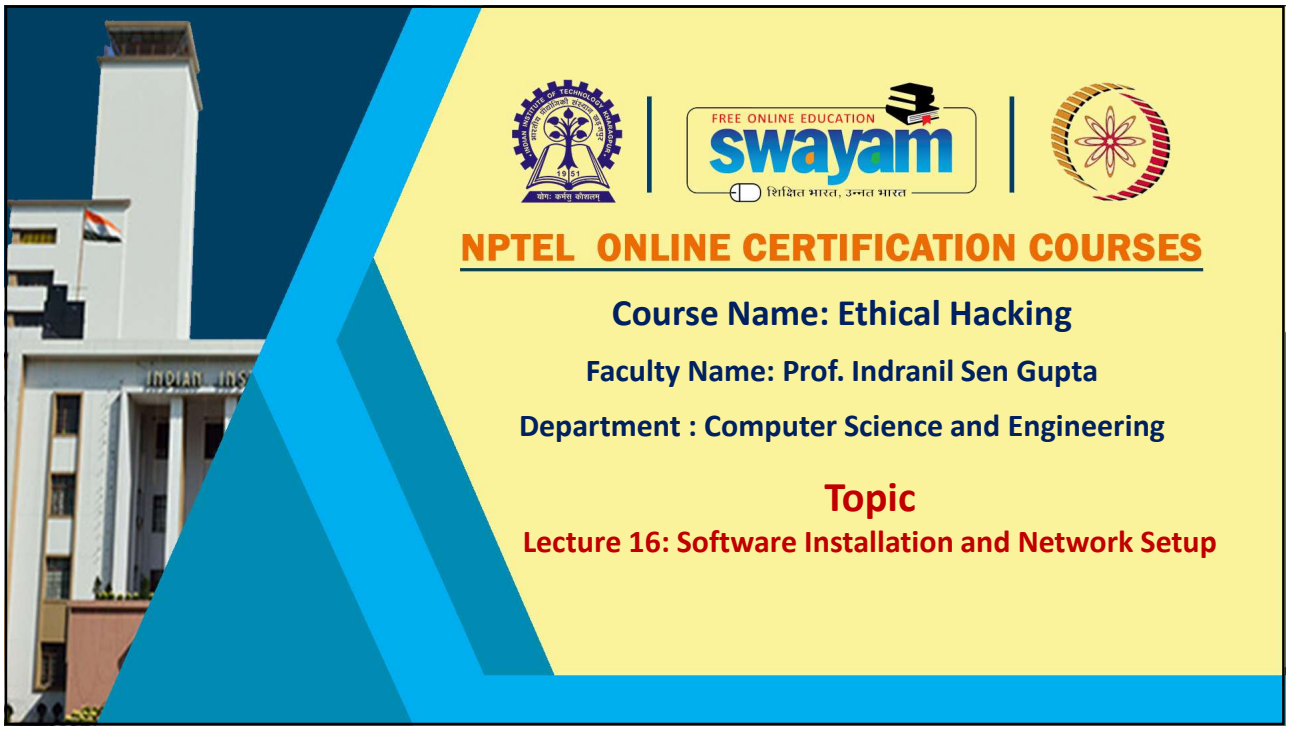
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Department : Computer Science and Engineering
Topic
Lecture 16: Software Installation and Network Setup

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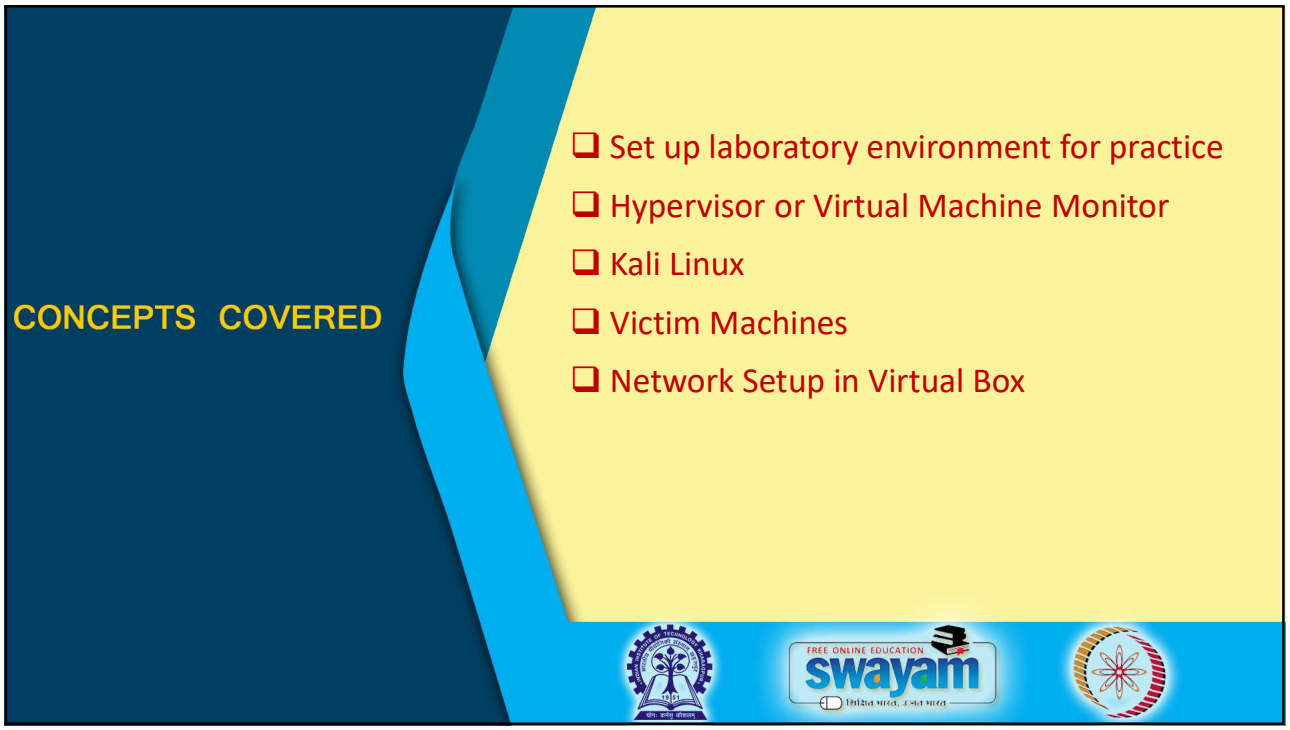
CONCEPTS COVERED
Set up laboratory environment for practice
Hypervisor or Virtual Machine Monitor
Kali Linux
Victim Machines
Network Setup in Virtual Box

