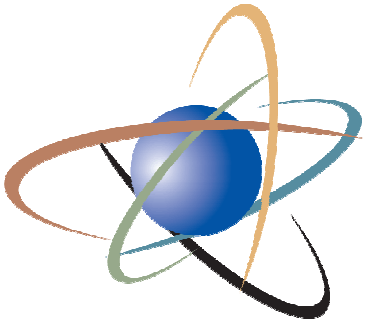

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Protecting People and the Environment

Firewall Presentation

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Disclaimer

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This presentation:

- does not contain NRC official positions
- is not guidance on how to configure firewalls
- is an overview of firewalls and their limitations
- is a demonstration of how attackers can bypass firewalls

What is a Firewall?

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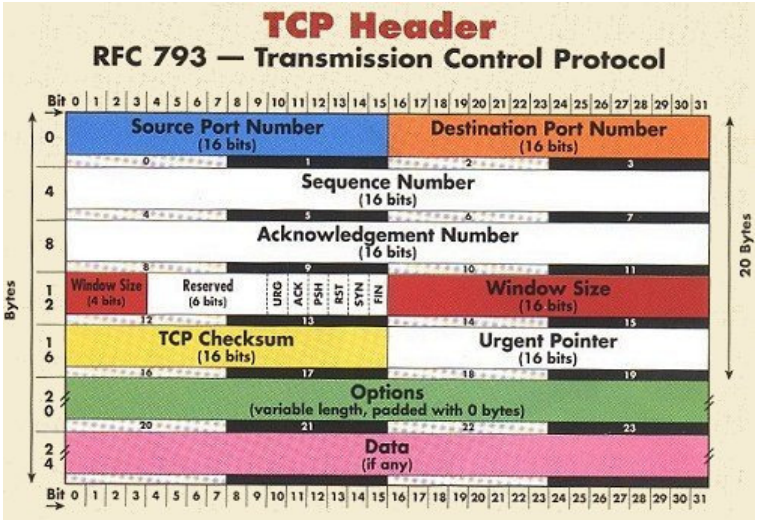
Q: What is a firewall?

A: A firewall is a computer.

- A firewall has the following:
  - Two or more network cards
  - Processor, RAM, hard drive
  - Operating System



Q: What makes a firewall different from other computers?

A: Very little.

- Designed to analyze and filter data flows at its most basic level
- May include additional logic to perform real-time contextual analysis of data flows
- May include specialized networking hardware to aid in this task

What is a Firewall?

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Q: What is the purpose of a firewall?

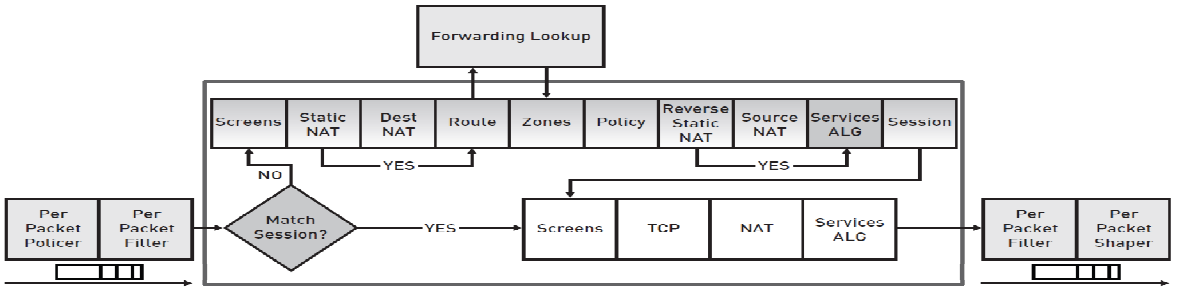
A: To control the flow of data between networks according to pre-defined rules

- Packet Filtering (by port, by protocol, by source address, by destination address)
- Stateful Inspection (can determine if a packet is part of an existing data flow)
- Other features include the following:

  -"Application Aware:" contains logic specific to common application (web, FTP, Secure Shell, etc.)

  - Quality of Service: Traffic prioritization and scheduling

  - Session Inspection: Can search a data flow for certain types of content



Firewall Limitations

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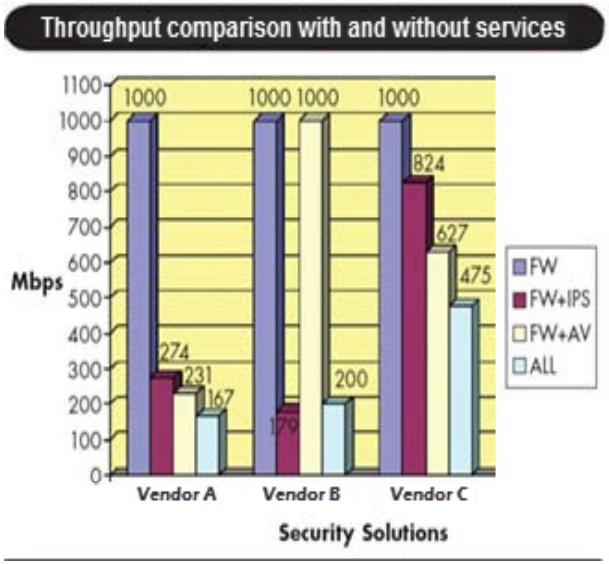
- A firewall cannot perform all security tasks
  - Hardware limitations
  - Memory and overhead limitations
  - Time limitations
  - Logic limitations
  - Encrypted traffic payloads are not visible
  - Firewalls do not typically do traffic normalization



- As a computer, a firewall can have vulnerabilities
  - CVE-2012-4661: Multiple Vulnerabilities in Cisco ASA 5500 Series Adaptive Security Appliances and Cisco Catalyst 6500 Series ASA Services Module
  - CVE-2012-5316: Multiple cross-site scripting (XSS) vulnerabilities in Barracuda Spam & Virus Firewall 600
  - **ICSA-12-102-05: Siemens Scalance S Multiple Security Vulnerabilities**

Firewall Limitations

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A firewall is only as good as its ruleset.

