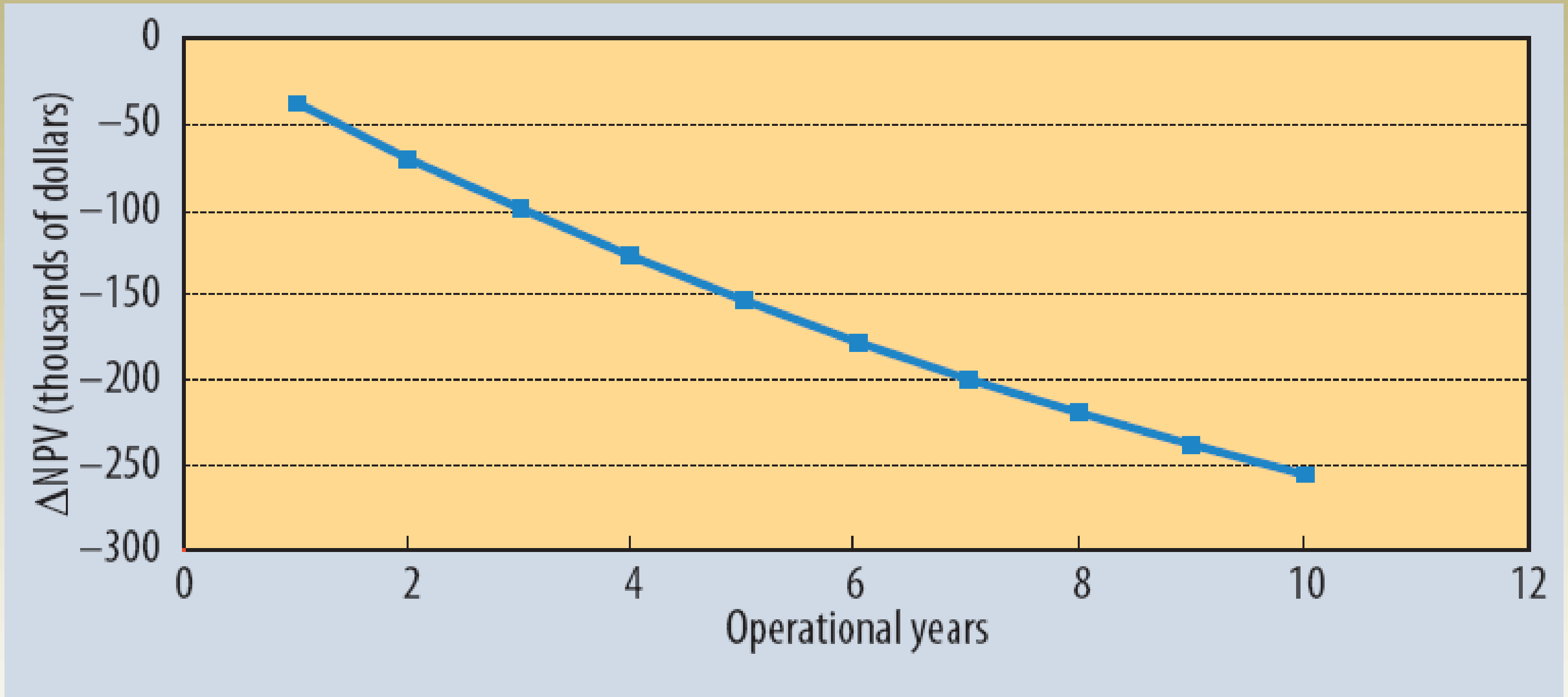


Figure 1. The calculated ΔNPV values for a medium-size enterprise deciding whether to buy or lease storage with life expectancy from 0 to 10 years.

Large-size enterprises

Figure 2. The calculated ΔNPVs for a large-size enterprise deciding whether to buy or lease storage with life expectancy from 0 to 10 years.

Cloud migration decisions III

On-premise or SaaS-based solutions: Cost models

Introduction

- The adoption of SaaS-based solutions (and of the cloud in general), is pushed forward due to three main factors:
  - cost savings
  - complexity of current IT operations
  - ‘anxiety’ for innovation
- SaaS-based applications save customers from huge upfront investments in IT infrastructure;
  - the SaaS provider sets up and maintains the overall

Migrating to clouds: SWOT analysis

STRENGTHS (INTERNAL)	**WEAKNESSES (INTERNAL)**
Small capital expenses (CAPEX)	Latency problems (until next-generation digital transfer tech)
Easy to set up	Reliability (data loss, code reset during operation)
Easy to maintain	No dedicated personnel
Horizontal scalability (number of instances)	Limited Customizability
Vertical scalability (size of the instances)	Limited Configurability
Redundancy in data/service	No revenue by support operations
OPPORTUNITIES (EXTERNAL)	**THREATS (EXTERNAL)**
'Going Green'	Data confidentiality, integrity, availability (CIA)
Elasticity	Difficulty in cloud switching-interoperability
Convert CAPEX to OPEX	Legislation problems (due to cross-country data distribution)
Quick time to markets	No clear downtime agreements or reimbursement policies
Flexible pricing (e.g., pay-per-use)	No guaranteed ROI
Tolerance to revenue shrinking during crisis periods	Compatibility issues