Laboratory Setup For Practice

- **IMPORTANT** – It is illegal to perform any kind of hacking activity on vulnerable machines on the Internet / Intranet that does not belong to you.
  - We shall perform all demonstration on the victim systems installed in virtual machine.
- **DISCLAIMER** – Learners of this course must not use any vulnerable machines available on the internet.
  - If any LEGAL action is taken against them, then NPTEL / IIT KHARAGPUR will not be responsible.
- ***NOTE:*** *Keep your system firewall turned on while practicing.*

3

Requirements for Laboratory Setup

a) **Hypervisor Software**
- VMware, VirtualBox

b) **Attacker System**
- Kali Linux ISO, Parrot Security, Backbox, etc.

c) **Victim System**
- Windows XP, Windows 7
- Metasploitable machines (Metasploitable 2 and Metasploitable 3)

4

(a) Hypervisor or Virtual Machine Monitor

- **Hypervisor** is a software that creates and runs ***virtual machines*** (VMs).
- It allows one host computer to support multiple guest VMs (different operating systems).
  - By virtually sharing its resources, viz. memory, network interface, storage and processing.
- Well-known hypervisor softwares: VMware, VirtualBox.
  - In our demonstration shall use VirtualBox.
- We shall download and install the latest version of virtual box from: https://www.virtualbox.org/wiki/Downloads

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(b) Kali Linux

- Kali Linux is an open-source, Debian-based Linux distribution.
- It contains thousand of tools that can be used for practicing penetration testing, security research, computer forensics and reverse engineering.
- Some other OS, like Parrot Security, can also be used for same purpose. However for the beginners we recommend to use Kali Linux.
- To install Kali Linux in Virtual box, the disk image file can be downloaded from: https://www.kali.org/get-kali/#kali-bare-metal

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(c) Victim Machines

- **Metasploitable Machines**: These are intentionally vulnerable (i.e. insecure and hackable) virtual machines designed for training, exploit testing, and general target practice.
  - **Metasploitable 2**: vulnerable Linux based virtual machine.
  - **Metasploitable 3**: vulnerable Windows based virtual machine.
- We can also install some older machines such as Windows XP for practice.

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Network Setup in Virtual Box

- By default virtual box uses ***Network Address Translation*** (NAT).
- In NAT mode the Virtual OS is separated from outside (i.e., HOST system).
  - The virtual box itself allocates virtual IP's to systems installed inside it.
  - We can check that all OS installed in VM have the same IP address.
  - We can connect to the Internet in this mode.
- To establish connection between host as well as other systems installed inside virtual box, the best option is to enable ***Bridge Adapter*** mode.

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Demonstration: Installation of Attacker and Victim System and Network Setup

Alternatives

- Software setup in virtual box demands high RAM and storage.
  - Minimum 4GB RAM, 30-40 GB storage.
- If we do not have such system, then we can use Live Kali Linux.
  - Kali Linux in flash/pen drive.
- If we do not have windows system, then alternatively we can install tools available in Kali such as NMAP, Metaexploit etc. in Unix/Linux based system.


