



Lecture (02) Introduction To Virtualization

By:

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Computer Networks

Introduction To Virtualization

- In a general sense, **virtualization**, is the creation of a virtual, rather than an actual, version of something.
- More generally, in a computing environment, virtualization will create a virtual version of a device or resource, such as a server, storage device, network or even an operating system where the framework divides the resource into one or more execution environments
- Virtualization is part of an overall trend in enterprise IT :
 - **autonomic computing**, which is a scenario in which the IT environment will be able to manage itself based on perceived activity,
 - **utility computing**, in which the processor's power is seen as a utility that clients can pay for only as needed.

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- Virtualization is not a new technology.
 - Mainframe computers have offered the ability to host multiple operating systems for more than 40 years.
 - However, four trends have converged in recent years that have allowed virtualization to migrate domain of mainframe computers to small and medium computing environment.
 - These four trends are:
 - Hardware is under utilized
 - Data centers are running out of space
 - Energy costs increase
 - System administration cost are increasing

Hardware is under utilized

- Moore's Law demonstrates increasing returns – the amount of improvement in processor speed grows over time because there is an exponential increase in capacity for every generation of processor improvement.
- Many data centers today have machines running at only 10-15% of the total processing capacity. In other words, 85-90% of the machine's power is unused.
- In a way, Moore's Law is no longer relevant to most companies because they aren't able to take advantage of the increased power available to them.
- By applying virtualization, organizations can improve their hardware utilization from 10-15% to 70-80 %.

Data Centers Are Running Out Of Space

- 20 years ago the vast majority of business processes were paper based.
- Computerized systems start increasing payroll, accounting, and the like.
- This has all changed with business process after business process being captured in software and automated.
- The rise of the Internet has exponentially increased this transformation as well.

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Energy Costs increase

- Electrical power was cheap and endlessly available.
- Several events have changed this line of thinking:
 - Increasing computerization means that companies are using more power than ever.
 - Escalating energy costs now make electricity one of the top five costs in many company's operation budgets.

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System Administration Costs Are Increasing

- Computer systems do not operate on their own.
- Every server requires proper care and feeding by system administrators who, as part of the operations group, ensure that the server runs properly.
- System administration is labor intensive and system administrators don't come cheap.
- Unlike system programmers who may be offsite, system administrators are almost always onsite due to their need to access the physical hardware.
- The steady increase in the number of servers world-wide has meant a very good job market for system administrators.

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Goal

- The typical goal of virtualization is to centralize administrative tasks while improving scalability and work loads across a system or network.
- Virtualization in a computing environment can be present in many different forms, some of which are:
 - Hardware virtualization
 - Storage and data virtualization
 - Software virtualization
 - Network virtualization

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Hardware Virtualization

- **Hardware virtualization** is the execution of software in an environment separated from the underlying hardware resources. There are four primary categories of hardware virtualization:
 - **Full virtualization:** Almost complete simulation of the actual hardware to allow software, which typically consists of a guest operating system, to run unmodified.
 - **Partial virtualization:** Some but not all of the target environment is simulated. Some guest programs, therefore, may need modifications to run in this virtual environment.
 - **Paravirtualization:** A hardware environment is not simulated; however, the guest programs are executed in their own isolated domains, as if they are running on a separate system. Guest programs need to be specifically modified to run in this environment.

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- **Hardware-assisted virtualization** is a way of improving the efficiency of hardware virtualization. It involves employing specially designed CPUs and hardware components that help improve the performance of a guest environment

Storage And Data Virtualization

- The amount of data that organizations are creating and storing is exploding.
 - Many applications generate more data than can be stored on a single server.
 - Many applications have multiple machines that need to access the same data. Having all the data sitting on one physical machine creates a bottleneck.
 - Creating backups can be a huge task when hundreds of machines are involved.
- These trends have led to data virtualization.
- Moving data from many physical servers to a central location enables backups to be performed more efficiently.

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- Furthermore, the central data repository can be configured with multiple physical storage devices to ensure that no hardware crash will ever make the organization's data unavailable.
 - The three basic approaches to data storage are:
Direct-Attached Storage (DAS)
 - DAS is the traditional mode of data storage: hard drives attached to whatever physical sever is running the application.

Network-Attached Storage (NAS)

- NAS is a machine that sits on your network and offers storage to other machines. If you've ever had a remote drive in Windows, you've experienced NAS.

Storage-Area Network (SAN)

- SAN uses highly specialized hardware and software to transform simple disk drives into a data storage solution that transfers data on its own high-speed network.
- SANs typically use their own network protocol (Fibre Channel) for the SAN network communications.

Software Virtualization

- **Software virtualization** is most often viewed from the perspective of OS virtualization. This allow for the hosting of multiple virtualized environments within a single OS instance.
- **Application virtualization** allows the hosting of individual applications in an environment separated from the underlying OS.
- **Virtual machine (VM)** is a software (possibly hardware assisted) implementation of a computer system that executes applications like an actual computer.

The Benefits Of Virtualization

- **Server consolidation:**
 - One of the primary benefits of virtualization software is that it allows you to increase the scale of your server infrastructure without purchasing additional pieces of hardware.
- **Energy conservation:**
 - In addition to savings in hardware costs, virtualization software may also save you money on your energy bill. According to Energy Star, the energy costs for running a server for a year will soon exceed the price of acquiring it.

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- **Improving ease of management:**
 - Managing virtual machines is a lot easier than managing “real” machines, since hardware upgrades, for example, can be done with the click of several buttons, rather than having to power down the machine, install the hardware, verify the change, then power up again.
 - Moreover, managing virtual machines can often be done via a console server, thereby reducing the time needed to deploy them.

- Reducing backup and recovery time:

- Since virtual machines are essentially files, backing up and restoring them is a lot less time-consuming.
- And while the files can be huge, a directory of many 2-GB files is still easier to restore than a real machine of the same specifications.
- Hardware failures such as a failed hard drive — will not affect virtual machines in the same way they would a physical machine. (Of course, the real hard drive on which the virtual machine reside needs to be backed up as usual.)

- Testing software configurations:

- Another way you can use virtualization software is for testing software configurations before deploying them on a live system.
- If you needed to verify whether a program is incompatible with your existing setup, for example, you may try testing in on a virtual machine first.
- This can be useful for organizations that have legacy systems or applications and must test out systems before deploying them.
- Virtual machines can also interact with one another in virtual networks, allowing you to test server-client applications virtually.