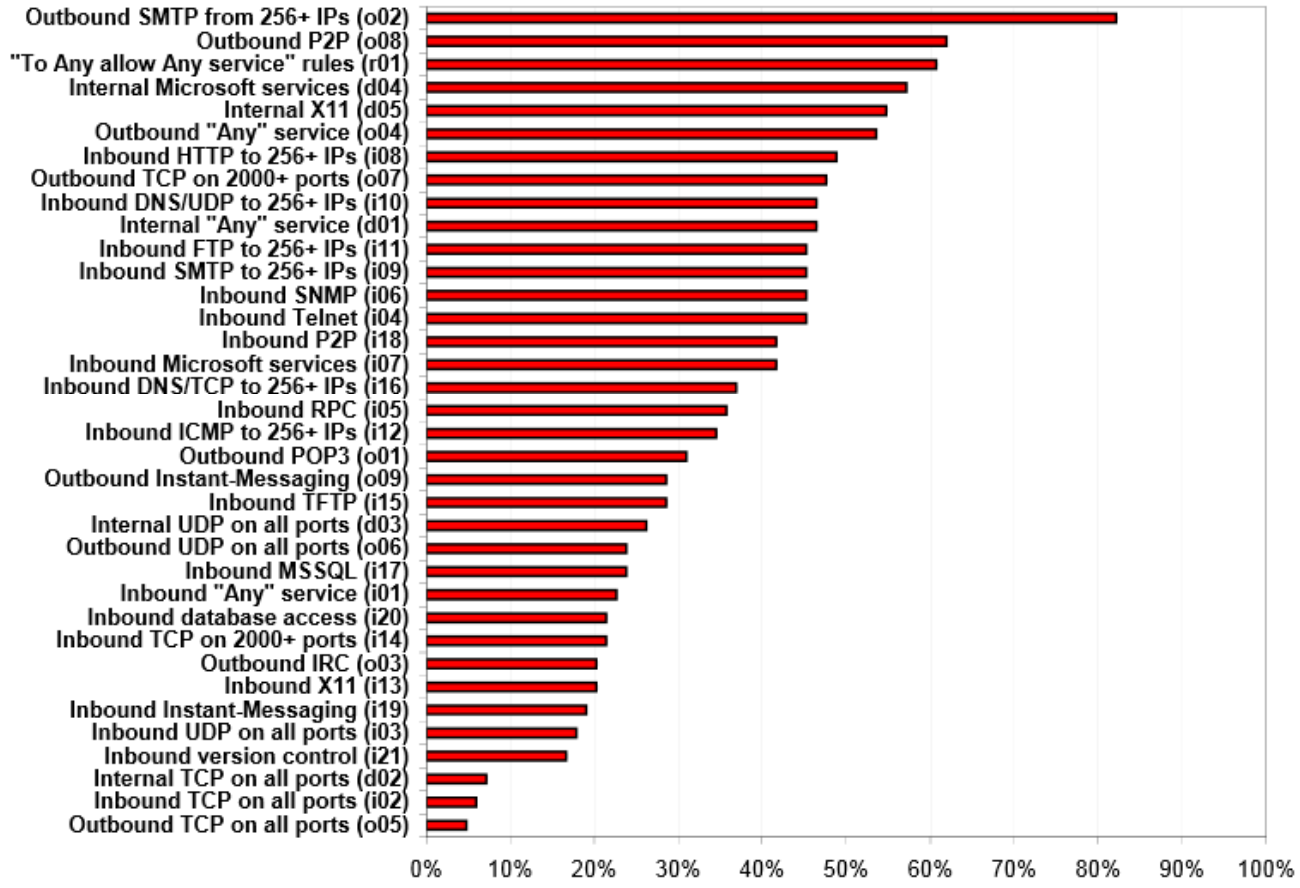

Figure 2: Distribution of configuration errors.

Source: Wool, Avishai. (2009). Firewall configuration errors revisited. Tel Aviv University School of Engineering. Retrieved from: http://arxiv.org/pdf/0911.1240v1.pdf

Typical Network Architecture

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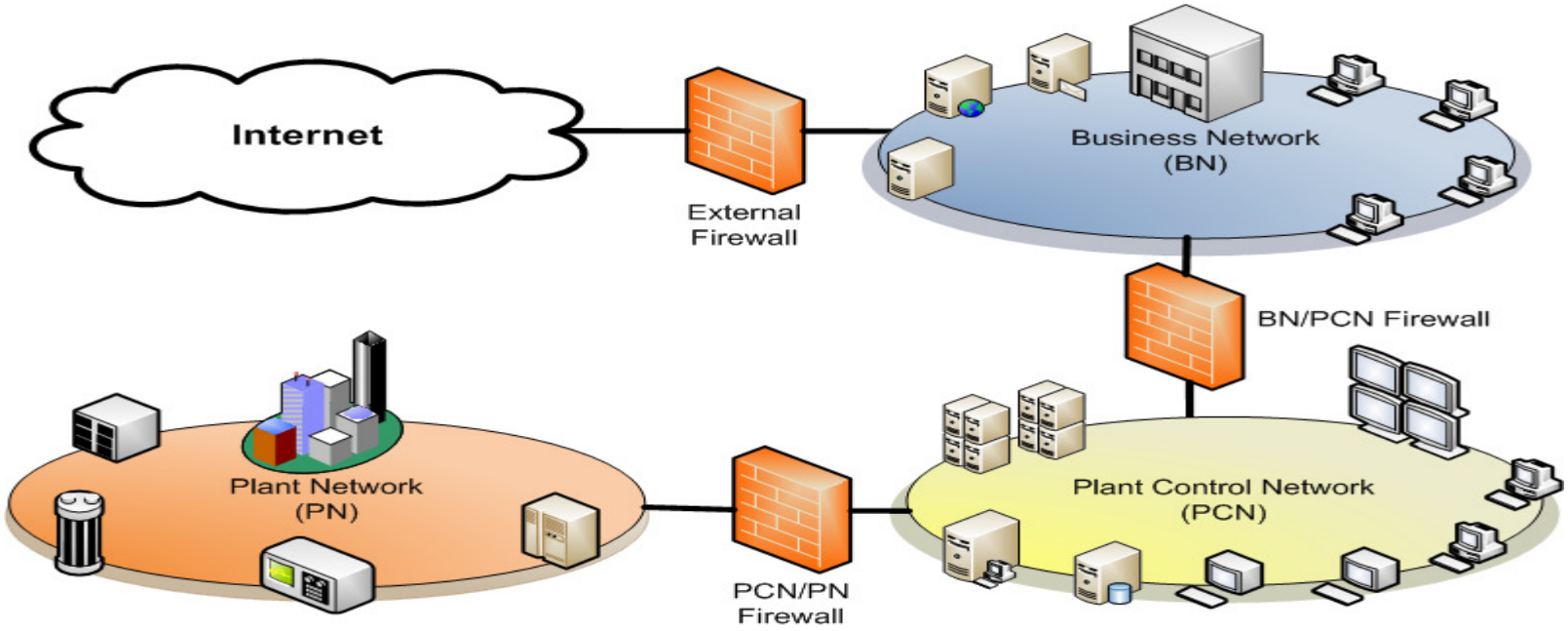
- Business network acts as backbone
- Firewall between business network (BN) and plant control network (PCN)
- Firewall between PCN and plant network (PN) may or may not be in place