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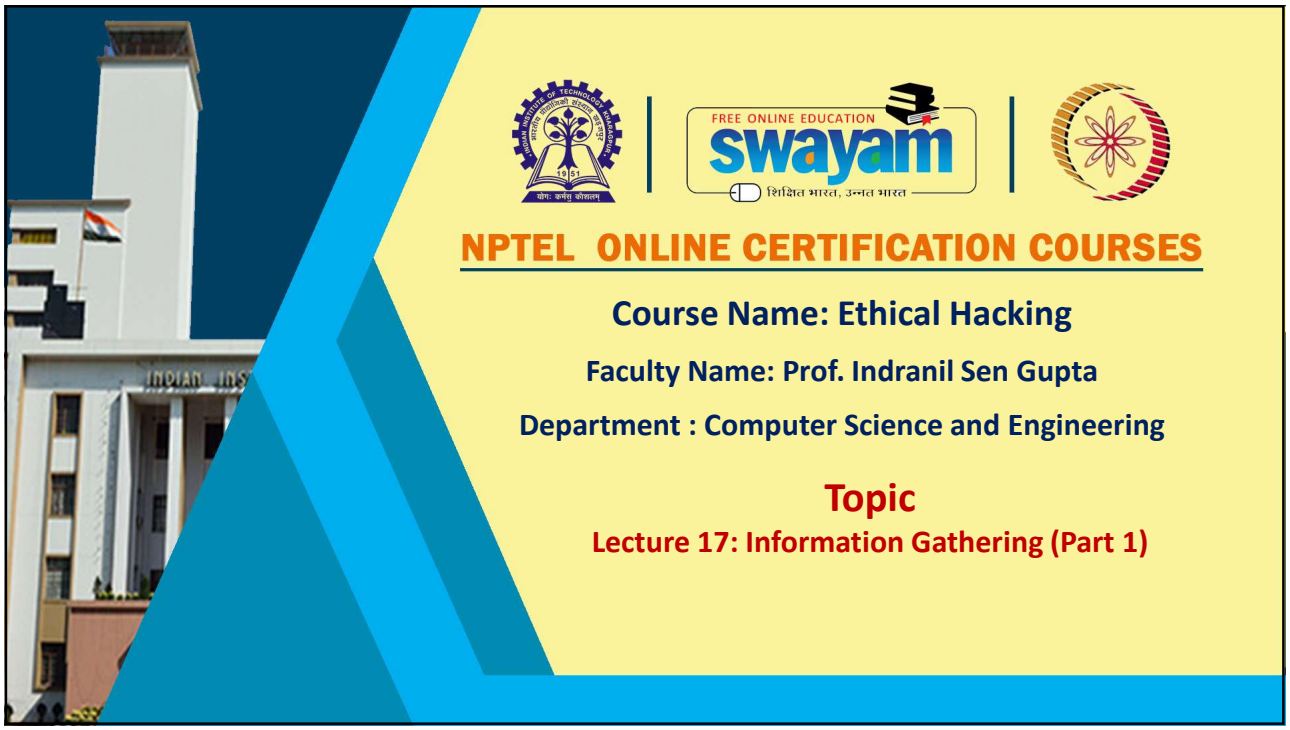
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Lecture 17: Information Gathering (Part 1)

CONCEPTS COVERED

- Reconnaissance or information gathering
- Passive and active reconnaissance
- Demonstration of passive reconnaissance

Reconnaissance (Information Gathering)

- Reconnaissance is the process of collecting as much information as possible about a target network.
  - Required for identifying ways to intrude into an organization's/victim's network system.
  - It is the first step before mounting any attack.
- We collect useful information about target PC.
  - Such as IP address, list of open ports, secure ports, vulnerability, etc.

Objectives of Reconnaissance

- Collect network information:
  - Domain name, IP addresses, internal domain name, services running (TCP, UDP).
- Collect system information:
  - User names, routing tables, system names, system architecture, password, etc.
- Collect organization information:
  - Employee details, organization names, location, contact information, security policies, etc.
- Two types of Reconnaissance:
  a) Passive reconnaissance
  b) Active reconnaissance.

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Passive Reconnaissance

- In this type of information gathering we collect information about the target indirectly.
  - Without direct communication with the target system.
  - Collection of the data that are publically available for webpage/application.
  - We can collect information using **archive.org**, **Whois**, **Netcraft** and **Harvester** tools.
  - We can also use search engine and search operator available with search engine.

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Active Reconnaissance

- In this type of information gathering we collect information directly by communicating with victim system.
  - Can provide more detailed information about target machine. But as we are directly communicating with target there is also risk of detection.
  - Can be carried out using Network Mapper (NMAP), Nessus, Metasploit framework, etc.
  - We can also use Mail tracker and DNS enumeration, Email enumeration, etc..

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(a) Passive Reconnaissance: archive.org

- In **archive.org** website we can get complete history of any website like when it was last updated.
- We can go back to the particular date and observe the webpage.
- We can mirror the website which will load all the files locally, such as HTML codes, images etc. that can be used to observe the directories used.

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(b) Passive Reconnaissance: Whois

- Whois database lookup allows us to access many useful information about target such as:
  - Registration details
  - IP address
  - Contact number and Email ID
  - Domain owner
  - Name servers
  - Regional Internet Registries

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(c) Passive Reconnaissance: Netcraft

- Netcraft is an internet service company.
- Through Netcraft we can find the list of subdomains and operating system of the corresponding server.
- This can be useful while exploiting the system.

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(d) Passive Reconnaissance: Search Engine and Search Operator

- Using search engine we can extract information such as platform used by organization, employee details, login pages.
  - Use various filters to restrict the search.
- We can also extract some information from search engine cache and internet archives.

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Useful Search Operators

- **site:** We can get result from specific website.
- **cache:** We can find the most recent cache of a specified webpage.
- **intitle:** This is a narrower operator that can help us find more targeted results for specific search phrases.
- **inurl:** Finds pages on a site that has the targeted search term in the URL.
- **filetype:** Finds files that only fall under a specific file type.

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Useful Search Operators (contd.)

- **@:** If we want the search to be restricted to only social media, then we use @ before the search key.
- **Quotes (“ ”):** Will help to get exact match result.
- Many more search operators are available.
  - We can also combine search operators to get more specific information.
  - Can be helpful for, targeted search, exclude/include specific terms/sites, site index information, etc.

