CIS 375
CHAPTER 1

Network Security

Outline

- Importance of Network Security
- Security Goals
- Network Controls
- Risk Assessment
- Ensuring Business Continuity
- Intrusion Prevention
- Best Practice Recommendations
- Implications for Management / Cyber Security

Importance of Network Security

- Security has always been a major business concern
- Computers and the Internet have redefined the nature of information security
- Average value of organizational data and applications far exceeds cost of networks
- Losses associated with security failures can be large
  - Financial loss due to theft and from system downtime
  - Loss of consumer confidence
  - Fines

Introduction

- Internet has completely redefined the nature of information security

HIPAA
Health Insurance Portability & Accountability Act

CERT APWG McAfee KASPERSKY lab Symantec.

- Reasons for an increase in computer security

Security Threats and Controls

threats

Preventing unauthorized access

controls

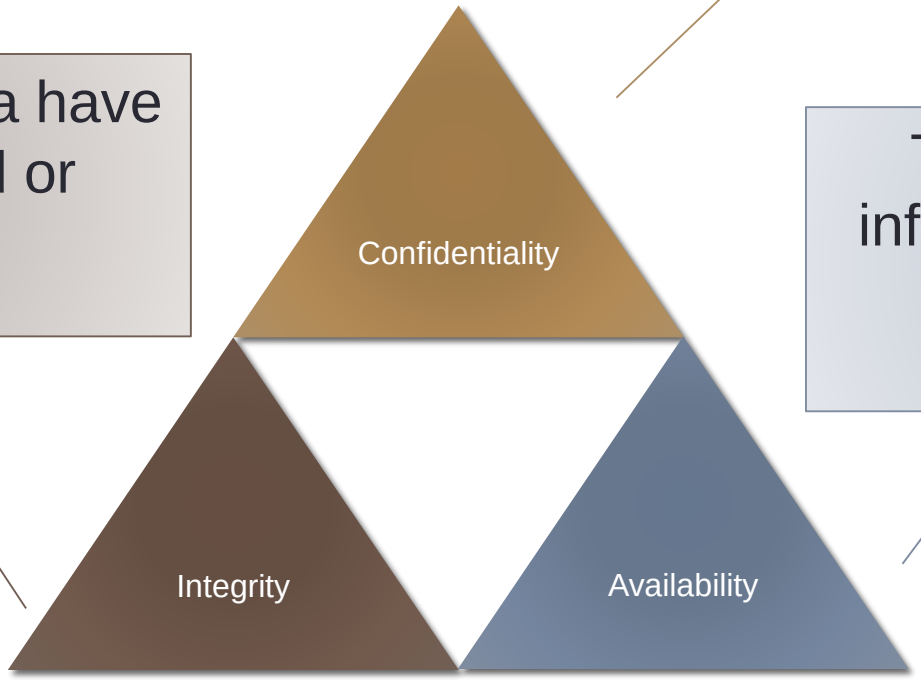
- Preventive controls
- Detective controls
- Corrective controls

Security Goals

- CIA triad

Protection of organizational data from unauthorized disclosure

Assurance that data have not been altered or destroyed



The degree to which information and systems are accessible to authorized users

Security Threats

- Threats to Business Continuity
  - Disruptions – A loss or reduction in network service
  - Destruction of data
  - Disasters
- Threat of Unauthorized Access (Intrusion)
  - External attackers exist, but most unauthorized access incidents involve employees

Network Controls

- **Network controls** are safeguards that reduce or eliminate threats to network security
- **Preventative controls**
  - Mitigate or stop a person from acting or an event from occurring
  - Act as a deterrent by discouraging or restraining
- **Detective controls**
  - Reveal or discover unwanted events (e.g., auditing)
  - Documenting events for potential evidence
- **Corrective controls**
  - Remedy an unwanted event or intrusion

Risk Assessment

- A key step in developing a secure network
- Assigns level of risks to various threats
- Risk assessment frameworks
  - Operationally Critical Threat, Asset, and Vulnerability Evaluation (OCTAVE)
  - Control Objectives for Information and Related Technology (COBIT)
  - Risk Management Guide for Information Technology Systems (NIST guide)

Risk Assessment

- Risk Assessment Steps

1. Develop risk measurement criteria
2. Inventory IT assets
3. Identify threats
4. Document existing controls
5. Identify improvements

Risk Assessment

1. Develop risk measurement criteria
   - The measures used to examine how threats impact the organization
   - Prioritize and evaluate each measure

Impact Area	Priority	Low Impact	Medium Impact	High Impact
Financial	High	Sales drop by less than 2%	Sales drop 2-10%	Sales drop by more than 10%
Productivity	Medium	Increase in operating expenses by less than 3%	Increase in operating expenses between 3-6%	Increase in operating expenses by more than 6%
Reputation	High	Decrease in number of customers by less than 2%	Decrease in number of customers by 2-15%	Decrease in number of customers by more than 15%
Legal	Medium	Incurring fines or fees less than $10,000	Incurring fines or fees between $10,000 and $60,000	Incurring fines or fees exceeding $60,000

Risk Assessment

2. Inventory IT assets
   - Mission-critical applications and data are the most important
   - Document and evaluate why each asset is important to the organization

Asset Type	Examples
Hardware	• Servers (e.g., mail, web, and file servers) • Client computers (e.g., desktops, laptops, tablets, phones, etc.) • Networking devices (e.g., switches and routers)
Circuits	• LANs, Backbone networks, WANs, Internet access circuits
Software	• Operating systems (servers, clients, and networking devices) • Application software ○ Some applications may be mission-critical and warrant special attention
Organizational data	• Databases