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- **Maintaining legacy applications:**
 - If you do have old applications that have compatibility issues with newer software or that must run on a certain version of an operating system, you can dedicate a virtual machine just for those tasks.
 - That way, your IT architecture and planning won't be constrained because of a few applications.
 - **Maintaining a cross-platform office:**
 - It is not uncommon for offices that run mostly Macs to need to run one or two Windows-only programs; in this case, virtual software can be an affordable, easy way to do this.
 - Note, however, that the reverse is not applicable; many virtualization applications for PCs allow you to run Linux, but not Mac operating systems

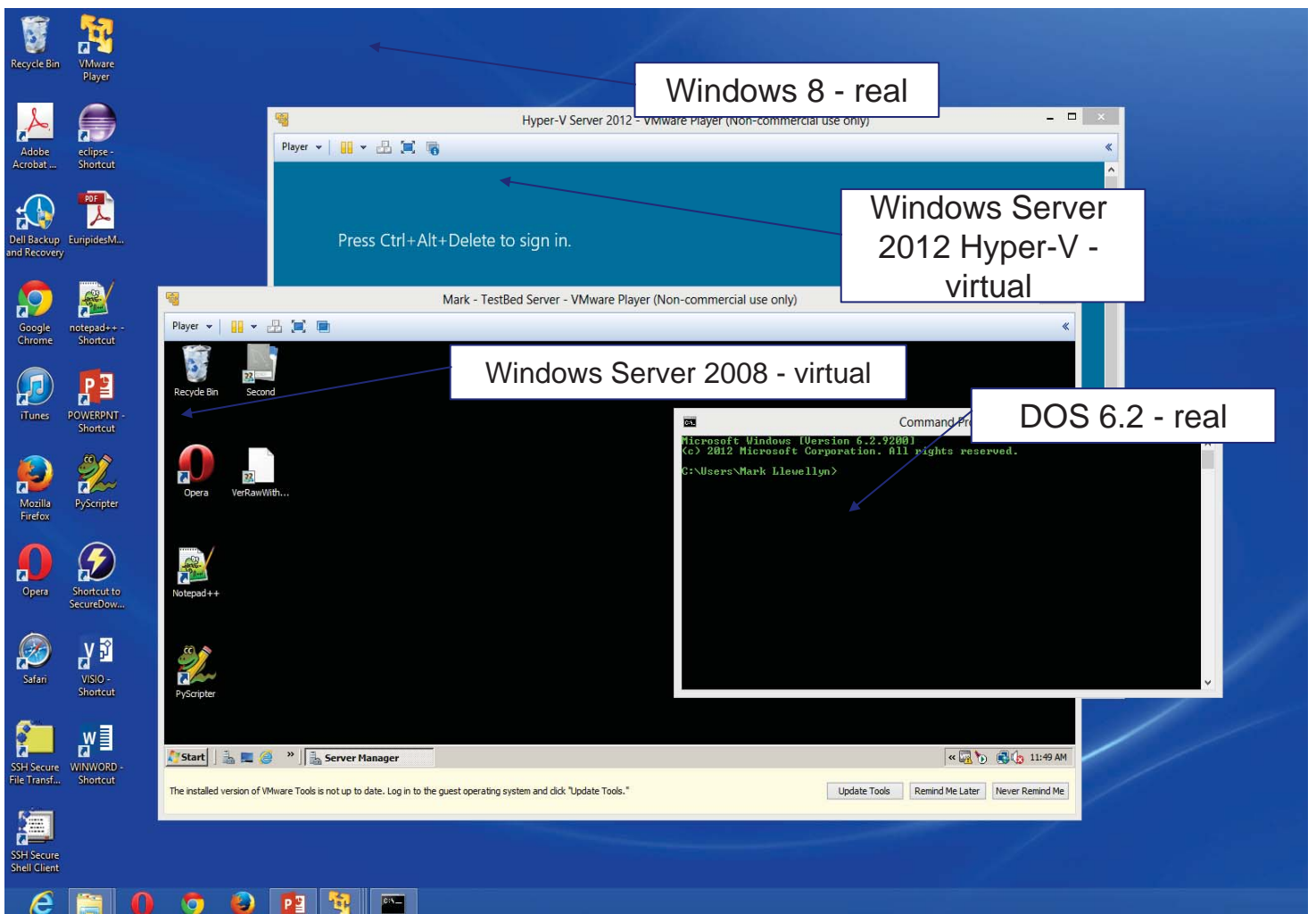
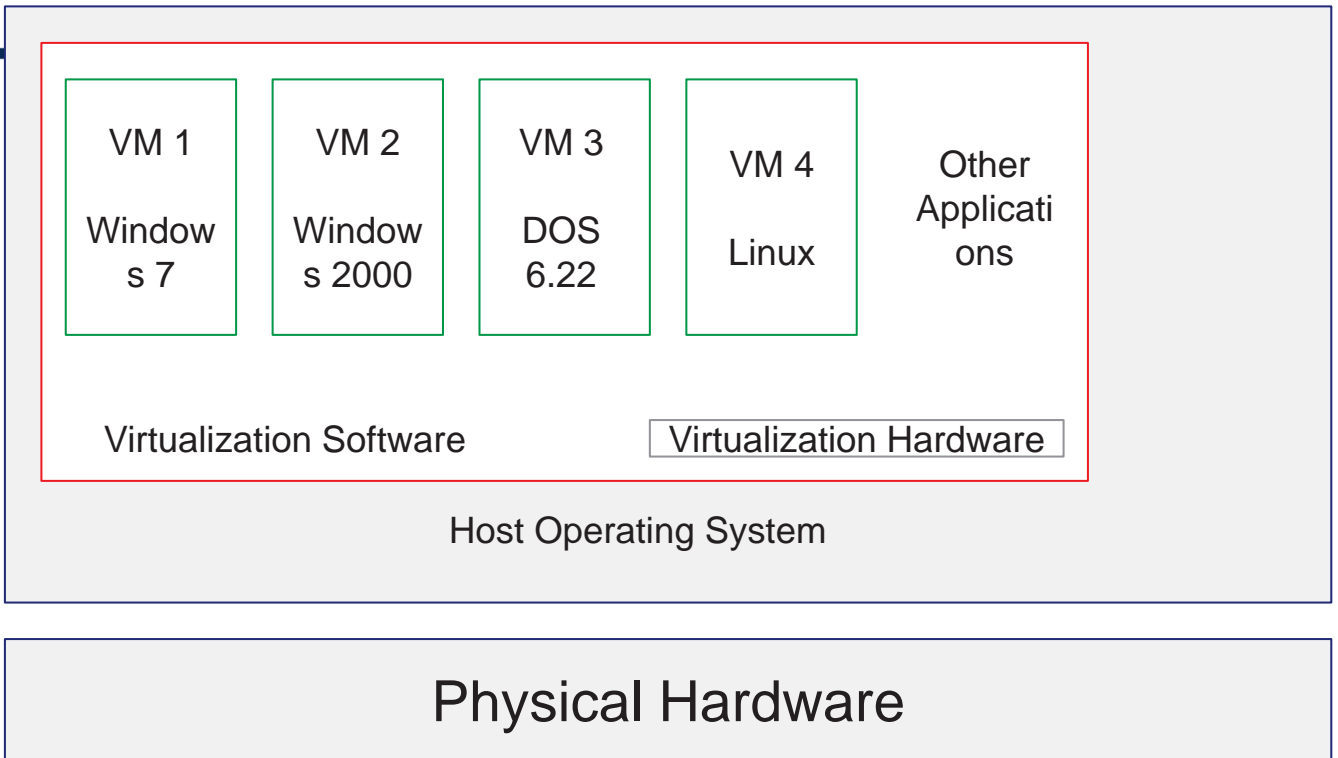
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Final word on Virtualization