Typical Network Architecture

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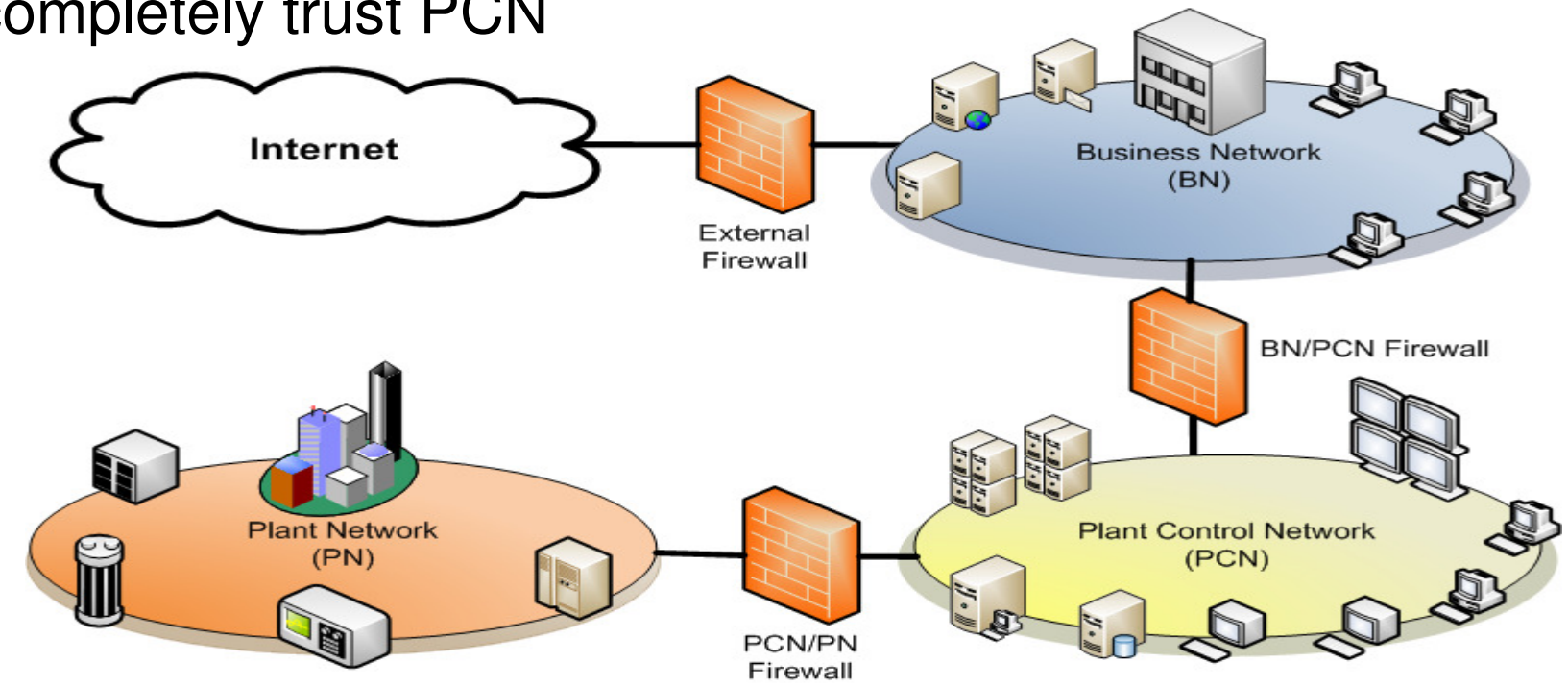
Problems:

- BN/PCN Firewall is configured to partially or completely trust BN
- PCN/PN Firewall is configured to partially or completely trust PCN



Common Weaknesses to Model

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- Poorly configured firewalls (historical, political, or legacy technical reasons)
  - Passing Microsoft Windows networking packets
  - Passing remote services (rsh, rlogin)
  - PCN/PN having trusted hosts on the business LAN
  - Not providing outbound data rules

- Peer links that bypass or route through external firewall direct to PCN or PN

Common Weaknesses to Model

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- IT controlled assets in the PCN or PN (communications links, replicated services)
- Vendor links for remote maintenance/monitoring
- Out-of-band communications channels (backup links to RTUs)

Getting Inside the Trusted Network

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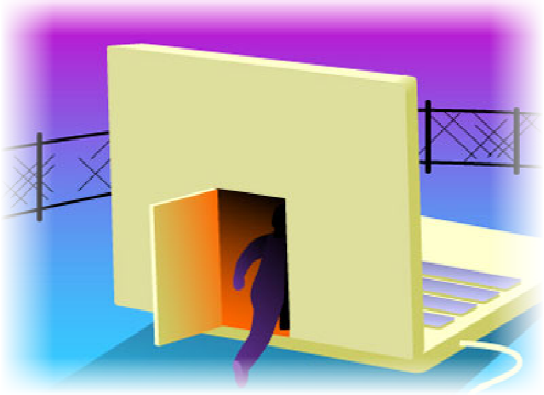
- Passive Evasion - The victim "phones home" to the attacker
  1. Phishing/spearphishing
  2. Malicious website/drive-by infection
  3. "Sneakernet" infection
  4. Social Engineering