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Other Ways of Reconnaissance

- We can register and opt for alerts to know all updates about a company /organization.
- If we are analyzing social media accounts then we can follow the targeted person / organization to get all new updates.
- We can even look into groups, forums, and blogs.
- Simple browsing of the website can identify the software, database used, etc.

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Demonstration: Passive Reconnaissance

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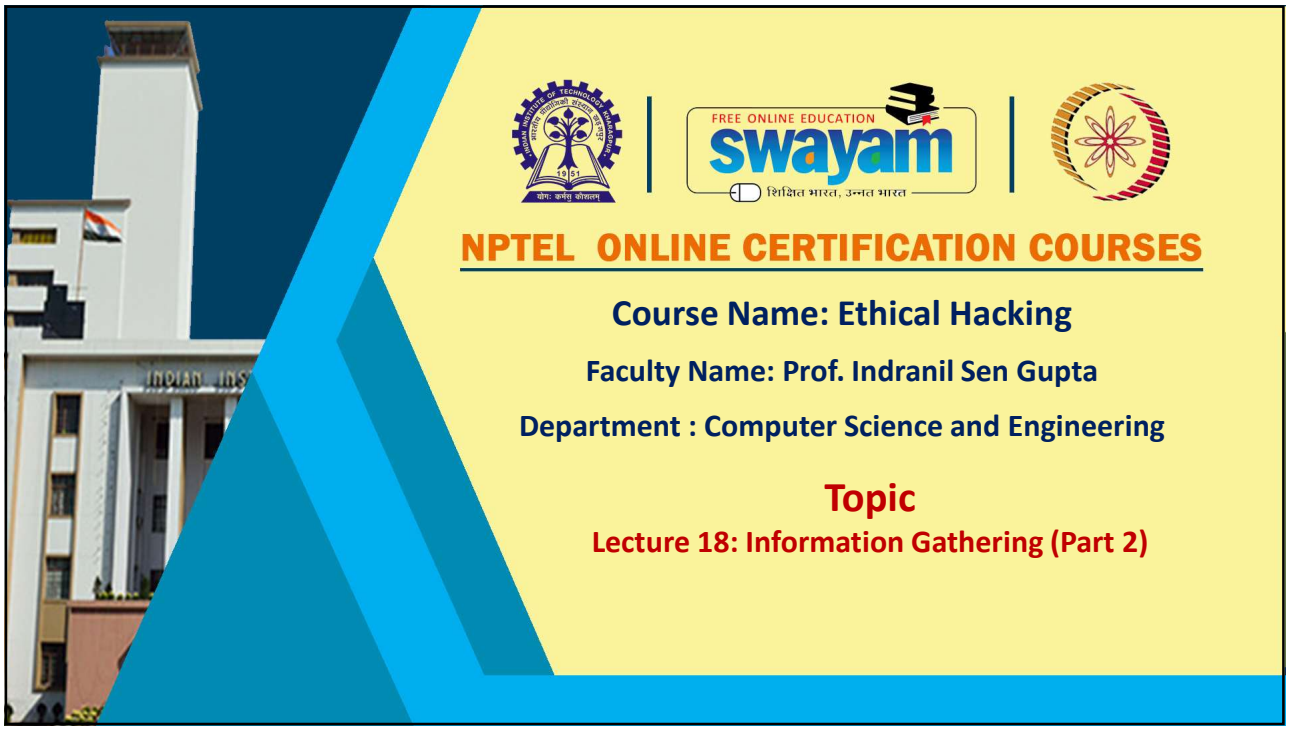
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CONCEPTS COVERED
Approaches to active reconnaissance
Demonstration of active reconnaissance

(1) Active Reconnaissance: DNS and Mail Server Enumeration

- In the enumeration process, attacker creates active connections to system and performs directed queries to gain more information about the target.
- DNS/Mail Server enumeration is the process of locating all DNS servers and their corresponding records for an organization.
  - Can yield usernames, computer names, and IP addresses of potential target systems.
  - Can reveal the size of the organization that can translate to the potential size of the attack.
- Tools used:
  - **nslookup**, **host**, **dig**, etc.

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Demonstration: DNS and Mail Server Enumeration

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(2) Active Reconnaissance: Scanning

- In active reconnaissance scanning tool performs major role.
- Scanning can be used to detect:
  - Live host in a network and network infrastructure
  - Open ports
  - Service running in some particular port
  - Operating system of target machine
  - Vulnerabilities of network/application/OS/target system.
- Tools used:
  - **NMAP**, **ZenMap**, **Nessus**, **Nexpose**, etc.

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Introduction to Network Mapper (NMAP)

- NMAP is a free, open-source tool for vulnerability scanning and network discovery.
- Generic command to run NMAP on command prompt:

```
nmap [scan types] [options] <host or network ...>
```

- The main feature of NMAP are:
  - **Host Discovery:** Which hosts are alive?
  - **Port Scanning:** What services are available?
  - **Service and Version Detection:** Which version is running?
  - **OS Detection:** Which OS version is running?