- Despite its many benefits, keep in mind that virtualization software is not for everyone.
- There is a learning curve in both conceptualizing how virtual machines will function in your network and organization, as well as managing them reliably and cost-effectively.
- In the IT world, most virtualization refers to the use of virtualization software that allows the physical hardware of a single PC (or server) to run multiple operating systems simultaneously in virtual machines (VMs).

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- The virtualization software simulates enough hardware to create an environment that allows an unmodified guest operating system (the one running inside a VM) to be run in isolation on a host operating system (the one running on the physical computer system).
 - We'll introduce you to virtualization using VMware Player or Oracle's VirtualBox .

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- The diagram on the next page illustrates, at a high-level, how virtualization works:
 - At the base layer you have the hardware of the physical computer system.
 - Above the hardware layer is the host operating system. The virtualization software runs within the host OS (as an application) and provides the virtual platform for the VMs.
 - An emulated hardware system (which imitates the function of the computer system) is provided within each VM for each guest OS. The OS and software within each VM are unaware of the other VMs and have full access to the virtual platform.
 - The page after illustrates an actual setting; the one on my office computer, in which two VMs are running alongside Vista and DOS.



Drawbacks Of Virtualization

- Unfortunately, there are also some disadvantages to virtualization. These include a drain on performance, limited scalability, and common hardware.
- In most cases the benefits of virtualization outweigh the drawbacks, however, you need to be aware of the disadvantages when considering virtualization so that you can make an informed decision as to the use of virtualization.

Performance Issues:

- Virtualization software adds a certain amount of overhead to the computer system on which it is running.
- Determining the overall impact that virtualization software imposes is a difficult task, but generally speaking, virtualization software has a minimal impact on processor and memory performance.
- A more significant impact is imposed on the disk and networking performance of the system.

Scalability:

- Most virtualization software is scalable to multiple VMs in the same physical system, however, almost all are uni-processor systems and limited to the amount of physical memory of the host system and can only run 32-bit OS.

Common Hardware:

- Since the only physical hardware on which the VMs run is the same for all VMs, this represents both benefits and drawbacks when it comes to virtualization.
- Hardware wizard builder and system flexibility are benefits of a common hardware arrangement.
- However, if the OS and application that you want to virtualize are not capable of running on the system hardware or require other hardware, you're out of luck with virtualization.

Common Uses Of Virtualization

- the most common areas in which virtualization can be readily applied are:
 - application development and
 - testing,
 - training,
 - demonstrations, and
 - help desk environments.

Application Development and Testing:

- Virtualization allows software development to run multiple VMs rather than multiple physical machines.
- When developing and testing an application, the developer might need a network of machines: a database server, a transaction server, and a client.
- Virtualization could be used to run this network on one physical machine.
- By using Hardware wizard builder , the developer can quickly and economically create the necessary network infrastructure.
- The developer can repeatedly test the software inside of VMs with the ability to quickly return to a clean, known state after each test.

Training:

- Virtual machines are great tools for implementing training and learning.
- Training employees about new OSs and computer applications involves extensive amounts of time and hardware.
 - For example, if you were training students to be network administrators, you would need to provide students with access to demonstration networks.
 - You would need to acquire enough hardware to supply isolated computer systems and the network infrastructure to provide an authentic training environment for each student.
 - Either you or your students would need to install the OSs and configure the computer systems appropriately.
 - Virtualization can reduce the amount of hardware needed for the necessary training environments.

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Training (continued):

- In many training environments, the trainees will be changing the system configuration.
- What happens if they do something accidentally wrong? You don't want this happening on the physical system.
- Allows for almost instant restoration of the training environment by restoring pre-saved images of system.
- Multiple VMs allow for different learning environments to be running simultaneously on the same hardware.

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Help Desks:

- Help desks must support several varieties of hardware and software configurations.
- The combinations of multiple Windows versions and various applications becomes infeasible.
- Help desk personnel must maintain multiple computers or restart their computers to support people who use various configurations.
- They might not even have access to a configuration that a customer is using, and so they must guess or fly blind with their assistance.
- Customer satisfaction can suffer under these scenarios.

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- Using virtualization, help desks are better able to duplicate users' environments, including the OS and applications.
 - For example, help desk personnel using Vista can support previous Windows OS by simply starting a prebuilt VM from a saved state, which takes only seconds.

Cost/Benefit Analysis For Server Virtualization

- In most organizations, deciding whether to go forward with a project is tied directly to the project's prospective financial benefits.
- One of the primary reasons that virtualization is such a vital IT topic is because that it promises significant payback.
- There are three commonly used methods for determining the projected financial value of projects:
 - Net present value (NPV) analysis
 - Return on investment (ROI)
 - Payback analysis

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- **Net present value (NPV)** analysis is a method of calculating the expected net monetary (money volume) gain or loss from a project by discounting all expected future cash inflows and outflows to the present point in time.
 - Projects with a **positive NPV** should be considered if financial value is a key criterion.
 - The higher the NPV, the better.
 - Notice in the next spreadsheet that the two projects have the same cash flows but different NPV.
 - (The cash flow represents the benefits minus costs or income minus expenses.)
 - The NPV accounts for the time value of money (a dollar earned today is worth more than a dollar earned 5 years from now).