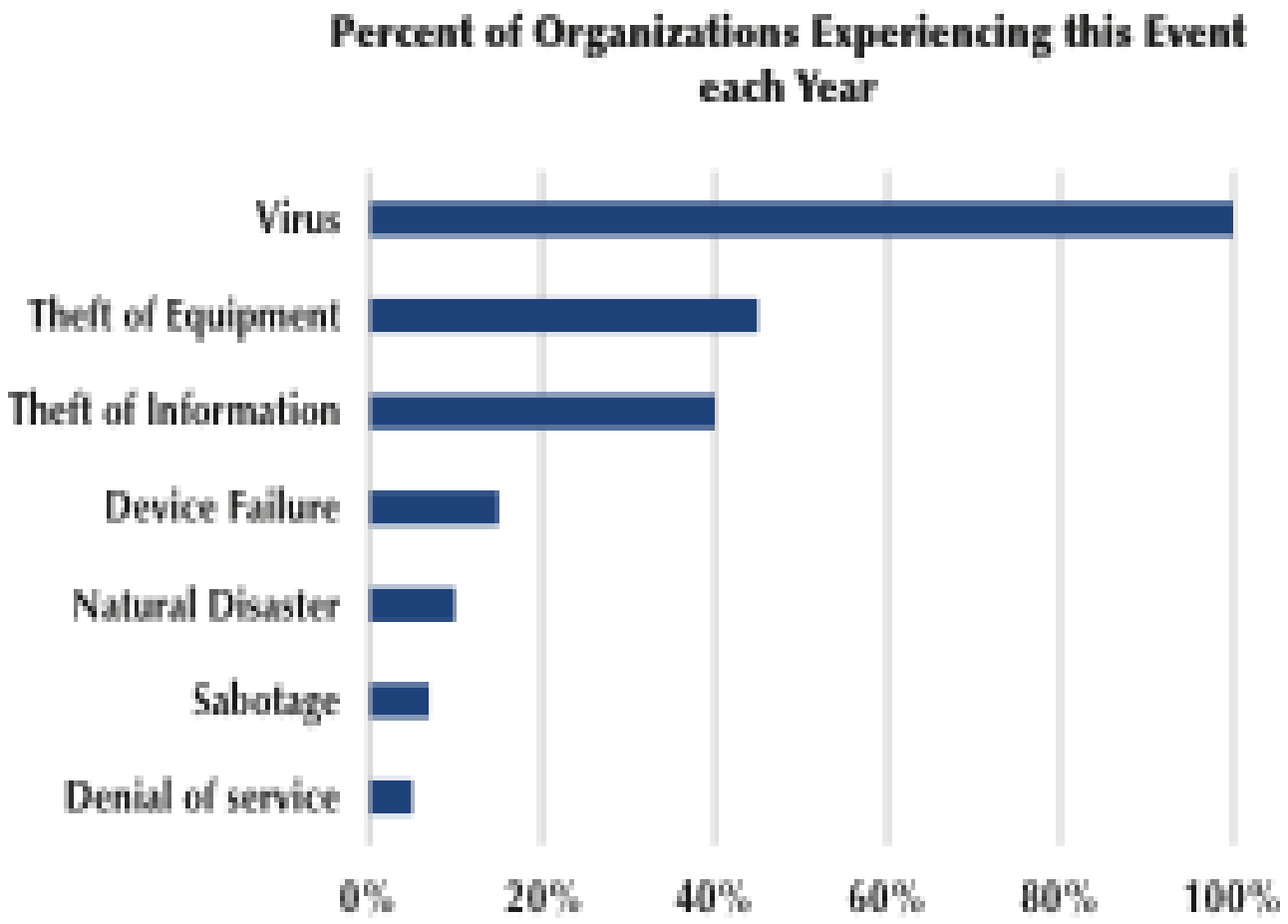
Risk Assessment

3. Identify threats
   - Any potential occurrence that can do harm, interrupt the systems using the network, or cause a monetary loss to the organization
   - Create **threat scenarios** that describe how an asset can be compromised by a threat
     - Likelihood of occurrence
     - Potential consequences of threat
     - **Risk Scores** can be used to quantify the impact and likelihood of occurrence

Risk Assessment

3. Identify threats

FIGURE 11-5
Likelihood of a threat



Risk Assessment

4. Document existing controls
   - Identify controls and determine how they will be used in the **risk control strategy**
   - Risk acceptance
     - Organizations may choose to take no actions for risks that have low impacts
   - Risk mitigation
     - Use of control to remove or reduce impact of threat
   - Risk sharing
     - Transferring all or part of impact (e.g., insurance)
   - Risk deferring
     - For non-imminent risks

Risk Assessment

5. Identify improvements
   - It is infeasible to mitigate all risks
   - Evaluate adequacy of the controls and degree of risk associated with each threat
   - Establish priorities for dealing with threats to network security

Ensuring Business Continuity

- Making certain that organization's data and applications will continue to operate even in the face of disruption, destruction, or disaster
  - Virus Protection
  - Denial of Service Protection
  - Theft Protection
  - Device Failure Protection
  - Disaster Protection

Ensuring Business Continuity

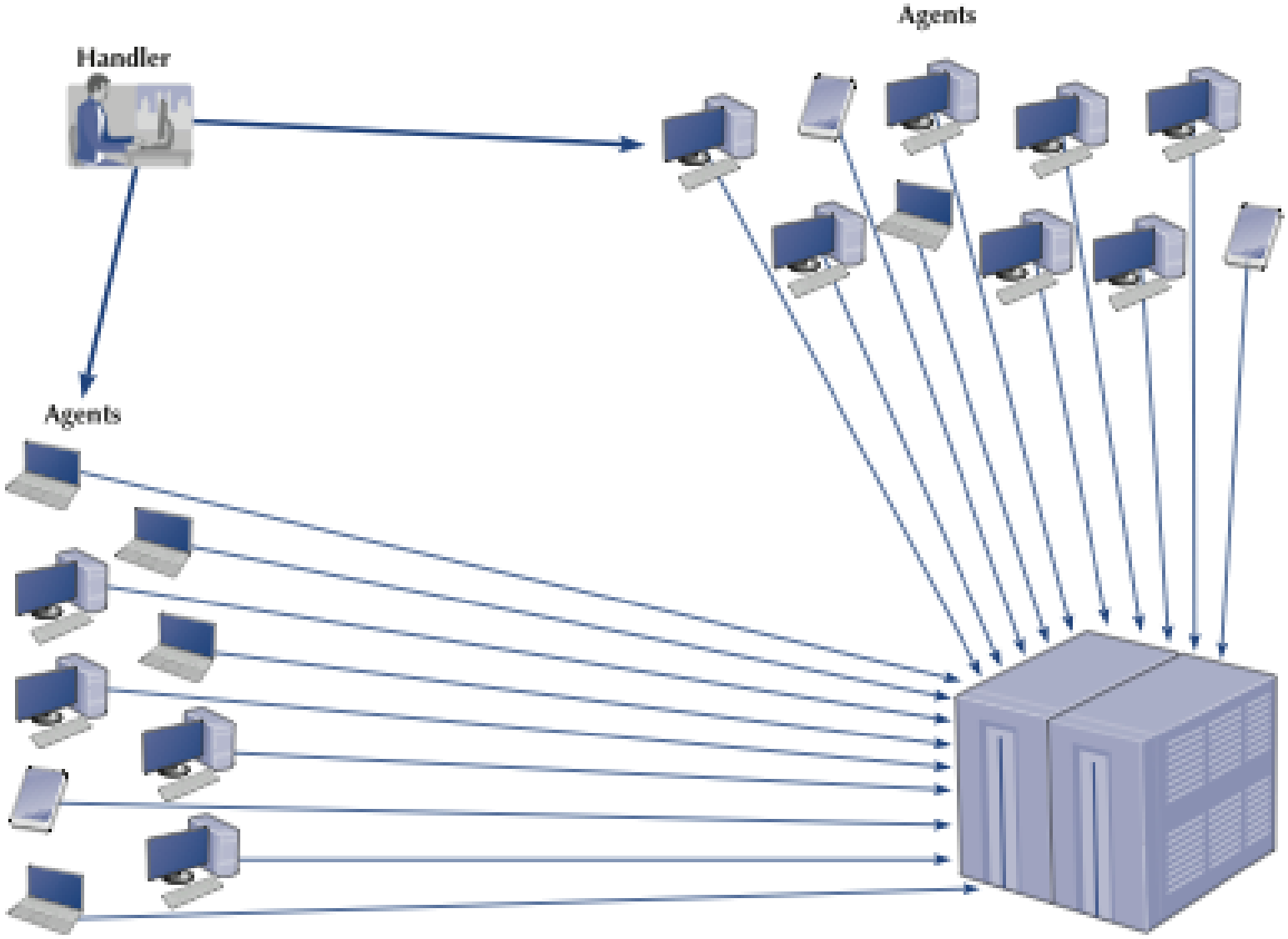
- Virus Protection
  - Nearly all organizations experience computer viruses
  - Widespread infection is less common
  - Viruses, worms, and Trojan horses
  - Malware, spyware, adware, and rootkits
  - Threat mitigated using antivirus software and training