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NMAP: Host Discovery (Live System Discovery)

- To detect live host NMAP queries multiple hosts.
  - If it gets reply then the target/host is marked as live.
  - This is known as **ping sweep** operation.
- Various host scan techniques are supported by NMAP:
  a) ICMP sweep
  b) Broadcast ICMP
  c) Non-Echo ICMP
  d) TCP sweep
  e) UDP sweep

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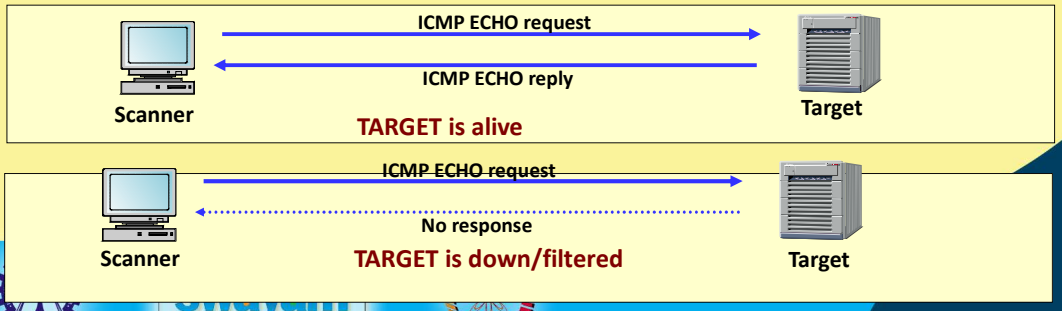
(a) Host discovery using ICMP Sweep

- How it works?
  - Send out an **ICMP ECHO request** (ICMP type 8)
  - If an **ICMP ECHO reply** (ICMP type 0) is received → ***TARGET IS ALIVE***
  - No response is received → ***TARGET IS DOWN***
  - To perform ICMP echo sweep `-PE` option is used.

- Easy to implement
- Rather slow
- Easy to block



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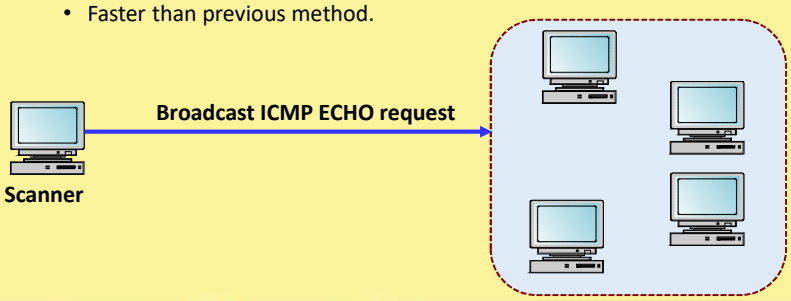
Demonstration: ICMP Sweep Scan

(b) Host discovery using Broadcast ICMP

- **Most routers block this.**
- **Windows ignore these requests.**

- How it works?
  - Send out an **ICMP ECHO request** to the network and/or broadcast address.
  - All the hosts in the network will simultaneously send back **ICMP ECHO reply** packets.
    - Faster than previous method.



(c) Host discovery using Non-ECHO ICMP

- How it works?
  - Instead of ICMP ECHO request, the scanner sends out other types of ICMP messages.
    - The target will respond to such messages.
  - **Approach 1**: Send ICMP type 13 messages (***TIMESTAMP***) (-PP option)
    - The scanner queries current time to the target.
  - **Approach 2**: Send ICMP type 17 messages (***ADDRESS MASK REQUEST***) (-PM option)
    - The scanner queries subnet mask to the target (this feature is used by diskless workstations during booting).

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Demonstration: Non-Echo ICMP Sweep

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(d) Host discovery using TCP Sweep

- How it works?
  - The scanner sends out **TCP SYN** or **TCP ACK** packet to the target.
  - It also detect open ports.
  - The port number can be suitably selected to prevent blocking by firewall.
    - Typical port numbers used: 21, 22, 23, 25, 80
- TCP sweep can be performed using two options:
  - `-PS` : for TCP SYN sweep
  - `-PA` : for TCP ACK sweep
- TCP sweep is also used by default **port scanning** options.

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Demonstration: TCP Sweep Scan

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(e) Host discovery using UDP Sweep

- How it works?
  - The scanner sends a UDP datagram to the target.
  - If no **ICMP PORT UNREACHABLE** message is received → ***TARGET IS ALIVE***
  - If an **ICMP PORT UNREACHABLE** message is received → ***TARGET IS DOWN***
- To perform UDP sweep **-PU** option is used.
- If the UDP port is unreachable then the port will be reported as closed.

> - **Routers can drop UDP packets as they cross the Internet.**
> - **Many UDP services do not respond.**
> - **Firewalls typically drop UDP packets (except DNS).**
> - **Not very reliable**

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Demonstration: UDP Sweep Scan