- The **discount rate** (see spread sheet) is an indirect measure of how fast an investment will pay for itself.
- For example, if a building is purchased for \$1,000,000 sale price and it produces \$100,000 in positive net operating income (the amount left over after fixed costs and variable costs is subtracted from gross lease income) during one year, then the discount rate is:

$$\text{\$100,000} / \text{\$1,000,000} = 0.10 = 10\%$$
- In the example, the purchased building will be fully capitalized (pay for itself) after ten years (100% divided by 10%). If the capitalization (discount) rate were 5%, the payback period would be twenty years.

Discount Rate	10%					
PROJECT 1	Year 1	Year 2	Year 3	Year 4	Year 5	Total
Benefits						\$0
Cost						\$0
Cash Flow	\$0	\$0	\$0	\$0	\$0	\$0
NPV(Discount Rate;Cash Flow)	\$0	\$0	\$0	\$0	\$0	

$$NPV(i, N) = \sum_{t=0}^N \frac{R_t}{(1+i)^t}$$

i → discount rate

N → number of years

R_t → cash flow / year t

- Project 01:

Discount Rate	10%				
PROJECT 1	Year 1	Year 2	Year 3	Year 4	Year 5
Benefits	\$0	\$2,000	\$3,000	\$4,000	\$5,000
Cost	\$5,000	\$1,000	\$1,000	\$1,000	\$1,000

- Project 02:

Discount Rate	10%				
PROJECT 2	Year 1	Year 2	Year 3	Year 4	Year 5
Benefits	\$1,000	\$2,000	\$4,000	\$4,000	\$4,000
Cost	\$2,000	\$2,000	\$2,000	\$2,000	\$2,000

- Project 01

Discount Rate	10%					
PROJECT 1	Year 1	Year 2	Year 3	Year 4	Year 5	Total
Benefits	\$0	\$2,000	\$3,000	\$4,000	\$5,000	
Cost	\$5,000	\$1,000	\$1,000	\$1,000	\$1,000	
Cash Flow	-\$5,000	\$1,000	\$2,000	\$3,000	\$4,000	

Discount Rate	10%					
PROJECT 1	Year 1	Year 2	Year 3	Year 4	Year 5	Total
Benefits	\$0	\$2,000	\$3,000	\$4,000	\$5,000	\$14,000
Cost	\$5,000	\$1,000	\$1,000	\$1,000	\$1,000	\$9,000
Cash Flow	-\$5,000	\$1,000	\$2,000	\$3,000	\$4,000	\$5,000

Discount Rate	10%					
PROJECT 1	Year 1	Year 2	Year 3	Year 4	Year 5	Total
Benefits	\$0	\$2,000	\$3,000	\$4,000	\$5,000	\$14,000
Cost	\$5,000	\$1,000	\$1,000	\$1,000	\$1,000	\$9,000
Cash Flow	-\$5,000	\$1,000	\$2,000	\$3,000	\$4,000	\$5,000
NPV(Dr, CF)	-\$4,545	-\$3,719	-\$2,216	-\$167	\$2,316	

- Project 02

- | | | | | | |
|----------------------|---------------|---------------|---------------|---------------|---------------|
| Discount Rate | 10% | | | | |
| PROJECT 2 | Year 1 | Year 2 | Year 3 | Year 4 | Year 5 |
| Benefits | \$1,000 | \$2,000 | \$4,000 | \$4,000 | \$4,000 |
| Cost | \$2,000 | \$2,000 | \$2,000 | \$2,000 | \$2,000 |
| Cash Flow | -\$1,000 | \$0 | \$2,000 | \$2,000 | \$2,000 |

Discount Rate	10%					
PROJECT 2	Year 1	Year 2	Year 3	Year 4	Year 5	Total
Benefits	\$1,000	\$2,000	\$4,000	\$4,000	\$4,000	\$15,000
Cost	\$2,000	\$2,000	\$2,000	\$2,000	\$2,000	\$10,000
Cash Flow	-\$1,000	\$0	\$2,000	\$2,000	\$2,000	\$5,000
NPV(Dr, CF)						

Discount Rate	10%					
PROJECT 1	Year 1	Year 2	Year 3	Year 4	Year 5	Total
Benefits	\$0	\$2,000	\$3,000	\$4,000	\$5,000	\$14,000
Cost	\$5,000	\$1,000	\$1,000	\$1,000	\$1,000	\$9,000
Cash Flow	-\$5,000	\$1,000	\$2,000	\$3,000	\$4,000	\$5,000
NPV(Dr, CF)	-\$4,545	-\$3,719	-\$2,216	-\$167	\$2,316	

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Discount Rate	10%					
PROJECT 1	Year 1	Year 2	Year 3	Year 4	Year 5	Total
Benefits	\$0	\$2,000	\$3,000	\$4,000	\$5,000	\$14,000
Cost	\$5,000	\$1,000	\$1,000	\$1,000	\$1,000	\$9,000
Cash Flow	-\$5,000	\$1,000	\$2,000	\$3,000	\$4,000	\$5,000
NPV(Dr, CF)	-\$4,545	-\$3,719	-\$2,216	-\$167	\$2,316	

Discount Rate	10%					
PROJECT 2	Year 1	Year 2	Year 3	Year 4	Year 5	Total
Benefits	\$1,000	\$2,000	\$4,000	\$4,000	\$4,000	\$15,000
Cost	\$2,000	\$2,000	\$2,000	\$2,000	\$2,000	\$10,000
Cash Flow	-\$1,000	\$0	\$2,000	\$2,000	\$2,000	\$5,000
NPV(Dr, CF)	-\$909	-\$909	\$594	\$1,960	\$3,201	

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Example

- Suppose you got 80,000, and you are going to invest them. Consider you are going to buy a new car with that amount of money, then you are going to rent it for 3200\$ monthly.
- If the expected maintenance fees/year for the car is 2500\$ LE.
- Calculate the NPV for the first five year (car life time)

Discount Rate	10%					
PROJECT (Car rent)	Year 1	Year 2	Year 3	Year 4	Year 5	Total
Benefits	\$36,000	\$36,000	\$36,000	\$36,000	\$36,000	\$180,000
Cost	\$80,000	\$2,500	\$2,500	\$2,500	\$2,500	\$90,000