Ensuring Business Continuity

- Denial of Service Protection
  - **Denial of Service (DoS) attacks** flood a network with messages that prevent normal access
    - A **Distributed DoS (DDoS)** attack uses multiple devices to perform the attack
    - DDoS attacks are often performed using a network of compromised devices (called agents, bots, or zombies)

Ensuring Business Continuity

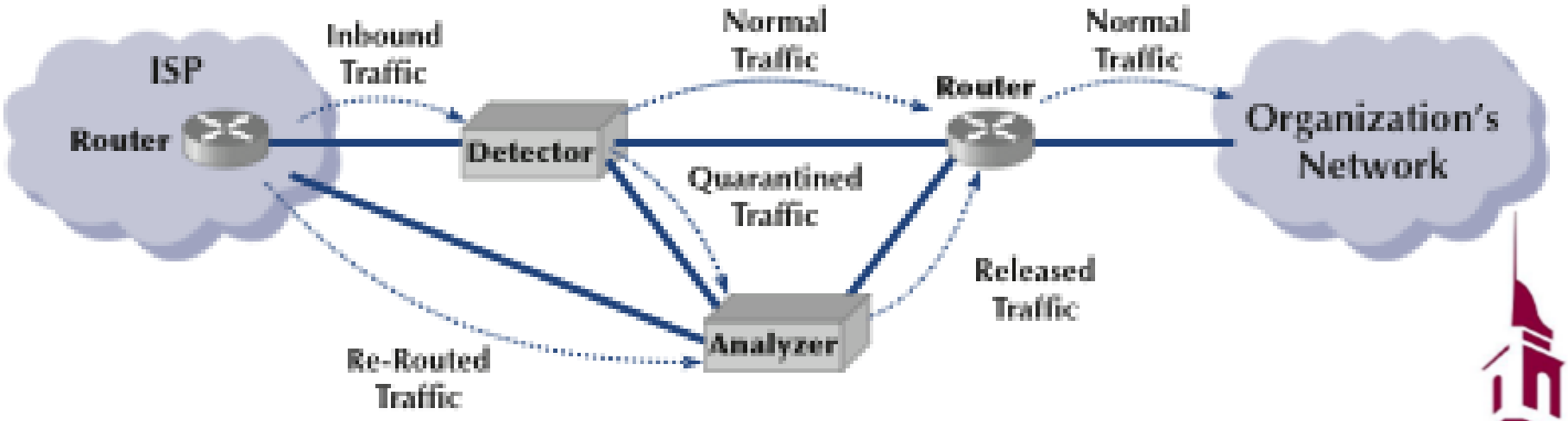
FIGURE 11-8 A distributed denial-of-service attack



Ensuring Business Continuity

- Denial of Service Protection
  - Traffic filtering
  - Traffic limiting
  - Traffic analysis
    - Using traffic anomaly analyzer

FIGURE 11-9 Traffic analysis reduces the impact of denial of service attacks



Ensuring Business Continuity

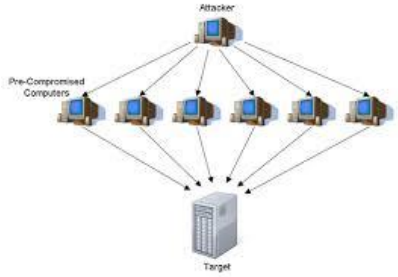
- Theft Protection
  - Mitigated using physical security and training
- Device Failure Protection
  - All devices fail eventually
  - Methods of reducing failures or their impacts
    - Redundancy in devices and circuits
      - e.g., redundant array of independent disks (RAID)
    - Uninterruptible power supplies (UPS)
    - Failover server clusters (or high-availability clusters)

Ensuring Business Continuity

- Disaster Protection
  - Avoidance
    - e.g., storing data in multiple locations and avoiding locations prone to natural disasters
  - Disaster Recovery
    - Organizations should have a clear **disaster recovery plan (DRP)**
      - Identify responses to different types of disasters
      - Provide recovery of data, applications and network
      - Specify the backup and recovery controls
    - Some organizations outsource to **disaster recovery firms**

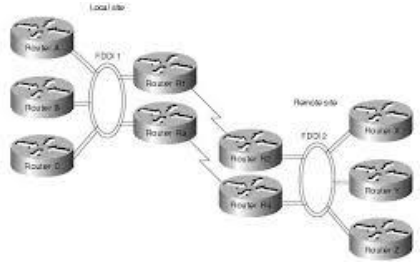
Ensuring Business Continuity

Virus Protection



Denial of Service Attack Protection

Theft Protection



Device Failure Protection

Disaster Protection

Intrusion Prevention

- Security Policy
- Physical Security
- Types of intruders
  - “Script kiddies” – novices using software created by others
  - Recreational hackers motivated by philosophy or entertainment
  - Professional hackers performing espionage or fraud
  - Organizational employees

Intrusion Prevention

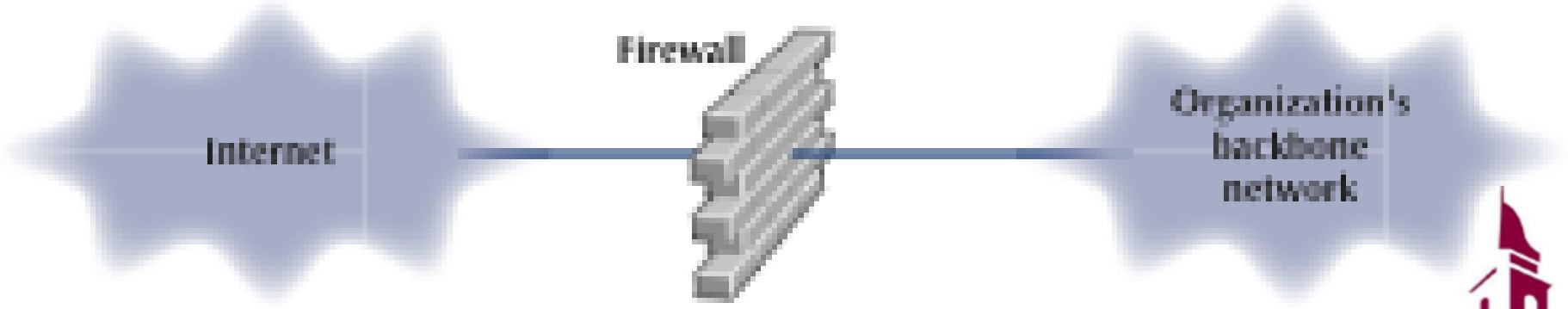
1. Casual intruder
2. Hacker
3. Professional hacker
4. Malicious insider

1. **Security Policy** – acceptable use policy, user training, annual risk assessment, reporting incidents (spam@ou.edu, security@ou.edu)
2. **Perimeter Security and Firewalls**
3. **Server and Client Protection** – security holes, update patches, zero-day attacks, spyware, adware, Trojan
4. **Encryption**
5. **User Authentication**
6. **Preventing Social Engineering** – mock phishing attacks, user training
7. **Intrusion Prevention Systems**
8. **Intrusion Recovery** – have a plan

Intrusion Prevention

- **Firewalls** restrict access to the network
- **Packet-level firewalls**
  - Examine the source/destination address of every packet
  - Using access control list (ACL) rules, decides which packets are allowed or denied