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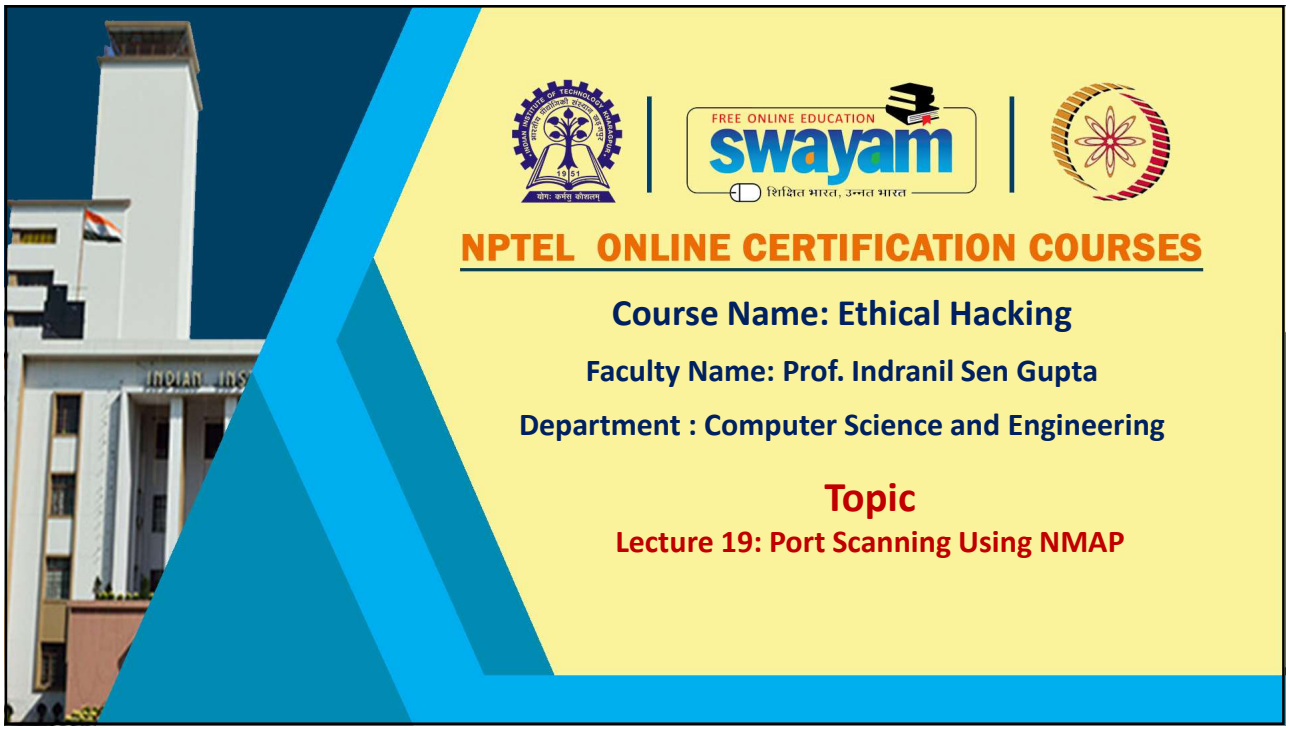
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Lecture 19: Port Scanning Using NMAP

CONCEPTS COVERED

- TCP Connect scan
- TCP SYN scan
- TCP Stealth scan
- FTP Bounce scan

Port Scanning Using NMAP

- To determine what services are running or LISTEN-ing.
  - Each running TCP service is associated with a port number, which ***listens*** for incoming connections.
  - Each running UDP service is associated with a port number.
- Various port scanning techniques in NMAP:
  a) TCP Connect scan
  b) TCP SYN scan
  c) TCP Stealth scan
  d) FTP Bounce scan

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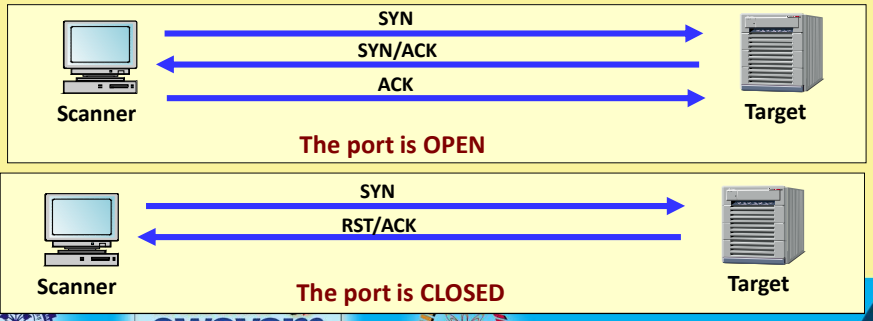
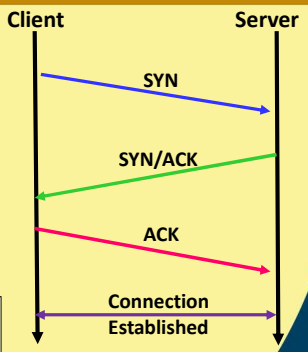
(a) TCP Connect scan

- How it works?
  - Use basic TCP connection establishment mechanism.
  - Complete 3-way handshake.
- Easy to detect by inspecting the system log.





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Demonstration: TCP Connect scan

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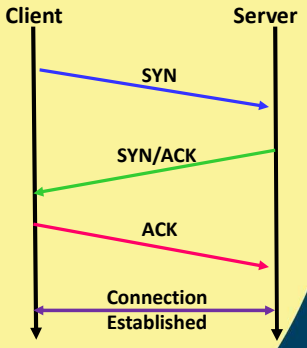
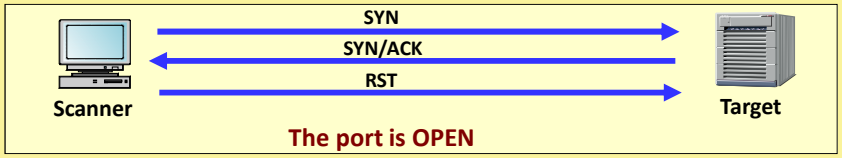
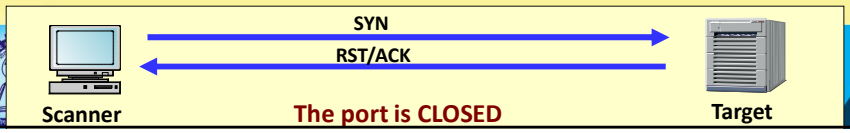
(b) TCP SYN scan

- How it works?
  - Do not establish complete connection (half-open scanning).
  - SYN/ACK is received → The port is ***LISTENING***
    - Immediately terminate connection by sending RST.
  - RST/ACK is received → The port is ***NON-LISTENING***
- The `-sT` scan uses both TCP SYN and TCP ACK packets.
  - It also uses ICMP ECHO sweep for checking if host is up or not.