Parameters

- C_u: The up-front investment costs of adopting a new software system include all relevant costs associated to software such as:
  - software development cost (C_d) or
  - subscription costs (C_{SaaS_sub}),
  - integration and customization costs (C_{in}),
  - professional services (C_{ps}) and
  - user training costs (C_{ut}).
- Software development costs can be approximated using a standard estimation model or a benchmarking data set like ISBSG (International Standards Benchmarking Group)
- Subscription costs for SaaS depend on the charge model of the provider
- An estimation of C_{SaaS} can be made knowing the number of users and considering an average subscription fee per month

- The other types of costs can be assessed estimating the amount of workload and services to be offered or by using rough percentages to derive each type of cost from software development cost C_d
- Hardware and middleware costs (C_h) are also accumulated to the first year's expenditures
- C_h is calculated by considering the number of servers, desktops, peripherals and the middleware installed on them
- For the IaaS solution hardware costs are transformed in IaaS subscription fees (C_{Iaas_sub}). Calculating C_{IaaS} usually demands an initial estimation of the number of instances (servers) required, the middleware installed on them (operating system, database servers, Web servers) and the level of usage and capacity of the instances

- Operational costs, involving all expenses mentioned in C_o, are included as well in the calculation of C_u.
- Analyzing the up-front investment costs for the three solutions normally we can say that for the inhouse and IaaS solution all the relevant costs are included in the calculations, while for the SaaS solution we can exclude hardware C_h and C_{ps}.
- The following equations can then be used to calculate Cu for SaaS, inhouse and IaaS solutions:

$$C_{u(SaaS)} = N \cdot C_{SaaS\_sub} + C_{in} + C_{ut} + C_o \quad (1)$$

$$C_{u(inhouse)} = C_d + C_{ps} + C_{in} + C_{ut} + C_h + C_o \quad (2)$$

$$C_{u(IaaS)} = C_d + C_{ps} + C_{in} + C_{ut} + \sum_{i=1}^{S} U_i \cdot F_i + C_o \quad (3)$$

where N is the number of users that subscribe in a SaaS application, S is the number of instances (servers) committed from the IaaS provider, U_i is the level of usage of each instance and F_i are the usage fees that are charged by the IaaS provider according to the capacity and calculation power of the instances

- C_{ad}: The annual divestment costs include all relevant annual costs necessary to preserve the operation of the existing software system. Such costs involve:
  - subscription fees
  - software and hardware maintenance expenses
  - customization costs and
  - professional support fees
- Annual subscription fees (for SaaS and IaaS) are calculated using the criteria mentioned earlier
- Software annual maintenance (C_{a_smain}), customization (C_{a_cust}) and professional support fees (C_{a_ps}) can be estimated empirically, or using benchmarking standards or as rough percentages from the initial software development cost (C_d)
- Annual professional support fees from the second year of operation may involve consulting, user training and support. Hardware maintenance cost (C_{a_hsmain}), for the inhouse solution can be calculated by using a percentage of the initial hardware expenditure

- The calculation of annual divestment cost can be performed by the following equations

$$C_{ad(SaaS)} = N \cdot C_{SaaS\_sub} + C_{a\_ps} + C_{a\_cust} \quad (4)$$

$$C_{ad(inhouse)} = C_{a\_smain} + C_{a\_hmain} + C_{a\_ps} + C_{a\_cust} \quad (5)$$

$$C_{ad(IaaS)} = C_{a\_smain} + C_{a\_ps} + C_{a\_cust} + \sum_{i=1}^{s} U_i \cdot F_i + C_o \quad (6)$$

- C_o: operational costs may include
  - networking infrastructure (C_{net}),
  - power and electricity costs (C_{pow}) and
  - floor space (C_{floor})
- Networking costs depend on the deployment model and may include the costs for Internet connection (C_{ic}), and administrator labor (C_{lab})
- C_{pow} and $C_{floo}r$ are calculated only for the inhouse solution

$$C_{o(SaaS)} = C_{ic} \quad (7)$$

$$C_{o(inhouse)} = C_{ic} + C_{adm} + C_{pow} + C_{rent} \quad (8)$$

$$C_{o(IaaS)} = C_{ic} \quad (9)$$

Total Cost of Ownership (TCO)

$$TCO = C_u + \sum_{i=2}^{n} (C_{ad} + C_o) \, . \qquad (10)$$

Case study: Description

- The case study describes a large industry activating in the area of Petroleum
- The subdivision of the company operating in the Balkans consists of 2300 employees mainly technicians and mechanics
- Most of the employees work at the refineries
- There are 15 different departments, that specialize in different aspects of oil production, for example chemists, quality assurance, etc.
- The company installed and operated 8 years ago an integrated ERP/CRM system, establishing a contract with *SAP Hellas*.