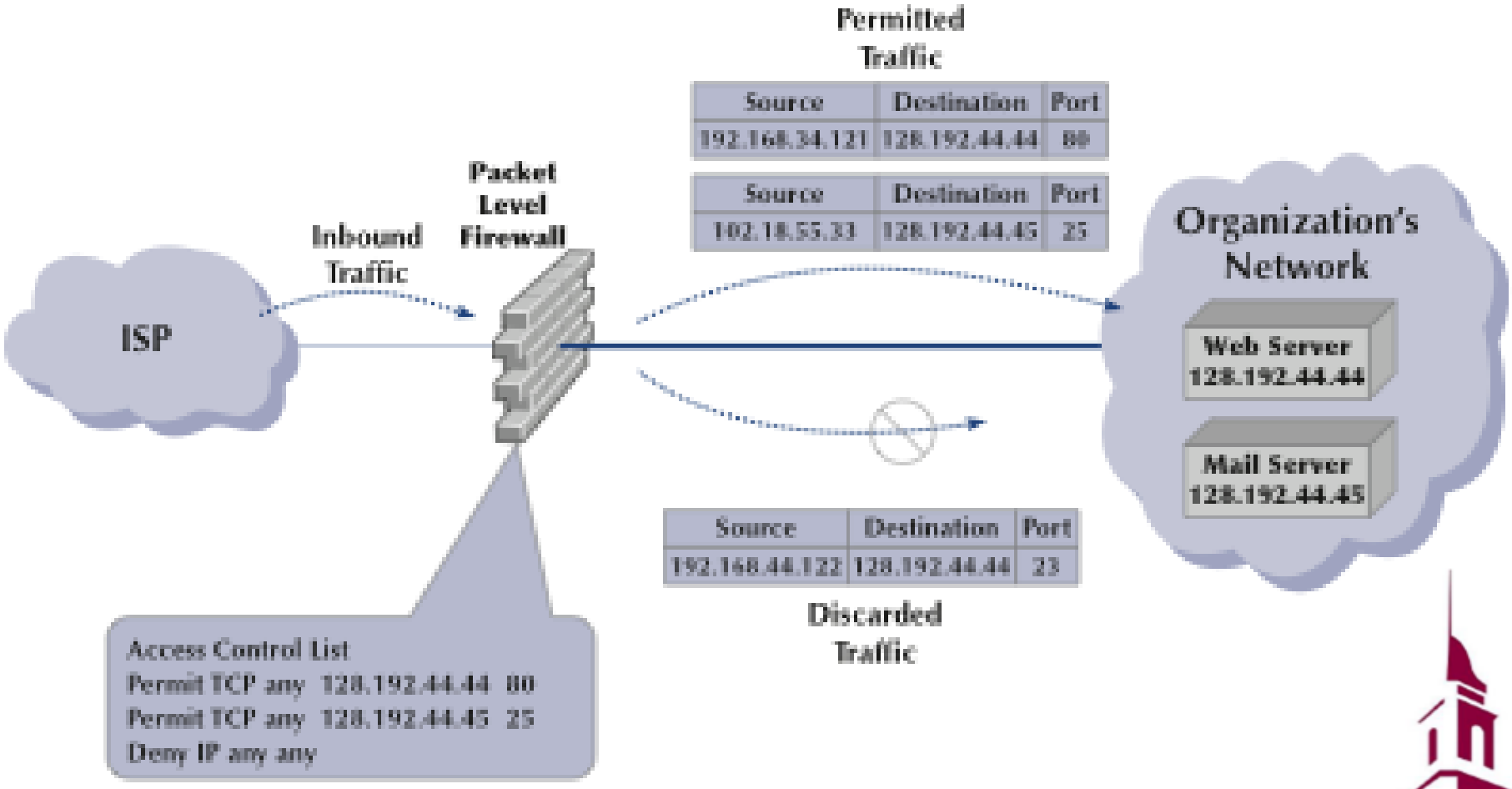
FIGURE 11-12
Using a firewall to protect networks