- Indirect Evasion – Traffic appears to be authentic
  1. Stolen remote access credentials
  2. VPN piggyback
  3. Session hijacking
  4. Address spoofing (for internal zones)

Getting Inside the Trusted Network

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- Active Evasion
  1. Attack exposed services (Web, E-mail)
  2. Attack firewall vulnerabilites
  3. Exploit weak ruleset/poor configuration
  4. “Trick” or subvert the firewall logic with protocol manipulation (AET)
  5. Find out-of-band channels (wireless, modems, satellite links)
  6. Get physical access to firewall or other infrastructure

Case Study – Palo Alto Networks

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- Founded in 2005 by Checkpoint veteran
- First firewall product developed in 2007
- First of the "Next Generation" firewalls1
- Named leader in the 2011 Gartner "Magic Quadrant" report2
- At Defcon 19 (Dec 2011), Palo Alto firewall demonstrated to have fatal design flaw

1. Pescatore, J. & Young, G. (2009, October 19). Defining the Next-Generation Firewall. Gartner RAS Core Research Group. Retrieved from: http://img1.custompublish.com/getfile.php/1434855.1861.sqqycbrdwq/Defining+the+Next-Generation+Firewall.pdf, retrieved 2012-12-02
2. Denne, S. (2011, December 16). Palo Alto Networks hits the Magic Quadrant for firewalls. The Wall Street Journal. Retrieved from: http://blogs.wsj.com/venturecapital/2011/12/16/palo-alto-networks-hits-the-magic-quadrant-for-firewalls/
3. Woodberg, B. (2011). Palo Alto Networks Security Bypass. Defcon 19. Retrieved from: http://www.youtube.com/watch?v=AuaCrRIlgnQ

Case Study – Palo Alto Networks

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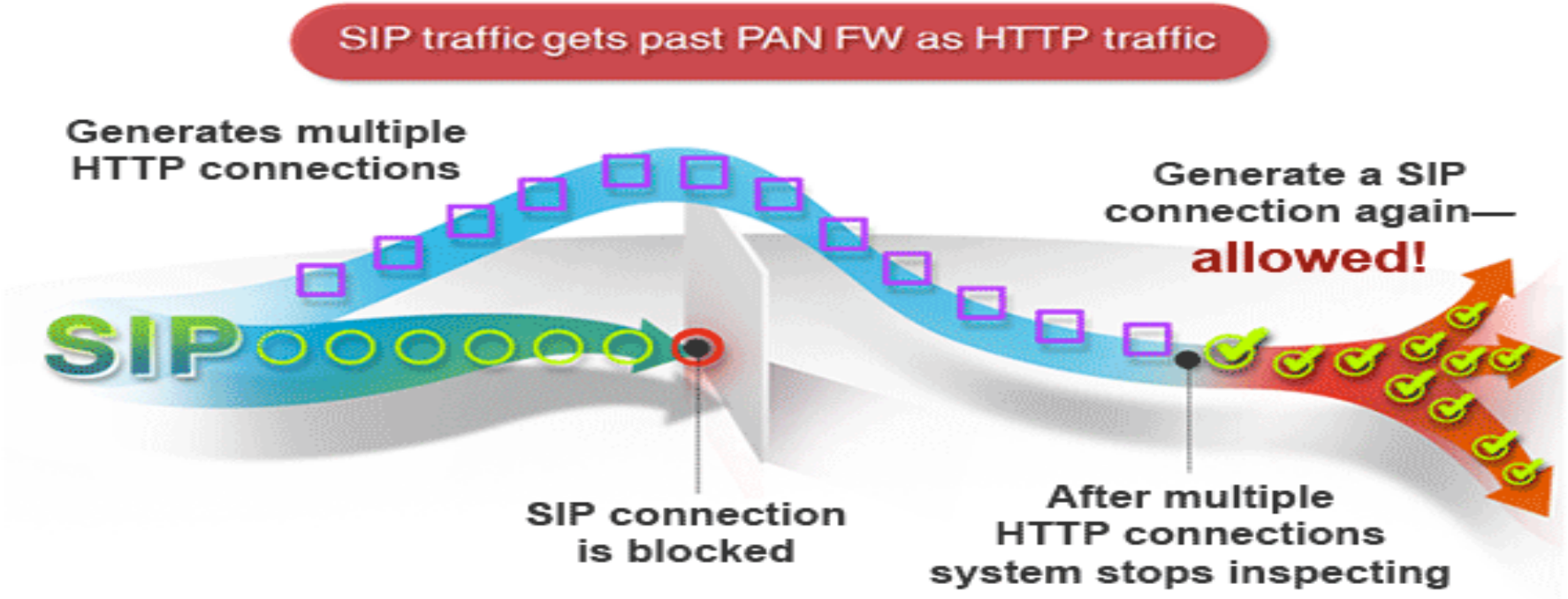
Cache poisoning attack:

- HTTP port open, SIP port blocked
- Attacker generates large number of HTTP sessions
- Memory cache fills, traffic no longer inspected
- HTTP session re-established as SIP, bypassing filter