Case study: Demographics

- The licences of SAP in the examined company's subdivision are around 200 with the term that each licence (username/password) is shared approximately between three users
- For each licence there is a fee of 3000 Euros per user per year
- There are four servers dedicated to SAP
- There is an IT department in the headquarters of the company consisting of 8 employees maintaining and supporting the SAP system
- Two of the aforementioned employees are administrators
- Also, each department in Northern Greece has one employee dedicated to customizing SAP for the needs of the particular department, training and supporting users
- There is a LAN installation in the company

Strengths	**Weaknesses**	**Opportunities**	**Threats**
Increased productivity, ability to remotely work	No platform, knowledge to find/select cloud providers	New business models and improved services [14]	Dependency on external providers
Reduced personnel and resources	Time and cost consuming transition of all critical corporate data	Greek government funding for technology innovators	Global and national economy recession
Knowledge background and expertise in related technological areas	Difficulty in confronting organizational changes	Mobile devices and computing will be popular.	Low security
On-going projects and open source technologies	Difficulty in customization and configuration	High awareness for the green agenda and new approaches to reduce the carbon footprint	No market knowledge and support by EU providers
S+O (Growth Strategy)	**W+O (Expansion Strategy)**	**S+T (Make-up Strategy)**	**W+T (Defense Strategy)**
• Selection of an open source SaaS. Integrations and new functions around ERP should be easily plugged-in, leading to improved services • The company has the knowledge and the expertise to better exploit possible funding • The ability to work remotely will exploit all possibilities provided by mobile devices and new IT trends	• No platform, knowledge to find/select cloud providers: Build a formal structure for strategy & decision making. Select the criteria that are important for your new business models enabled by SaaS and pursue them. • Time consuming transition of all critical corporate data, difficulty in confronting organizational changes: establish a safety mechanism, encourage and motivate employees assigned to the task • Difficulty in customization: Select an ERP relevant to the existing one, check the available automated customization modules offered by the SaaS provider. Another solution is to consider the anticipated open source SaaS (currently being on the way, e.g., Apatar.com)	• Dependency on external providers: the company has an experienced IT department and certain customizations can be done internally • Global and national economy recession: personnel and resources costs are estimated to decrease, the CRM is expected to attract more customers • Low security: There is Knowledge background and expertise to establish a security process internally. Deploy encryption, VLANs, and firewalls • No market knowledge and support by EU Providers (USA cloud providers are more mature), an open SaaS deployment minimizes the problem as only an IaaS provider would be necessary	• Organizational changes can be smoothly enforced by the management. The dependency on external providers and security threats can be minimized by defining a strategic plan to motivate employees for the organizational change. The management has the power to motivate them to participate and contribute to that change (data transfer, security issues, lack of instant support are the issues that need to be confronted by the employees) • A well established decision model for the selection of the appropriate SaaS provider can help in selecting a cost effective deployment model that will help the company survive from the economic recession

System Installation Costs	inhouse solution	SaaS	IaaS (open source)
Software costs	1300000(C_d)	31200(C_{SaaS_sub})	
Professional services (C_{ps})	234000	56160	234000
Integration (C_{int})	975000	234312	975000
User training (C_{ut})	39000	10000	10000
Hardware-Middleware (C_h)	40000		3745.44
Operational expenses (C_o)	490760	383000	446000
TOTALS	3078760	995472	1668745.44

Annual Costs			
Subscription free *(I-S)aaS*	600000	312000(C_{SaaS_sub})	3745.44
Software maintenance			
Hardware maintenance (C_{a_hsmain})	2000		2000
Professional support fees (C_{a_ps})			
Customization			
TOTALS	602000	312000	5745.44

Operational Expenses			
Administrator/IT staff *(C_{adm})*	483000	357000	483000
Switches, routers, wireless *(C_{sec})*	2000	2000	2000
Network infrastr. and Internet *(C_{ic})*		24000	24000
Power, electricity *(C_{electr})*	1440		
Floor space (for hardware) *(C_{floor})*	4320		
TOTALS	490760	383000	446000
Up-front expense	3078760	995472	1668745.44
Recurring annual fees	602000	312000	5745.44
Operational expenses	490760	383000	446000
Total TCO for 1 year	3078760	995472	1668745.44
Total TCO for 5 years	7449800	3775472	3475727.2
Total TCO for 10 years	12913600	7250472	5734454.4