Intrusion Prevention

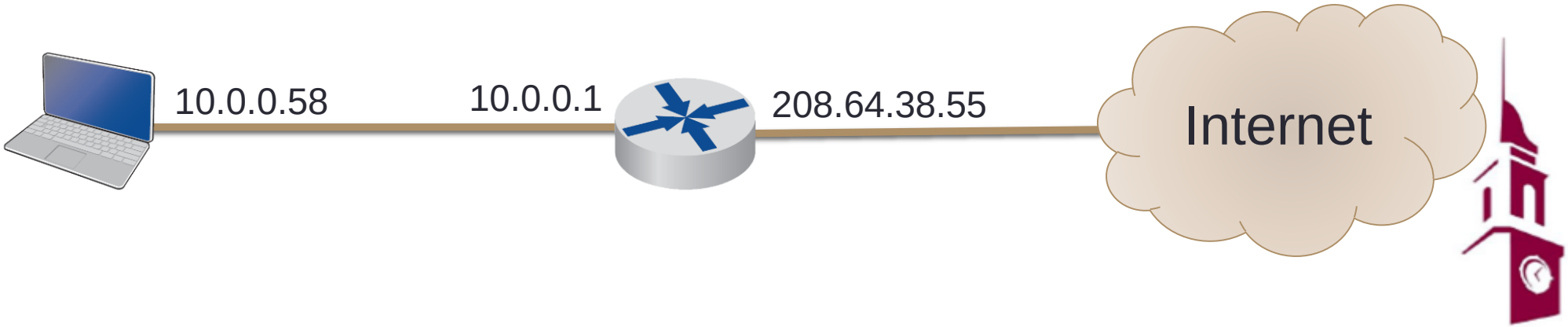
- Packet-level firewall

FIGURE 11-13 How packet-level firewalls work



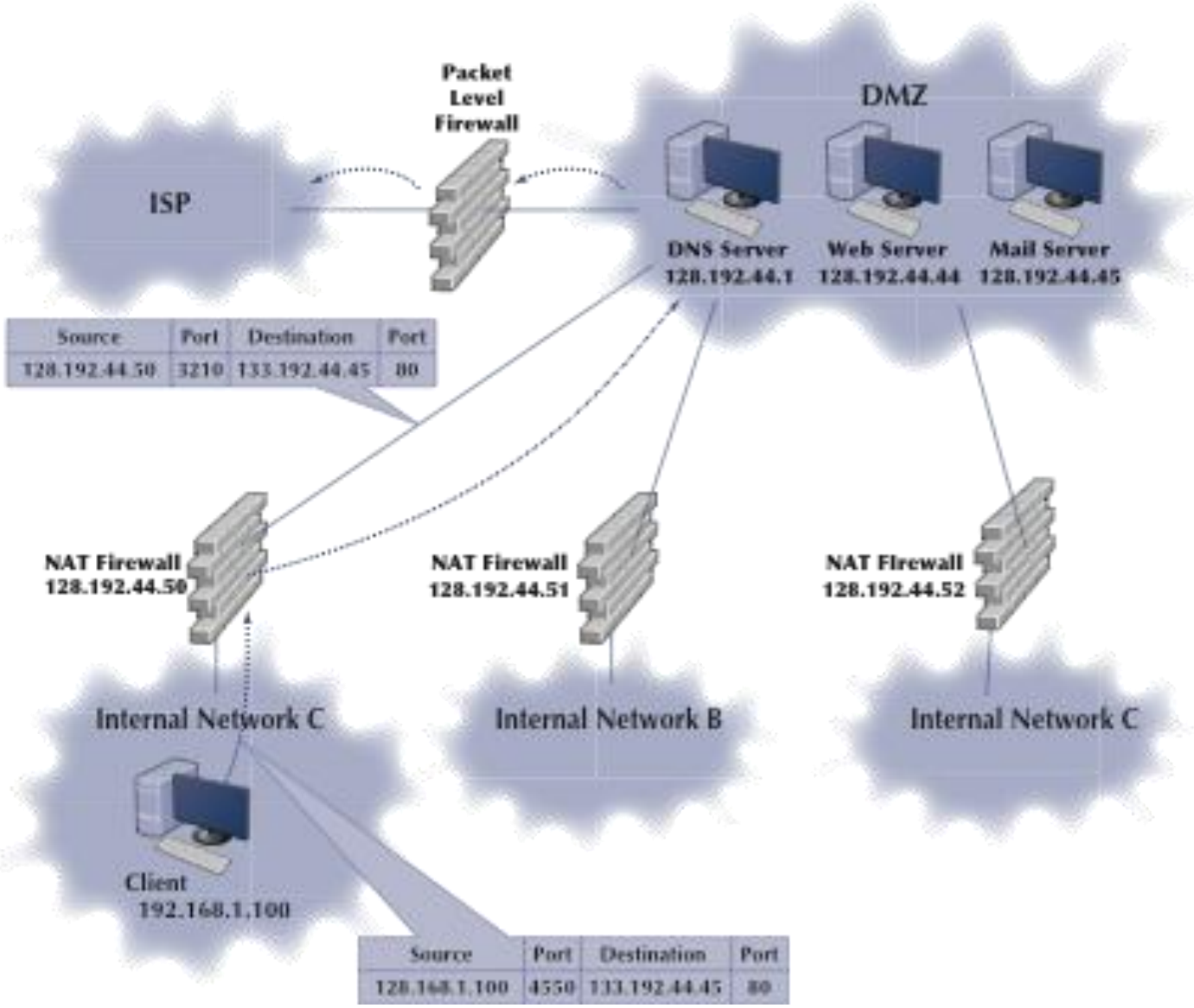
Intrusion Prevention

- **Application-level firewalls**
  - Use stateful inspection to examine traffic at layer 5 for anomalous behavior
- **Network address translation (NAT)**
  - Converts one IP address to another
  - Often from a publicly routable address to a private address



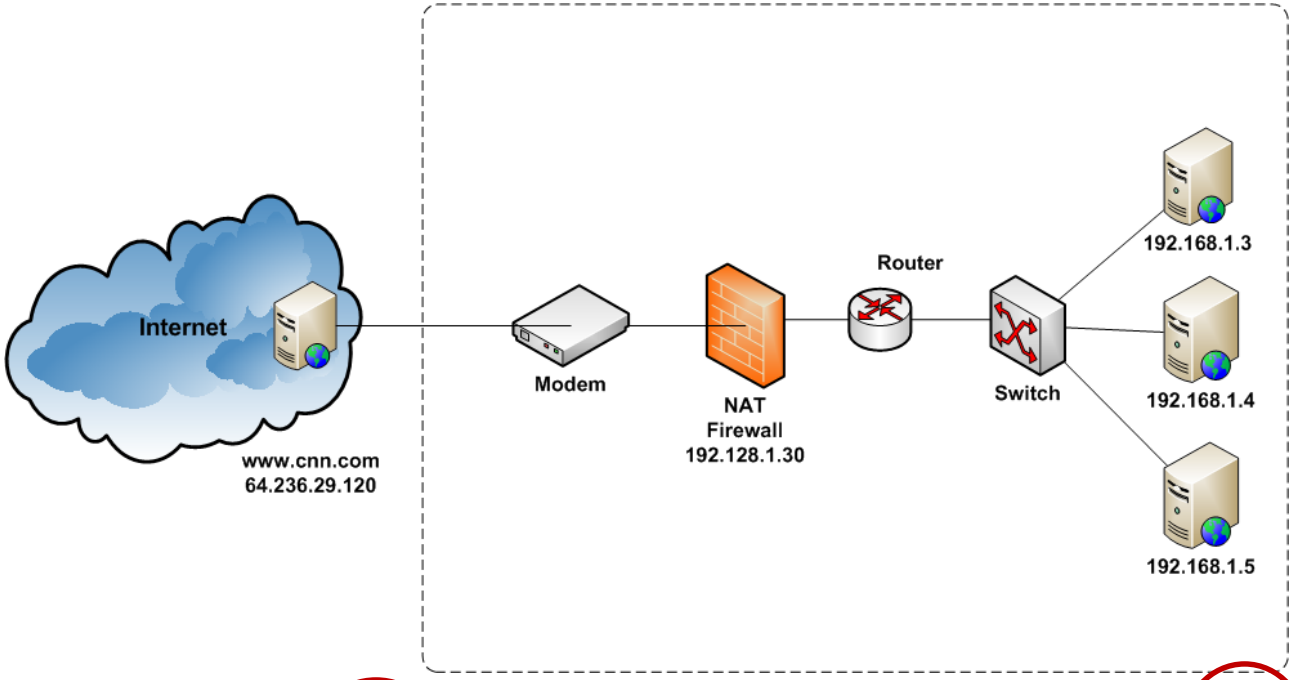
Intrusion Prevention

FIGURE 11-14 A typical network design using firewalls



NAT Firewall

Class A 10.0.0.0 – 10.255.255.255
Class B 172.16.0.0 – 172.31.0.0
Class C 192.168.0.0 – 192.168.255.255



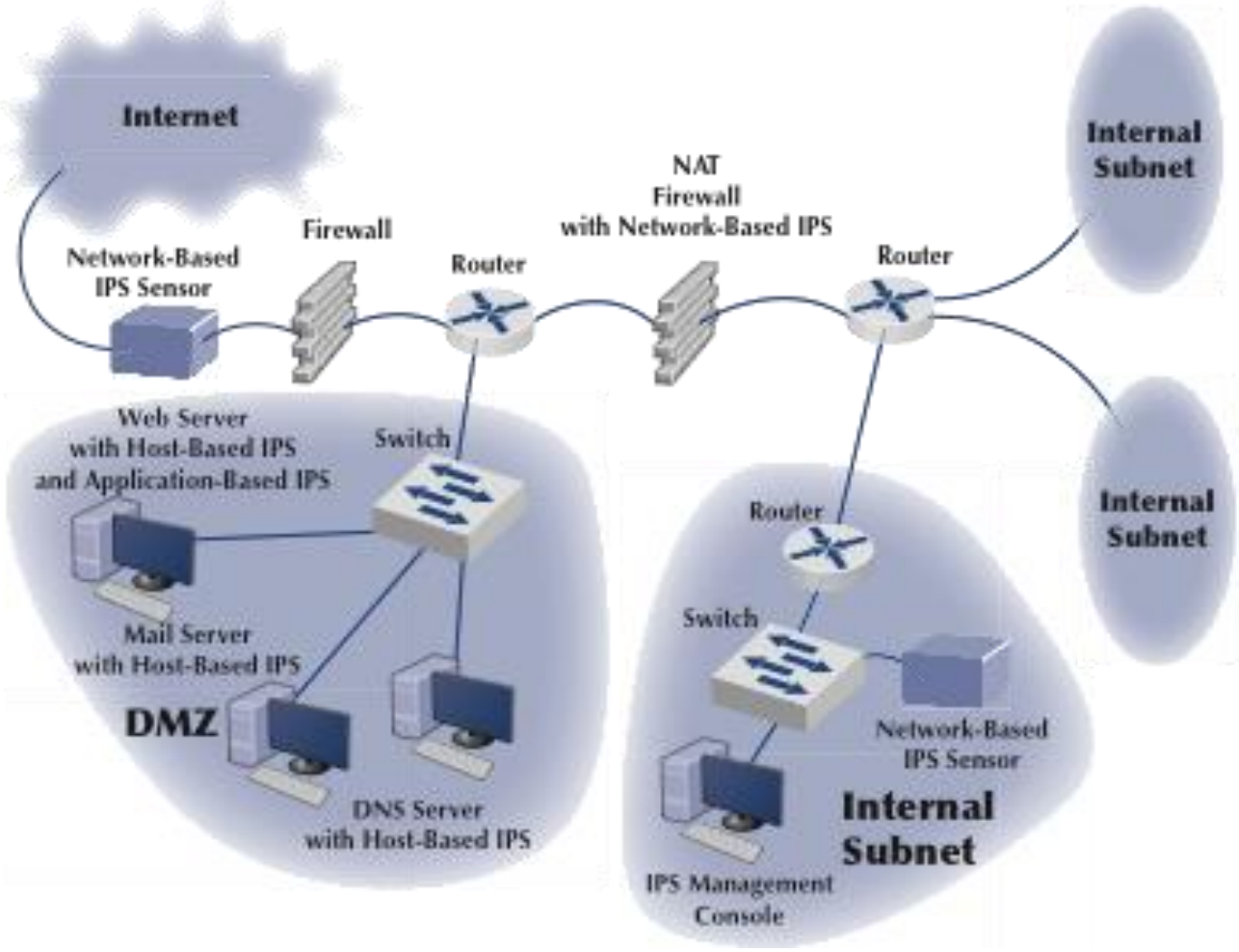
DIP	D Port	SIP	S Port
64.236.29.120	80	192.128.1.30	100