Demonstration

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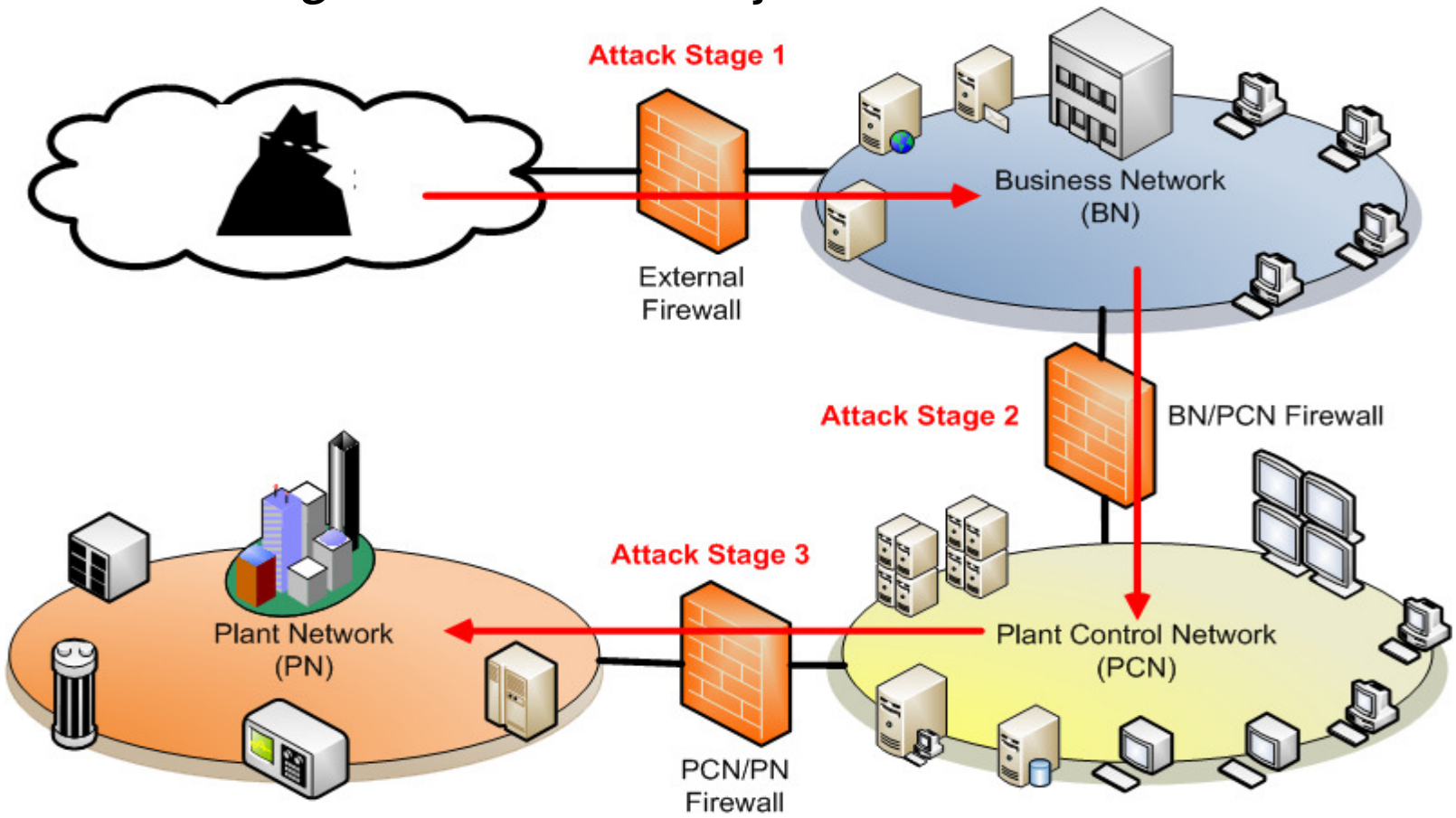
Attack Stage 1 – Desktop attack
Attack Stage 2 – Impersonation Attack
Attack Stage 3 – Session Hijack



Attack Stage 1– Desktop Attack

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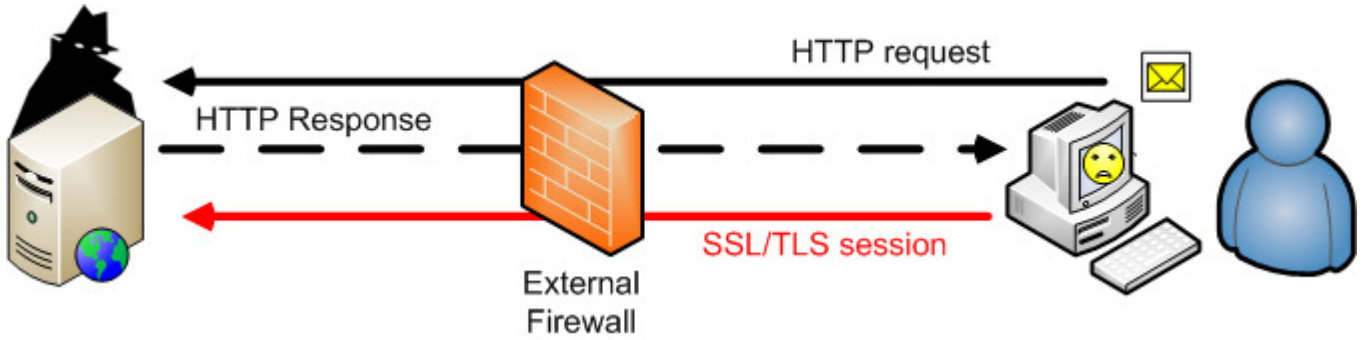
Scenario 1:

- Attacker crafts email message to employee
  - Looks very believable, may come from spoofed address of trusted source
- Email contains link to compromised website

Scenario 2:

- Employee goes to trusted website, which has link to infected website, employees computer is infected without knowledge (watering hole attack)



Attack Stage 1– Desktop Attack

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Both Scenarios:

- Zero-day exploits in desktop software (e.g. browsers, operating system, browser plugin)
- Anti-virus/anti-malware measures will not detect if no signature available
- IDS/IPS will not detect if no signature available or if connection is encrypted
- Payload deploys rootkit or Remote Access Toolkit (RAT)
- Payload initiates outbound connection over SSL/TLS or other encrypted protocol to bypass IDS/IPS/firewall inspection measures
- Attacker now has full control over employee's system and can attack local servers