Discount Rate	10%					
PROJECT (Car rent)	Year 1	Year 2	Year 3	Year 4	Year 5	Total
Benefits	\$36,000	\$36,000	\$36,000	\$36,000	\$36,000	\$180,000
Cost	\$80,000	\$2,500	\$2,500	\$2,500	\$2,500	\$90,000
Cash Flow	-\$44,000	\$33,500	\$33,500	\$33,500	\$33,500	\$90,000

Discount Rate	10%					
PROJECT (Car rent)	Year 1	Year 2	Year 3	Year 4	Year 5	Total
Benefits	\$36,000	\$36,000	\$36,000	\$36,000	\$36,000	\$180,000
Cost	\$80,000	\$2,500	\$2,500	\$2,500	\$2,500	\$90,000
Cash Flow	-\$44,000	\$33,500	\$33,500	\$33,500	\$33,500	\$90,000
NPV(Discount Rate;Cash Flow)	-\$40,000	-\$12,314	\$12,855	\$35,736	\$56,537	

example

- Suppose you got 500,000, and you are going to invest them. Consider you are going to buy a new apartment with that amount of money, then you are going to rent it for 15000\$ monthly.
- If the expected maintenance fees/year for the apartment is 5000\$.
- Calculate the NPV for the first 5 year

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Discount Rate	10%					
PROJECT (apartment rent)	Year 1	Year 2	Year 3	Year 4	Year 5	Total
Benefits	\$180,000	\$180,000	\$180,000	\$180,000	\$180,000	\$900,000
Cost	\$500,000	\$5,000	\$5,000	\$5,000	\$5,000	\$520,000

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Discount Rate	10%					
PROJECT (apartment rent)	Year 1	Year 2	Year 3	Year 4	Year 5	Total
Benefits	\$180,000	\$180,000	\$180,000	\$180,000	\$180,000	\$900,000
Cost	\$500,000	\$5,000	\$5,000	\$5,000	\$5,000	\$520,000
Cash Flow	-\$320,000	\$175,000	\$175,000	\$175,000	\$175,000	\$380,000

Discount Rate	10%					
PROJECT (apartment rent)	Year 1	Year 2	Year 3	Year 4	Year 5	Total
Benefits	\$180,000	\$180,000	\$180,000	\$180,000	\$180,000	\$900,000
Cost	\$500,000	\$5,000	\$5,000	\$5,000	\$5,000	\$520,000
Cash Flow	-\$320,000	\$175,000	\$175,000	\$175,000	\$175,000	\$380,000
NPV(Discount Rate;Cash Flow)	-\$290,909	-\$146,281	-\$14,801	\$104,726	\$213,388	

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- **Return on investment (ROI)** is calculated by subtracting the project costs from the benefits and then dividing by the costs
$$\text{ROI} = (\text{total discounted benefits} - \text{total discounted costs}) / \text{total discounted costs}$$
 - For example, if you invest \$100 today and next year it is worth \$110, your ROI is $(110-100)/100$ or 10%.
 - The higher the ROI, the better. Many organizations use ROI in the project selection process. Most of IT decisions required an ROI analysis.
 - Many organizations have a **required rate of return** or minimum acceptable rate of return on investment for projects.
 - **Internal rate of return (IRR)** can be calculated by finding the discount rate that makes the NPV equal to zero.

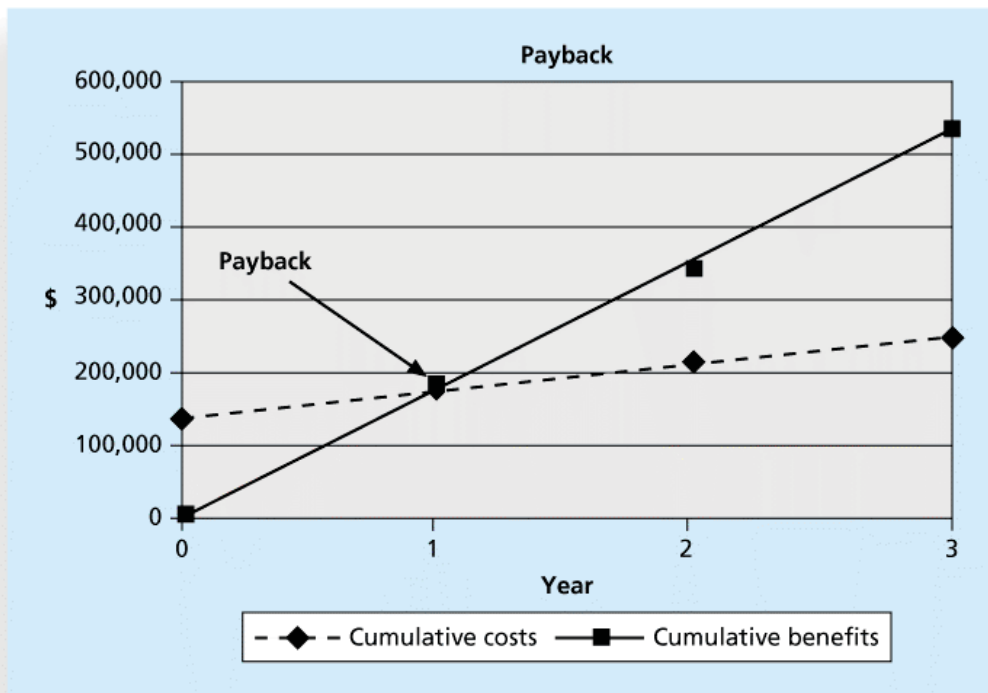
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- Another important financial consideration is payback analysis
 - The **payback period** is the amount of time it will take to recoup, in the form of net cash inflows, the total money invested in a project.
 - Payback occurs when the net cumulative discounted benefits equals the costs.
 - Many organizations want IT projects to have a fairly short payback period.

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Project					
Discount Rate	10%				
time	Year 0	Year 1	Year 2	Year 3	Total
Costs					\$0
Discount Factor	1.00	0.90	0.80	0.70	
Discounted costs	\$0	\$0	\$0	\$0	\$0
Benefits					
Discount Factor	1.00	0.90	0.80	0.70	
Discounted benefits	\$0	\$0	\$0	\$0	\$0
Discounted benefits - costs	\$0	\$0	\$0	\$0	\$0
Cumulative benefits - costs	\$0	\$0	\$0	\$0	← ≈NPV
ROI ((DB-DC)/DC)	→	#DIV/0!			