DIP	D Port	SIP	S Port
64.236.29.120	80	192.128.1.3	3472

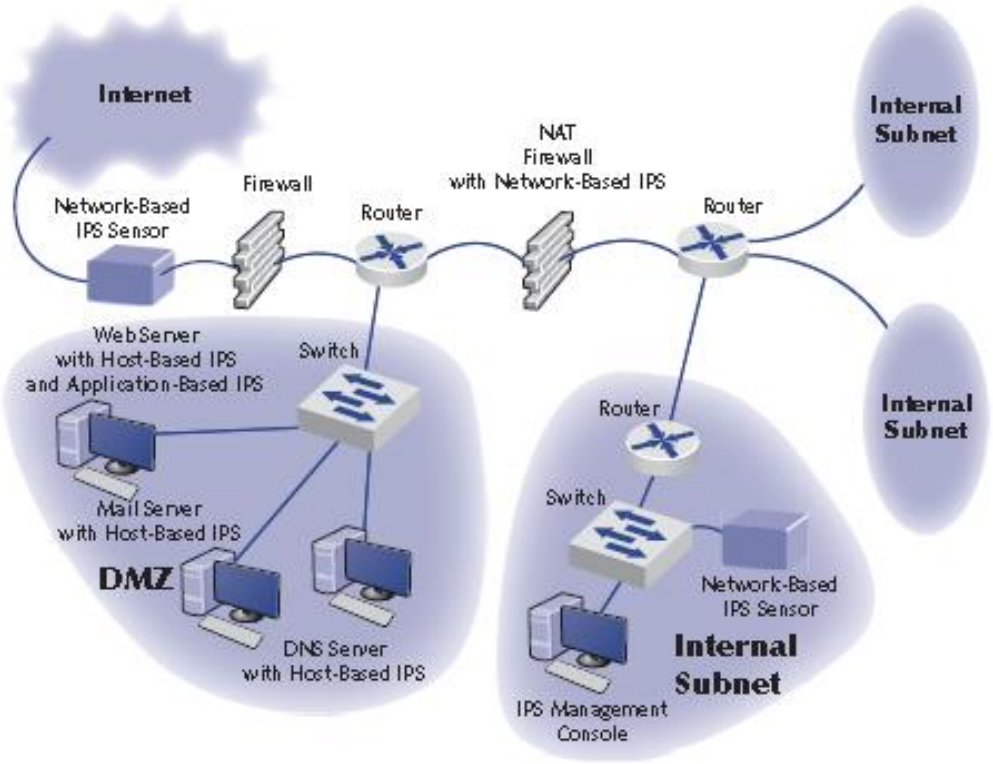
SIP should be 192.168.1.3

Intrusion Prevention

FIGURE 11-18 Intrusion prevention system (IPS)
DMZ = demilitarized zone; DNS = Domain Name Service; NAT = network address translation