Attack Stage 2 – Impersonation Attack

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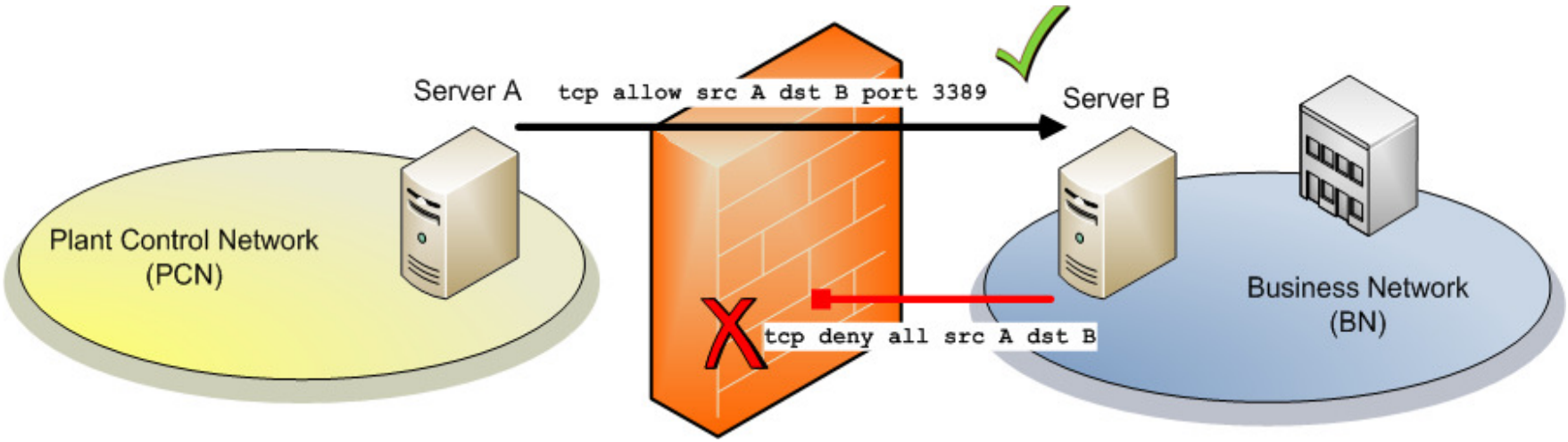
Scenario:

- No connections are allowed thru firewall from PCN to BN
- Firewall is configured as “one way”
- Server A, behind the firewall, sends a requests for data to Server B
- Server B cannot talk to Server A



TCP “Handshake”

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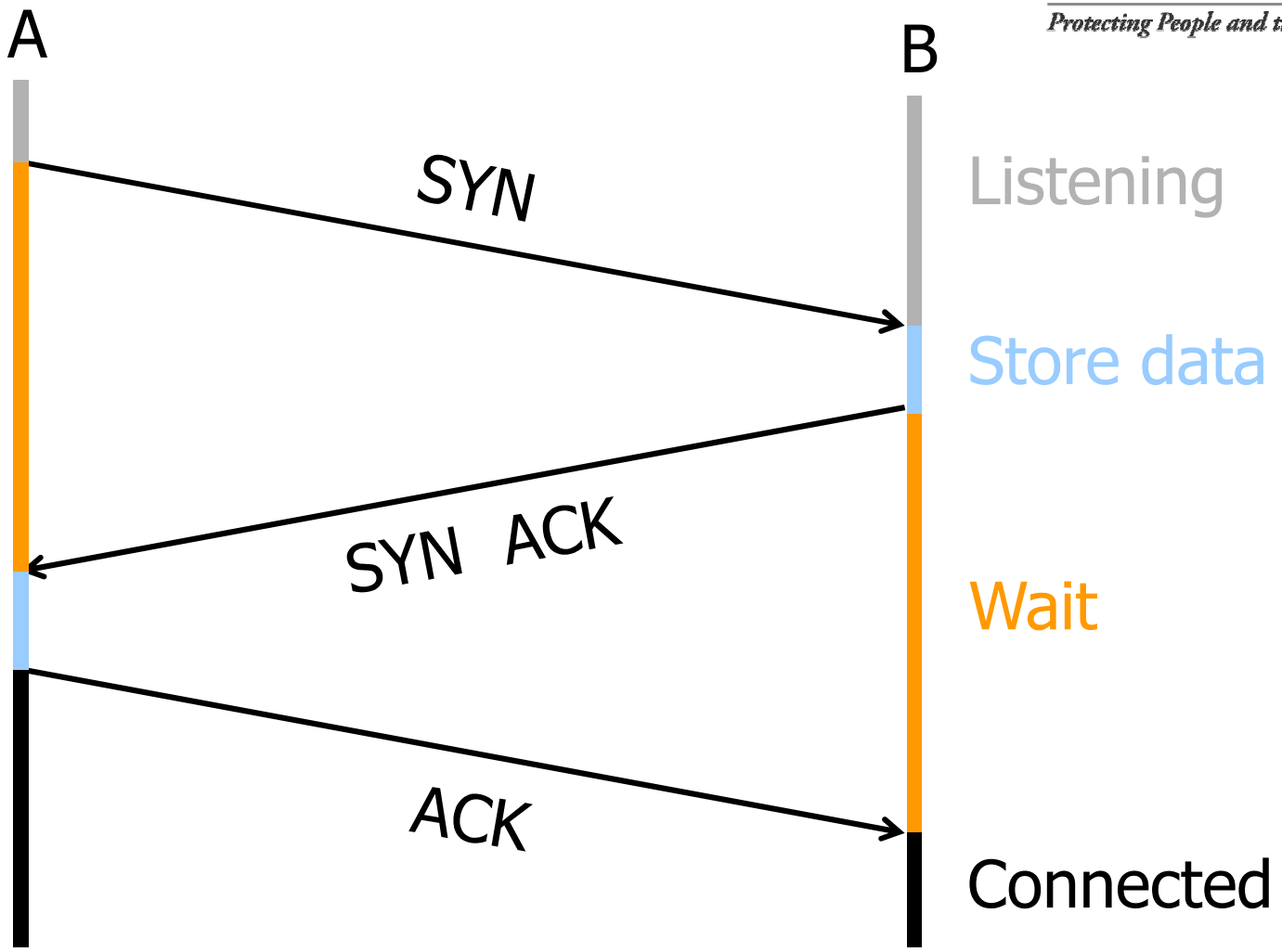

Once established, all TCP connections are bi-directional. Attacks can flow back to clients!