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example

- Project 2

Discount Rate	10%				
PROJECT 2	Year 1	Year 2	Year 3	Year 4	Year 5
Benefits	\$1,000	\$2,000	\$4,000	\$4,000	\$4,000
Cost	\$2,000	\$2,000	\$2,000	\$2,000	\$2,000

Find

- NPV/year
- ROI
- Payback period

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Discount Rate	10%					
PROJECT 2	Year 1	Year 2	Year 3	Year 4	Year 5	Total
Benefits	\$1,000	\$2,000	\$4,000	\$4,000	\$4,000	\$15,000
Cost	\$2,000	\$2,000	\$2,000	\$2,000	\$2,000	\$10,000
Cash Flow	-\$1,000	\$0	\$2,000	\$2,000	\$2,000	\$5,000
NPV(Dr, CF)	-\$909	-\$909	\$594	\$1,960	\$3,201	

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Project 2						
Discount Rate	10%					
time	Year 1	Year 2	Year 3	Year 4	Year 5	Total
Costs	\$2,000	\$2,000	\$2,000	\$2,000	\$2,000	\$10,000
Discount Factor	1.00	0.90	0.80	0.70	0.60	
Discounted costs	\$2,000	\$1,800	\$1,600	\$1,400	\$1,200	\$6,800

Project 2						
Discount Rate	10%					
time	Year 1	Year 2	Year 3	Year 4	Year 5	Total
Costs	\$2,000	\$2,000	\$2,000	\$2,000	\$2,000	\$10,000
Discount Factor	1.00	0.90	0.80	0.70	0.60	
Discounted costs	\$2,000	\$1,800	\$1,600	\$1,400	\$1,200	\$6,800
Benefits	\$1,000	\$2,000	\$4,000	\$4,000	\$4,000	
Discount Factor	1.00	0.90	0.80	0.70	0.60	
Discounted benefits	\$1,000	\$1,800	\$3,200	\$2,800	\$2,400	\$8,800

Project 2						
Discount Rate	10%					
time	Year 1	Year 2	Year 3	Year 4	Year 5	Total
Costs	\$2,000	\$2,000	\$2,000	\$2,000	\$2,000	\$10,000
Discount Factor	1.00	0.90	0.80	0.70	0.60	
Discounted costs	\$2,000	\$1,800	\$1,600	\$1,400	\$1,200	\$6,800
Benefits	\$1,000	\$2,000	\$4,000	\$4,000	\$4,000	
Discount Factor	1.00	0.90	0.80	0.70	0.60	
Discounted benefits	\$1,000	\$1,800	\$3,200	\$2,800	\$2,400	\$8,800
Discounted benefits - costs	-\$1,000	\$0	\$1,600	\$1,400	\$1,200	\$2,000

Project 2						
Discount Rate	10%					
time	Year 1	Year 2	Year 3	Year 4	Year 5	Total
Costs	\$2,000	\$2,000	\$2,000	\$2,000	\$2,000	\$10,000
Discount Factor	1.00	0.90	0.80	0.70	0.60	
Discounted costs	\$2,000	\$1,800	\$1,600	\$1,400	\$1,200	\$6,800
Benefits	\$1,000	\$2,000	\$4,000	\$4,000	\$4,000	
Discount Factor	1.00	0.90	0.80	0.70	0.60	
Discounted benefits	\$1,000	\$1,800	\$3,200	\$2,800	\$2,400	\$8,800
Discounted benefits - costs	-\$1,000	\$0	\$1,600	\$1,400	\$1,200	\$2,000
Cumulative benefits - costs	-\$1,000	-\$1,000	\$600	\$2,000	\$3,200	← ≈NPV

Project 2						
Discount Rate	10%					
time	Year 1	Year 2	Year 3	Year 4	Year 5	Total
Costs	\$2,000	\$2,000	\$2,000	\$2,000	\$2,000	\$10,000
Discount Factor	1.00	0.90	0.80	0.70	0.60	
Discounted costs	\$2,000	\$1,800	\$1,600	\$1,400	\$1,200	\$6,800
Benefits	\$1,000	\$2,000	\$4,000	\$4,000	\$4,000	
Discount Factor	1.00	0.90	0.80	0.70	0.60	
Discounted benefits	\$1,000	\$1,800	\$3,200	\$2,800	\$2,400	\$8,800
Discounted benefits - costs	-\$1,000	\$0	\$1,600	\$1,400	\$1,200	\$2,000
Cumulative benefits - costs	-\$1,000	-\$1,000	\$600	\$2,000	\$3,200	← ≈NPV
ROI ((DB-DC)/DC)	→ 29%					

payback in three years

example

- Project 03

Discount Rate	7%			
PROJECT 3	Year 0	Year 1	Year 2	Year 3
Benefits	\$0	\$200,000	\$200,000	\$200,000
Cost	\$140,000	\$40,000	\$40,000	\$40,000

Find

- NPV/year
- ROI
- Payback period

Discount Rate	7%			
PROJECT 3	Year 0	Year 1	Year 2	Year 3
Benefits	\$0	\$200,000	\$200,000	\$200,000
Cost	\$140,000	\$40,000	\$40,000	\$40,000
Cash Flow	-\$140,000	\$160,000	\$160,000	\$160,000

Discount Rate	7%				
PROJECT 3	Year 0	Year 1	Year 2	Year 3	Total
Benefits	\$0	\$200,000	\$200,000	\$200,000	\$600,000
Cost	\$140,000	\$40,000	\$40,000	\$40,000	\$260,000
Cash Flow	-\$140,000	\$160,000	\$160,000	\$160,000	\$340,000

Discount Rate	7%				
PROJECT 3	Year 0	Year 1	Year 2	Year 3	Total
Benefits	\$0	\$200,000	\$200,000	\$200,000	\$600,000
Cost	\$140,000	\$40,000	\$40,000	\$40,000	\$260,000
Cash Flow	-\$140,000	\$160,000	\$160,000	\$160,000	\$340,000
NPV(Dr, CF)	-\$130,841	\$8,909	\$139,517	\$261,580	

Project 3					
Discount Rate	7%				
Assume that project is completed in year 0					
time	Year 0	Year 1	Year 2	Year 3	Total
Costs	\$140,000	\$40,000	\$40,000	\$40,000	\$260,000
Discount Factor	1.00	0.93	0.86	0.79	
Discounted costs	\$140,000	\$37,200	\$34,400	\$31,600	\$243,200