Layered Architecture



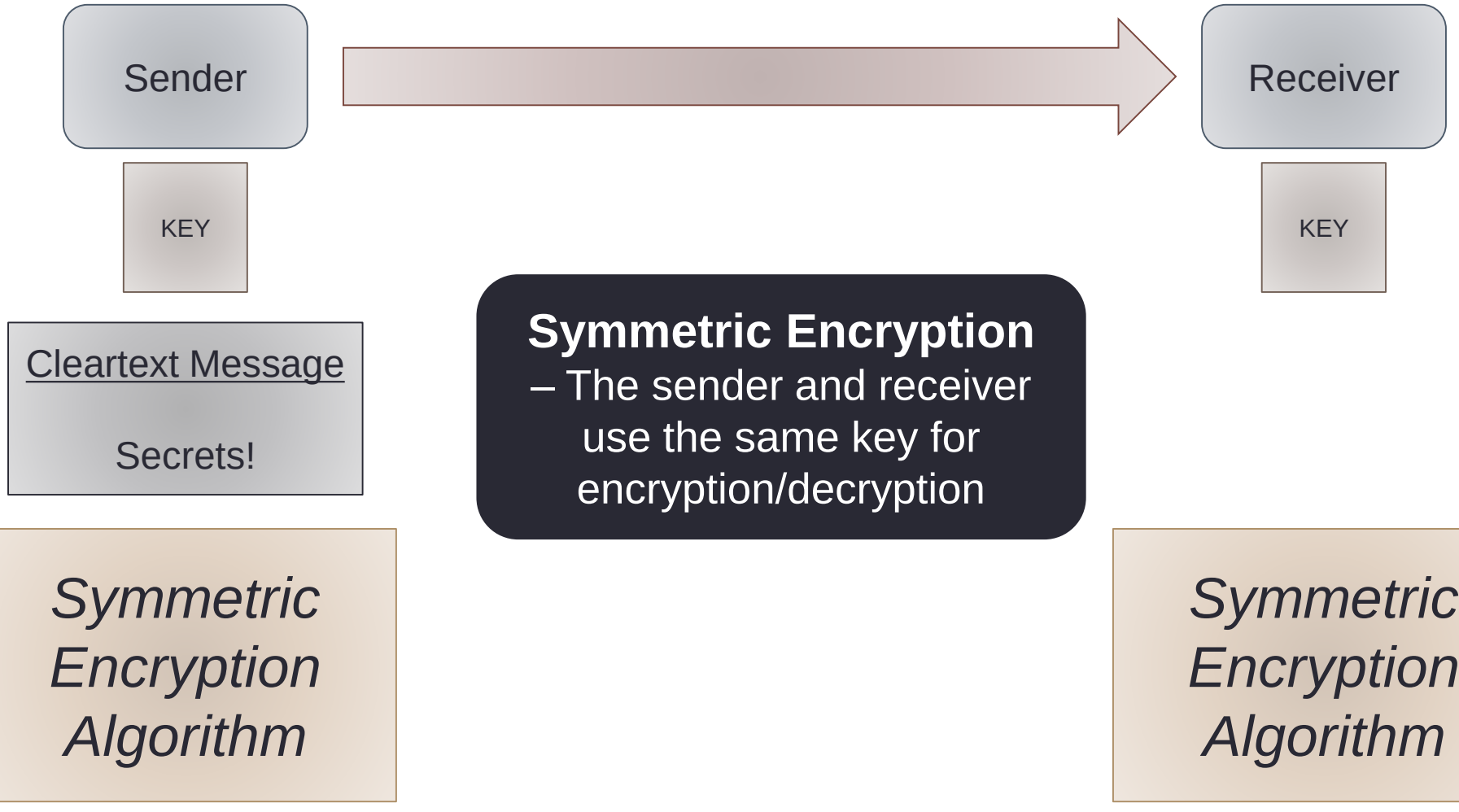
Intrusion Prevention

- **Encryption** is disguising information using mathematical rules, providing confidentiality
- The strength of the encryption is based on
  - The strength of the algorithm
  - The strength of the key
- Often the algorithm is widely known
- A **brute-force attack** on encryption means to try every possible key

Intrusion Prevention

- **Symmetric encryption**
  - Uses a single key for encrypting and decrypting
  - Challenge in sharing key
  - Used for bulk encryption because the algorithms are usually fast
  - Stream Ciphers
    - Encrypt one bit at a time
    - e.g., RC4
  - Block Ciphers
    - Encrypt a group of bits at a time
    - e.g., advanced encryption standard (AES)

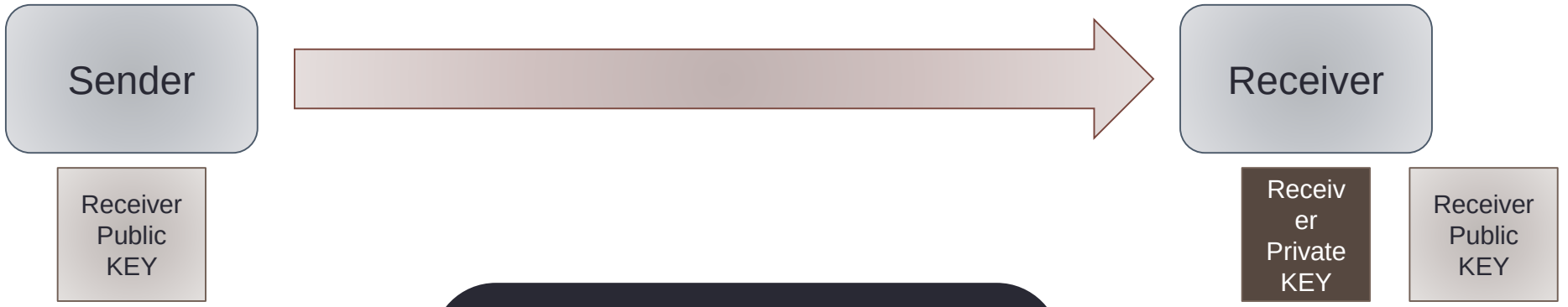
Intrusion Prevention



Intrusion Prevention

- **Asymmetric (public-key) encryption**
  - A pair of keys are used
  - One key is designated the public key and can be freely shared
  - The other key is designated the secret private key
  - When a message is encrypted using one key, it can only be decrypted with the other
  - Based on mathematical calculations that are easy in one direction but difficult in reverse
  - e.g., RSA

Intrusion Prevention



Cleartext Message

Secrets!

Asymmetric Encryption – The sender uses the public key of the receiver to encrypt the message and then the receiver uses its private key to decrypt

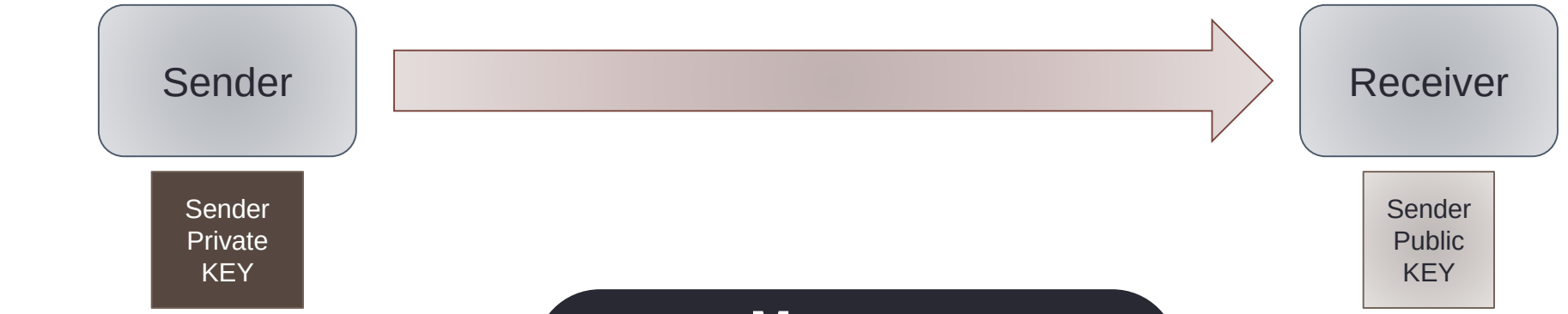
Asymmetric Encryption Algorithm

Asymmetric Encryption Algorithm

Intrusion Prevention

- **Asymmetric (public-key encryption)**
  - The **public key infrastructure (PKI)** is a set of hardware, software, organizations, and policies to associate a set of keys with an individual or organization
  - **Certificate authorities (CAs)** are trusted organizations that issue **digital certificates** proving that an individual or organization owns a public key
  - Digital certificates can be used to authenticate messages

Intrusion Prevention



Cleartext Message

Secrets!

Message Authentication – The sender uses its private key encrypt the message and then the receiver uses the sender's public key to decrypt