Attack Stage 2 Buffer Overflow

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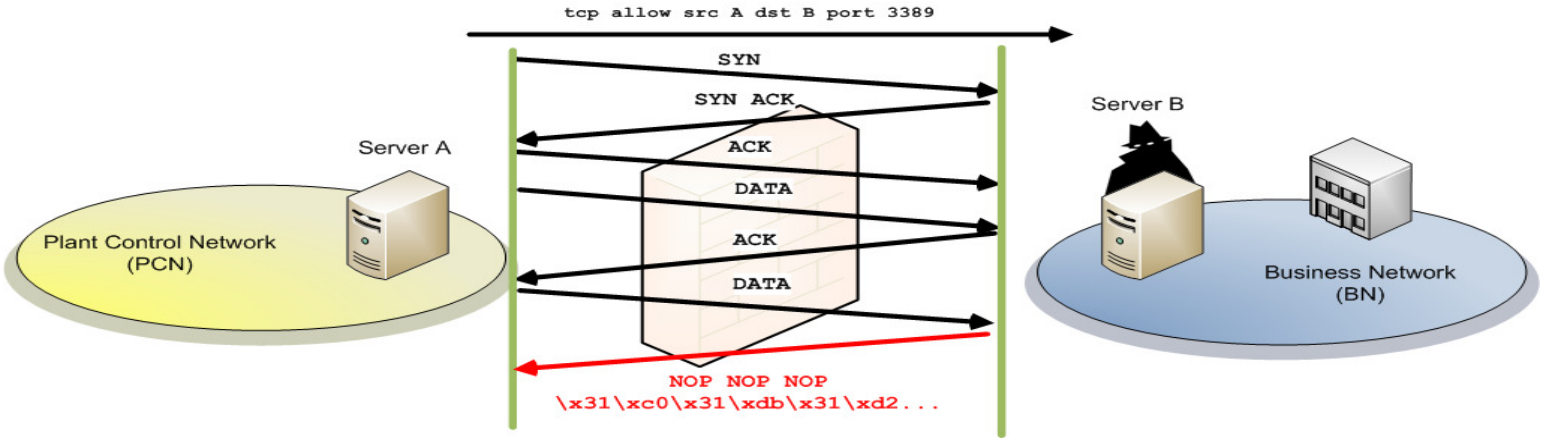
- A buffer overflow occurs when attacker sends data that cannot be adequately handled by the victim program
  - -Unexpected value
  - -Value out-of-bounds
  - -Memory violation
- Attack packet contains executable instructions to request victim open a shell prompt
- The original session has **not** terminated



Attack Stage 3 – Session Hijack

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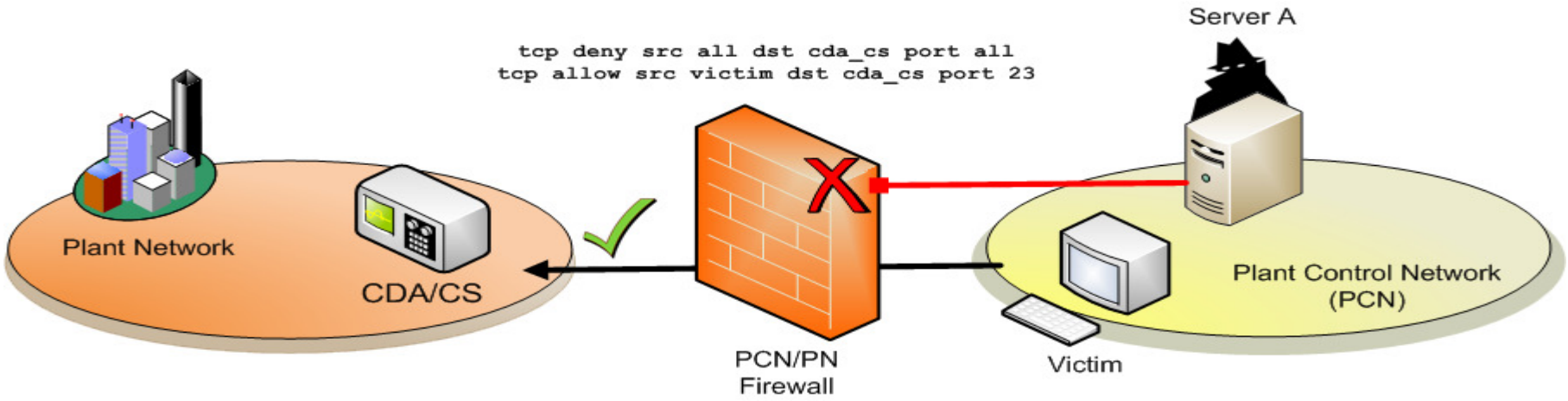
Scenario:

- Victim is logged into CDA/CS, through the firewall
- Telnet connection is allowed from Victim to ICS
- No other hosts are allowed to connect thru firewall to ICS
- Telnet Connection is authenticated



Blind TCP Session Hijacking

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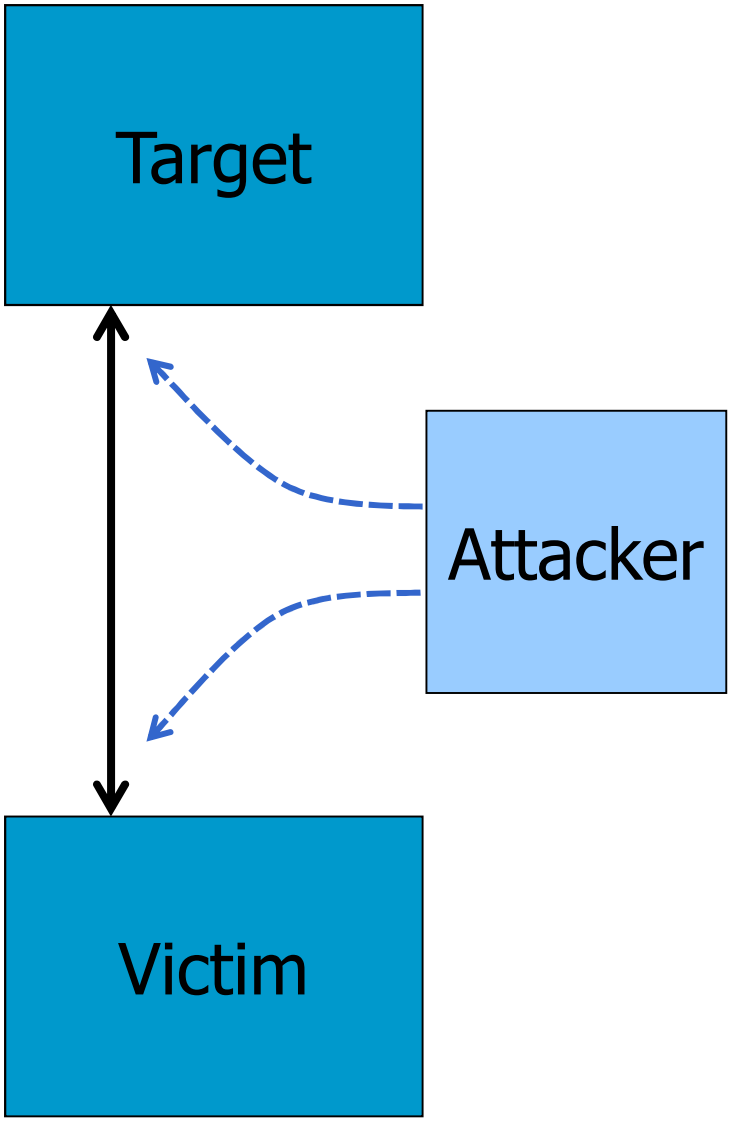