Project 3					
Discount Rate	7%				
Assume that project is completed in year 0					
time	Year 0	Year 1	Year 2	Year 3	Total
Costs	\$140,000	\$40,000	\$40,000	\$40,000	\$260,000
Discount Factor	1.00	0.93	0.86	0.79	
Discounted costs	\$140,000	\$37,200	\$34,400	\$31,600	\$243,200
Benefits	\$0	\$200,000	\$200,000	\$200,000	
Discount Factor	1.00	0.93	0.86	0.79	
Discounted benefits	\$0	\$186,000	\$172,000	\$158,000	\$516,000

Project 3					
Discount Rate	7%				
Assume that project is completed in year 0					
time	Year 0	Year 1	Year 2	Year 3	Total
Costs	\$140,000	\$40,000	\$40,000	\$40,000	\$260,000
Discount Factor	1.00	0.93	0.86	0.79	
Discounted costs	\$140,000	\$37,200	\$34,400	\$31,600	\$243,200
Benefits	\$0	\$200,000	\$200,000	\$200,000	
Discount Factor	1.00	0.93	0.86	0.79	
Discounted benefits	\$0	\$186,000	\$172,000	\$158,000	\$516,000
Discounted benefits - costs	-\$140,000	\$148,800	\$137,600	\$126,400	\$272,800

Project 3					
Discount Rate	7%				
Assume that project is completed in year 0					
time	Year 0	Year 1	Year 2	Year 3	Total
Costs	\$140,000	\$40,000	\$40,000	\$40,000	\$260,000
Discount Factor	1.00	0.93	0.86	0.79	
Discounted costs	\$140,000	\$37,200	\$34,400	\$31,600	\$243,200
Benefits	\$0	\$200,000	\$200,000	\$200,000	
Discount Factor	1.00	0.93	0.86	0.79	
Discounted benefits	\$0	\$186,000	\$172,000	\$158,000	\$516,000
Discounted benefits - costs	-\$140,000	\$148,800	\$137,600	\$126,400	\$272,800
Cumulative benefits - costs	-\$140,000	\$8,800	\$146,400	\$272,800	← ≈NPV

Project 3					
Discount Rate	7%				
Assume that project is completed in year 0					
time	Year 0	Year 1	Year 2	Year 3	Total
Costs	\$140,000	\$40,000	\$40,000	\$40,000	\$260,000
Discount Factor	1.00	0.93	0.86	0.79	
Discounted costs	\$140,000	\$37,200	\$34,400	\$31,600	\$243,200
Benefits	\$0	\$200,000	\$200,000	\$200,000	
Discount Factor	1.00	0.93	0.86	0.79	
Discounted benefits	\$0	\$186,000	\$172,000	\$158,000	\$516,000
Discounted benefits - costs	-\$140,000	\$148,800	\$137,600	\$126,400	\$272,800
Cumulative benefits - costs	-\$140,000	\$8,800	\$146,400	\$272,800	← ≈NPV
ROI ((DB-DC)/DC)	→ 112%				

payback in one years

Example (car)

- Suppose you got 80,000, and you are going to invest them. Consider you are going to buy a new car with that amount of money, then you are going to rent it for 3200\$ monthly.
- If the expected maintenance fees/year for the car is 2500\$ LE.
- Calculate the NPV for the first five year (car life time)
- ROI
- Payback period

Discount Rate	10%					
PROJECT (Car rent)	Year 1	Year 2	Year 3	Year 4	Year 5	Total
Benefits	\$36,000	\$36,000	\$36,000	\$36,000	\$36,000	\$180,000
Cost	\$80,000	\$2,500	\$2,500	\$2,500	\$2,500	\$90,000
Cash Flow	-\$44,000	\$33,500	\$33,500	\$33,500	\$33,500	\$90,000
NPV(Discount Rate;Cash Flow)	-\$40,000	-\$12,314	\$12,855	\$35,736	\$56,537	

Car project						
Discount Rate	10%					
time	Year 1	Year 2	Year 3	Year 4	Year 5	Total
Costs	\$80,000	\$2,500	\$2,500	\$2,500	\$2,500	\$90,000
Discount Factor	1.00	0.90	0.80	0.70	0.60	
Discounted costs	\$80,000	\$2,250	\$2,000	\$1,750	\$1,500	\$87,500

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Car project						
Discount Rate	10%					
time	Year 1	Year 2	Year 3	Year 4	Year 5	Total
Costs	\$80,000	\$2,500	\$2,500	\$2,500	\$2,500	\$90,000
Discount Factor	1.00	0.90	0.80	0.70	0.60	
Discounted costs	\$80,000	\$2,250	\$2,000	\$1,750	\$1,500	\$87,500
Benefits	\$36,000	\$36,000	\$36,000	\$36,000	\$36,000	
Discount Factor	1.00	0.90	0.80	0.70	0.60	
Discounted benefits	\$36,000	\$32,400	\$28,800	\$25,200	\$21,600	\$144,000

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Car project						
Discount Rate	10%					
time	Year 1	Year 2	Year 3	Year 4	Year 5	Total
Costs	\$80,000	\$2,500	\$2,500	\$2,500	\$2,500	\$90,000
Discount Factor	1.00	0.90	0.80	0.70	0.60	
Discounted costs	\$80,000	\$2,250	\$2,000	\$1,750	\$1,500	\$87,500
Benefits	\$36,000	\$36,000	\$36,000	\$36,000	\$36,000	
Discount Factor	1.00	0.90	0.80	0.70	0.60	
Discounted benefits	\$36,000	\$32,400	\$28,800	\$25,200	\$21,600	\$144,000
Discounted benefits - costs	-\$44,000	\$30,150	\$26,800	\$23,450	\$20,100	\$56,500

Car project						
Discount Rate	10%					
time	Year 1	Year 2	Year 3	Year 4	Year 5	Total
Costs	\$80,000	\$2,500	\$2,500	\$2,500	\$2,500	\$90,000
Discount Factor	1.00	0.90	0.80	0.70	0.60	
Discounted costs	\$80,000	\$2,250	\$2,000	\$1,750	\$1,500	\$87,500
Benefits	\$36,000	\$36,000	\$36,000	\$36,000	\$36,000	
Discount Factor	1.00	0.90	0.80	0.70	0.60	
Discounted benefits	\$36,000	\$32,400	\$28,800	\$25,200	\$21,600	\$144,000
Discounted benefits - costs	-\$44,000	\$30,150	\$26,800	\$23,450	\$20,100	\$56,500
Cumulative benefits - costs	-\$44,000	-\$13,850	\$12,950	\$36,400	\$56,500	← ≈NPV