Demonstration: TCP SYN scan

(c) TCP Stealth scan

- Basic idea:
  - Carry out port scanning while avoiding detection.
  - Try to hide themselves among normal network traffic.
  - Not to be logged (stealth).
- How it works?
  - Flag probe packets (also known as *Inverse Mapping*)
    - Response is sent back only by closed port.
    - Intruder determines what services do not exist, and can infer the ones that exist.
  - Slow scan rate
    - Difficult to detect, and needs long history log.

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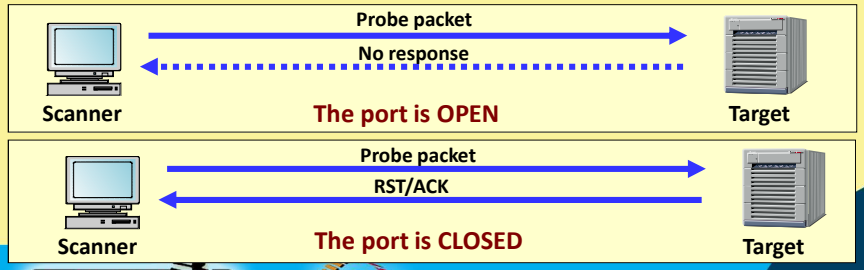
- How it can be done?
  - RFC793 talks about how to handle wrong packets.
    - Closed ports → Reply with a RESET packet
    - Open ports → Ignore any packet in question
  - Various ways:
    - Send a RST scan packet.
    - Send a FIN probe with FIN flag set.
    - Send an XMAS probe with FIN, URG, SYN, RST, PSH flags set.



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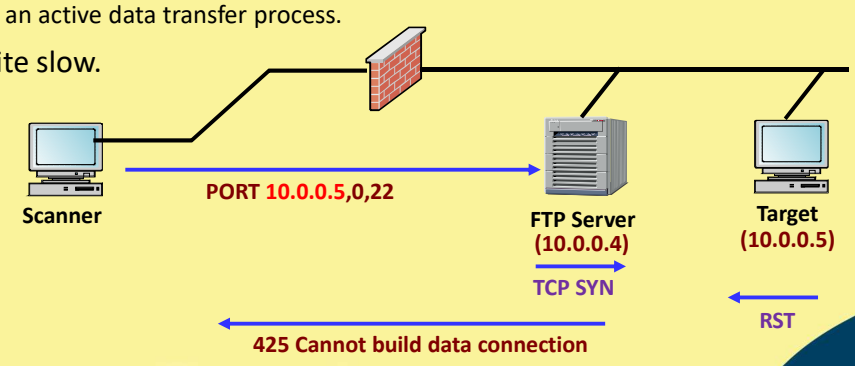
(d) FTP Bounce scan

- How it works?
  - Connect to a FTP server, and establish a control connection, and ask the FTP server to initiate an active data transfer process.
- Quite slow.



Demonstration: TCP Stealth and FTP Bounce Scan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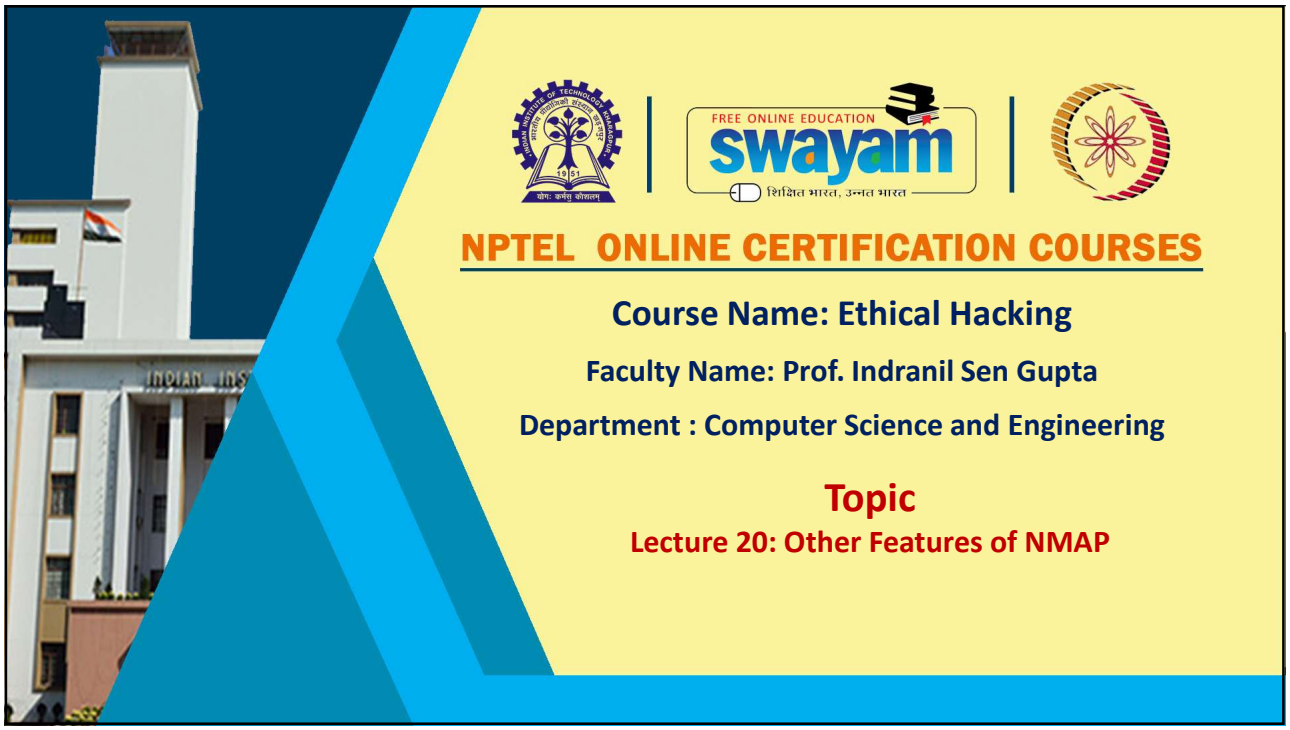
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Lecture 20: Other Features of NMAP