- Victim, target trusted authenticated connection
  - Packets will have predictable sequence numbers
- Attacker impersonates victim to target
  - Opens connection to target to get initial seq number
  - Fills victim's receive queue
  - Sends packets to target that resemble victim's transmission
  - Attacker cannot receive, but may execute commands on target

Attack Stage 3 – Session Hijack

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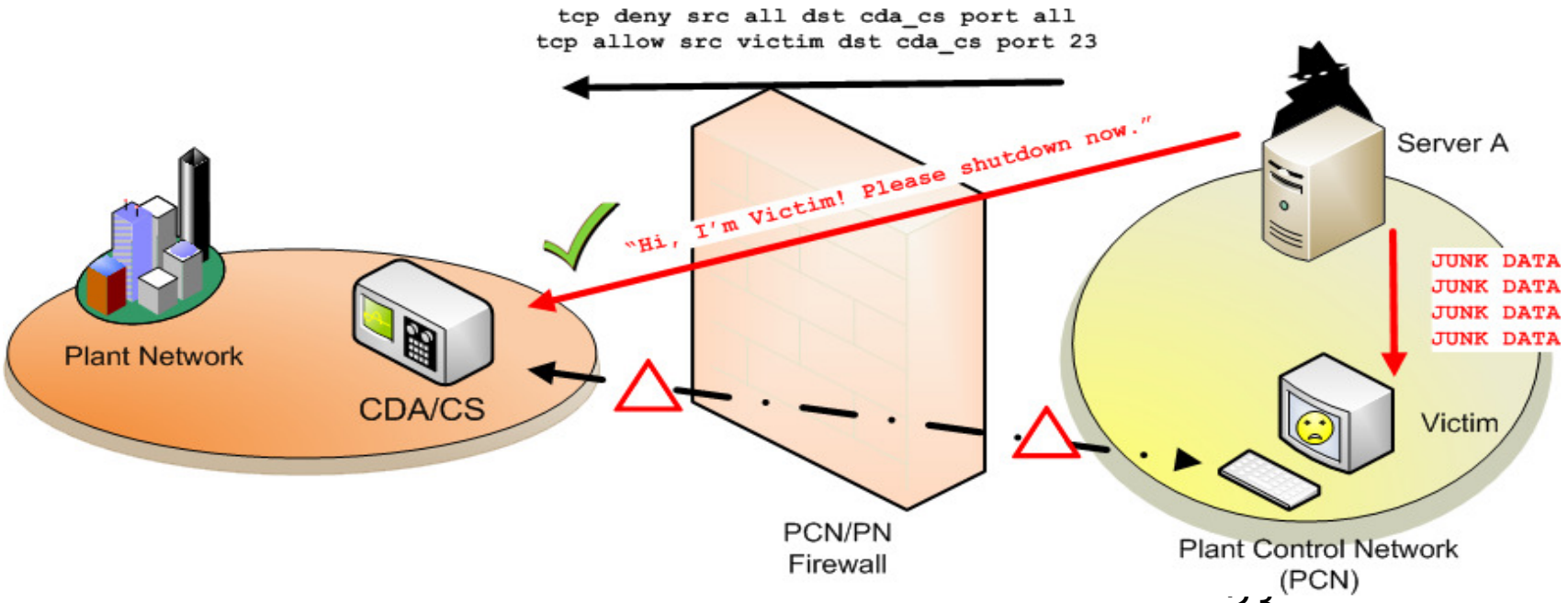
- Attacker listens to unencrypted session
- Attacker uses probes to determine sequence numbers
- Attacker sends spoofed identity packets to ICS while performing Denial of Service on Victim
- Attacker sends shutdown command to ICS



How Easy are These Attacks?

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- Numerous RAT/trojan toolkits available on underground market
  - Push-button ease of use
  - Exploits as a Service (EaaS) becoming viable business model1,2
- Buffer overflow attack methodologies have been well-known and well-documented for many years
  - "Smashing the Stack for Fun and Profit" by AlephOne, *Phrack* magazine,1996
- Session hijacking is one of the oldest attack methods on the Internet
  - Kevin Mitnick "man-in-the-middle" attack, 1994

1. Grier, Ballard, Caballero, et. al. (2012). Manufacturing Compromise: The Emergence of Exploit-as-a-Service. 19th ACM Conference on Computer and Communications Security. Retrieved from http://cseweb.ucsd.edu/~voelker/pubs/eaas-ccs12.pdf
2. Asprey, D. (2011). New type of cloud emerges: Exploits as a Service (EaaS). TrendMicro Security. Retrieved from http://cloud.trendmicro.com/new-type-of-cloud-emerges-exploits-as-a-service-eaas/

How Easy are These Attacks?

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- Free, easily available hacking tools and toolkits can perform some or all firewall bypass attack types:
  - -Metaploit Framework
  - -Cain and Abel
  - -Firesheep
  - -LOIC
  - -Evader
  - -Backtrack Live CD
  - -Nmap
  - -Ettercap

Firewall Limitations

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- Firewall technology is not one way (non-deterministic, not application-fluent)
- Firewalls can be bypassed in many ways
- Firewalls have their own vulnerabilities
- Effective Security Programs must do the following:
  - -Prevent
  - -Detect
  - -Delay
  - -Deny
  - -Deter
  - -Respond
  - -Recover
- Firewalls cannot do all of these things alone