Car project						
Discount Rate	10%					
time	Year 1	Year 2	Year 3	Year 4	Year 5	Total
Costs	\$80,000	\$2,500	\$2,500	\$2,500	\$2,500	\$90,000
Discount Factor	1.00	0.90	0.80	0.70	0.60	
Discounted costs	\$80,000	\$2,250	\$2,000	\$1,750	\$1,500	\$87,500
Benefits	\$36,000	\$36,000	\$36,000	\$36,000	\$36,000	
Discount Factor	1.00	0.90	0.80	0.70	0.60	
Discounted benefits	\$36,000	\$32,400	\$28,800	\$25,200	\$21,600	\$144,000
Discounted benefits - costs	-\$44,000	\$30,150	\$26,800	\$23,450	\$20,100	\$56,500
Cumulative benefits - costs	-\$44,000	-\$13,850	\$12,950	\$36,400	\$56,500	← ≈NPV
ROI ((DB-DC)/DC)	→ 65%					

Example (apartment)

- Suppose you got 500,000, and you are going to invest them. Consider you are going to buy a new car with that amount of money, then you are going to rent it for 7500\$ monthly.
- If the expected maintenance fees/year for the car is 500\$.
- Calculate the NPV for the first ten year
- ROI
- Payback period

Discount Rate	10%					
PROJECT (apartment rent)	Year 1	Year 2	Year 3	Year 4	Year 5	Total
Benefits	\$180,000	\$180,000	\$180,000	\$180,000	\$180,000	\$900,000
Cost	\$500,000	\$5,000	\$5,000	\$5,000	\$5,000	\$520,000
Cash Flow	-\$320,000	\$175,000	\$175,000	\$175,000	\$175,000	\$380,000
NPV(Discount Rate;Cash Flow)	-\$290,909	-\$146,281	-\$14,801	\$104,726	\$213,388	

apartment						
Discount Rate	10%					
time	Year 1	Year 2	Year 3	Year 4	Year 5	Total
Costs	\$500,000	\$5,000	\$5,000	\$5,000	\$5,000	\$520,000
Discount Factor	1.00	0.90	0.80	0.70	0.60	
Disconted costs	\$500,000	\$4,500	\$4,000	\$3,500	\$3,000	\$515,000

apartment						
Discount Rate	10%					
time	Year 1	Year 2	Year 3	Year 4	Year 5	Total
Costs	\$500,000	\$5,000	\$5,000	\$5,000	\$5,000	\$520,000
Discount Factor	1.00	0.90	0.80	0.70	0.60	
Discounted costs	\$500,000	\$4,500	\$4,000	\$3,500	\$3,000	\$515,000
Benefits	\$180,000	\$180,000	\$180,000	\$180,000	\$180,000	
Discount Factor	1.00	0.90	0.80	0.70	0.60	
Discounted benefits	\$180,000	\$162,000	\$144,000	\$126,000	\$108,000	\$720,000

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apartment						
Discount Rate	10%					
time	Year 1	Year 2	Year 3	Year 4	Year 5	Total
Costs	\$500,000	\$5,000	\$5,000	\$5,000	\$5,000	\$520,000
Discount Factor	1.00	0.90	0.80	0.70	0.60	
Discounted costs	\$500,000	\$4,500	\$4,000	\$3,500	\$3,000	\$515,000
Benefits	\$180,000	\$180,000	\$180,000	\$180,000	\$180,000	
Discount Factor	1.00	0.90	0.80	0.70	0.60	
Discounted benefits	\$180,000	\$162,000	\$144,000	\$126,000	\$108,000	\$720,000
Discounted benefits - costs	-\$320,000	\$157,500	\$140,000	\$122,500	\$105,000	\$205,000

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apartment						
Discount Rate	10%					
time	Year 1	Year 2	Year 3	Year 4	Year 5	Total
Costs	\$500,000	\$5,000	\$5,000	\$5,000	\$5,000	\$520,000
Discount Factor	1.00	0.90	0.80	0.70	0.60	
Discounted costs	\$500,000	\$4,500	\$4,000	\$3,500	\$3,000	\$515,000
Benefits	\$180,000	\$180,000	\$180,000	\$180,000	\$180,000	
Discount Factor	1.00	0.90	0.80	0.70	0.60	
Discounted benefits	\$180,000	\$162,000	\$144,000	\$126,000	\$108,000	\$720,000
Discounted benefits - costs	-\$320,000	\$157,500	\$140,000	\$122,500	\$105,000	\$205,000
Cumulative benefits - costs	-\$320,000	-\$162,500	-\$22,500	\$100,000	\$205,000	← ≈NPV

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apartment						
Discount Rate	10%					
time	Year 1	Year 2	Year 3	Year 4	Year 5	Total
Costs	\$500,000	\$5,000	\$5,000	\$5,000	\$5,000	\$520,000
Discount Factor	1.00	0.90	0.80	0.70	0.60	
Discounted costs	\$500,000	\$4,500	\$4,000	\$3,500	\$3,000	\$515,000
Benefits	\$180,000	\$180,000	\$180,000	\$180,000	\$180,000	
Discount Factor	1.00	0.90	0.80	0.70	0.60	
Discounted benefits	\$180,000	\$162,000	\$144,000	\$126,000	\$108,000	\$720,000
Discounted benefits - costs	-\$320,000	\$157,500	\$140,000	\$122,500	\$105,000	\$205,000
Cumulative benefits - costs	-\$320,000	-\$162,500	-\$22,500	\$100,000	\$205,000	← ≈NPV
ROI ((DB-DC)/DC)	→ 40%					

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-
- As a system administrator you may be in charge of performing a project's cost/benefit analysis. It is important that you understand how to approach such a project.
 - Having a documented financial analysis is sure to help you communicate the benefits of a project, whether it deals with virtualization or not, and it can help you to “sell” the project to decision makers.

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- There are many different techniques that can be utilized to prepare a cost/benefit financial analysis. We'll focus on standard approach that involves a five step process.
 - The five steps you'll need to accomplish are:
 1. Define your proposed virtualization scheme.
 2. Establish the current cost structure.
 3. Identify the virtualization project's costs.
 4. Identifying the benefits of the proposed virtualization solution.
 5. Create the virtualization project's overview spreadsheet.



To be continue,..
Thanks,..
See you next week (ISA),...

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