CONCEPTS COVERED

- Service version and OS detection
- NMAP command options for host discovery
- Some countermeasures for reconnaissance

Service Version and OS Detection

- Some OS responds with specific messages in response to certain requests.
  - Helps in identification of its type.
- TCP/IP fingerprinting (IP stack implementation will respond differently).
  - FIN probe, Bogus Flag probe
  - TCP initial sequence number sampling, TCP initial window, ACK value
  - ICMP error quenching, message quoting, ICMP echo integrity
  - IP: DF, TOS, Fragmentation

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Some Specific Examples

- **ACK**: sending ***FIN|PSH|URG*** to a closed port
  - Most OS → ACK with the same sequence number.
  - Windows → ACK with sequence number + 1
- **Type of Service**: Probing with ***ICMP_PORT_UNREACHABLE*** message
  - Most OS → Returns with TOS = 0.
  - Linux → Returns with TOS = 0xC0.
- For detecting OS and version –o and – sV options are used.

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More on Host Detection

- By default NMAP uses all types of sweep operations in common scanning options such that it can get better details about any system.
- Commands that use all types (except UDP sweep) are **`-sP`**, **`-sn`**, **`-sl`**, **`-Pn`**, etc.
- We will show example of **`-sP`** command.
  - This is used to print whether all or specific hosts are up and running.

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NMAP Command Options for Host Discovery in Brief

- **sL:** List Scan - simply list targets to scan
- **-sP:** Ping Scan - go no further than determining if host is online
- **-PN:** Treat all hosts as online - skip host discovery
- **-PS/PA/PU [portlist]:** TCP SYN/ACK or UDP discovery to given ports
- **-PE/PP/PM:** ICMP echo, timestamp, and netmask request discovery probes
- **-PO [protocol list]:** IP Protocol Ping
- **-n/-R:** Never do DNS resolution/Always resolve [default: sometimes]
- **--dns-servers** <serv1[,serv2],...>: Specify custom DNS servers
- **--system-dns:** Use OS's DNS resolver
- **-sU:** UDP Scan

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More NMAP Options for Port Scanning

- **Scan Techniques:**
  - -sS/sT/sA/sW/sM: TCP SYN/Connect()/ACK/Window/Maimon scans
  - -sN/sF/sX: TCP Null, FIN, and Xmas scans
  - -b <FTP relay host>: FTP bounce scan
- **Port specification and Scan Order:**
  - -p <port ranges>: Only scan specified ports
    - Examples: -p22; -p1-65535; -p U:53,111,137,T:21-25,80,139,8080
  - -F: Fast mode - Scan fewer ports than the default scan
  - -r: Scan ports consecutively - don't randomize
  - --top-ports <number>: Scan <number> most common ports

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More NMAP Options for OS Detection

- **Service / Version Detection:**
  - -sV: Probe open ports to determine service/version info
  - --version-intensity <level>: Set from 0 (light) to 9 (try all probes)
  - --version-light: Limit to most likely probes (intensity 2)
  - --version-all: Try every single probe (intensity 9)
  - --version-trace: Show detailed version scan activity (for debugging)
- **OS Detection:**
  - -O: Enables OS detection
  - --osscan-limit: Limit OS detection to promising targets
  - --osscan-guess: Guess OS more aggressively

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Demonstration: OS and Version Detection

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Demonstration: Some more options of NMAP

Reconnaissance Countermeasures

- Some steps can be taken to prevent reconnaissance such as:
  - Do not release critical info publically.
  - Use footprint techniques to discover and remove sensitive information.
  - Use split DNS, and restrict zone transfer.
  - Disable directory listing.
  - Educate employee about various social engineering attacks.
  - Encrypt password and sensitive information
  - Keep your system updated.
  - Use server mask

Reconnaissance Countermeasures (contd.)

- Use different file extension such as use .htm instead of .asp
- Examine logs for suspicious packets
- Identify connections not properly terminated
- Analyze ports usage

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