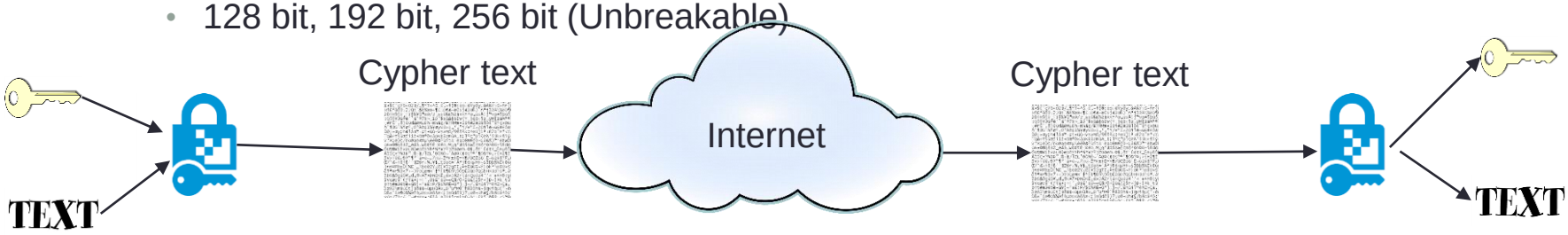
Asymmetric Encryption Algorithm

Asymmetric Encryption Algorithm

Encryption

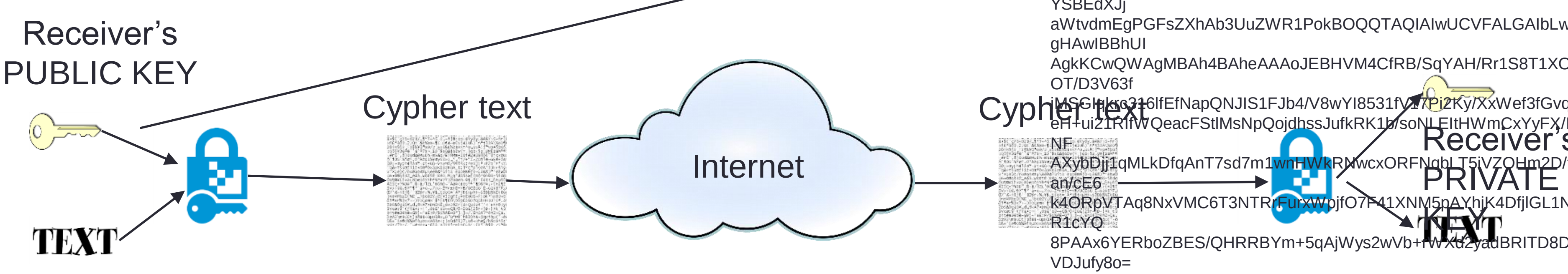
- **Single key**
  - DES 56 bit key 7 characters
    - Breakable by Brute force method
  - Triple DES (3x DES) 3x 7 characters
    - 3x 56 bit (Unbreakable)
  - AES 16 characters, 24 characters, 32 characters
    - 128 bit, 192 bit, 256 bit (Unbreakable)

Key management is a problem



Encryption (cont.)

- **Dual key**
  - 2 keys (1 public encryption, 1 private decryption)
  - 256, 512, 1024 bits



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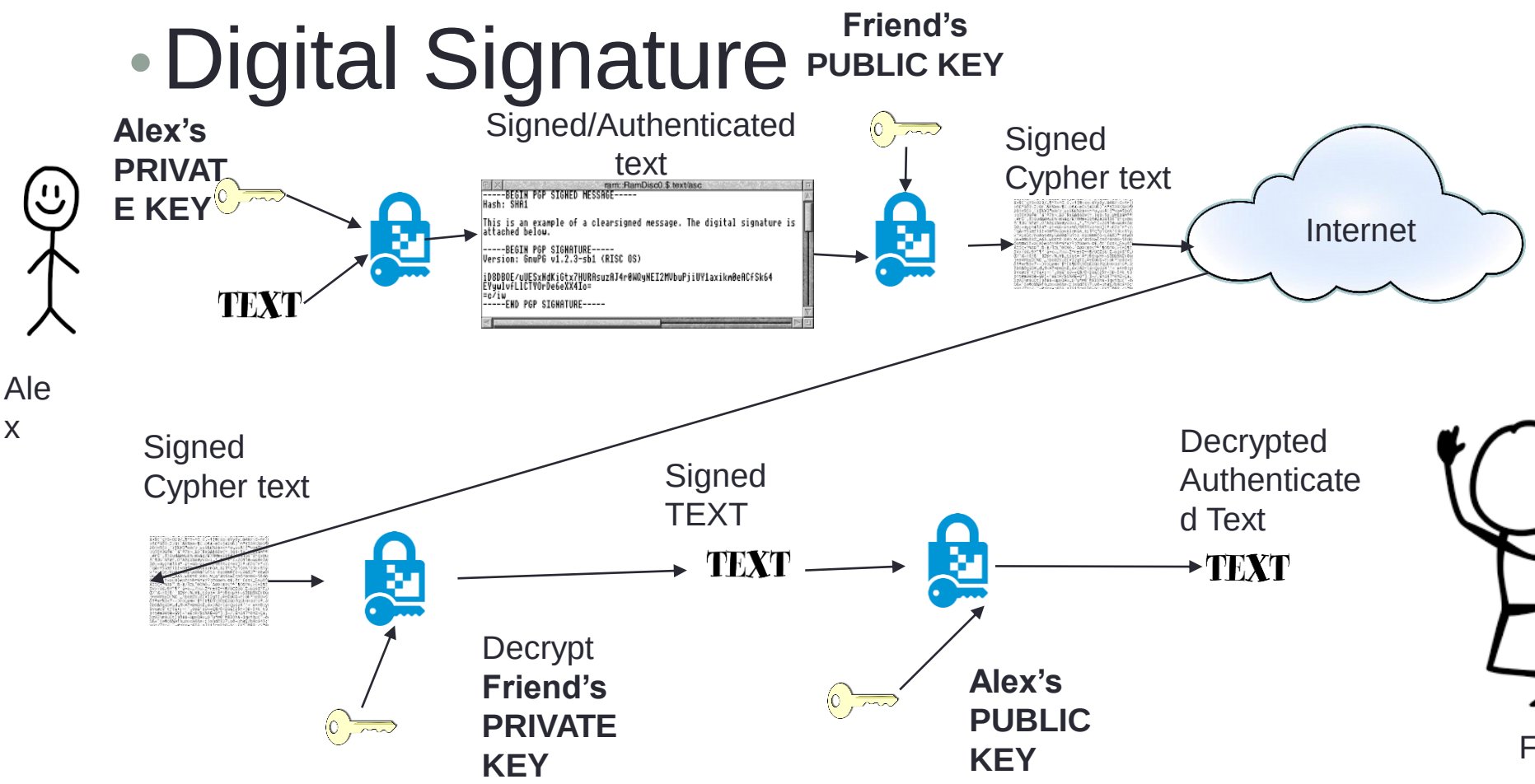
=Y6Fk
-----END PGP PUBLIC KEY BLOCK-----

Digital Signature



Intrusion Prevention

- Applications of encryption
  - **Pretty good privacy (PGP)** is used for encrypting email and some files
  - **Transport layer security (TLS)** succeeds **secure sockets layer (SSL)** as the primary encryption protocol on the Internet
  - **IP security protocol (IPSec)** is a network layer encryption protocol

Intrusion Prevention

- User authentication
  - **User profiles** are used to manage access to resources
  - Types of authentication
    - Something you know
      - e.g., passwords, passphrases, and pin numbers
    - Something you have
      - e.g., access cards, smart cards, tokens, phones
    - Something you are
      - Biometrics like fingerprints, handprints, retina
  - Using multiple types of authentication provides increased security (multi-factor authentication)
  - Most organizations moving to centralized authentication

User Authentication

- **Level 1 –**

g you

Level 2 – Something you have

Access Card
Token/One time password

Level 3 – Something you are

Biometrics

Single Sign On

Central Authentication – RADIUS, PAP, CHAP, EAP, KERBEROS

Social Engineering - Phishing

Recovery

- Public statements
- Correct security plan
- Collect evidence for court
  - Forensic computing

Recommended Practices

- Clear disaster recovery plan
- Strong security policy
  - Rigorously enforced
  - User training
- Use of security controls
- Content filtering

Implications for Management

- Fastest growing area of networking
- Cost of security expected to increase
  - More sophisticated controls
  - More sophisticated attacks
- Network becoming mission critical

Best Practice Recommendations

- Security policy
- Disaster recovery plan
- Encryption – stored data & moving data
- Content filtering
- Security attacks are here to stay