Firewalls and intrusion detection systems

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Lecture topics

- Firewalls
- Security model with firewalls
- Intrusion detection systems
- Intrusion prevention systems
- How to prevent and detect attacks

What is a firewall

- Divides network into two (or more) parts with *different security policy*
  - internal network ⇔ Internet
  - engineering ⇔ accounting: the other network must not be less secure that the other one. They just have different security policies or different assets to protect.
  - internal network ⇔ public servers ⇔ Internet
  - building automation ⇔ VoIP ⇔ surveillance system
- Enforces security policy
  - allowed traffic
  - prohibited traffic

  Refer to IPsec security policy database (SPD): traffic is bypassed, discarded, or bypassed as protected.
- May have additional roles, such as VPN endpoint

Firewall types

Packet-filtering makes decision based only packet fields

- router ACL (access control list)
- TCP implicit state: for example to disallow incoming connections, firewall will drop any packet that has SYN flag set but no ACK and allows any packet with SYN+ACK.
- difficult with UDP, also some other TCP-based protocols such as FTP in active mode, where server establishes connection to client.

Stateful keeps track on connections

- maintains connection state
  - single point of failure
  - has to have some timeout mechanism as the state space is limited. Some attacks may exhaust state space.
    ⇒ random disconnections

- possible to accept related connections: for some protocols this needs application gateway.

Application gateway interpret connection on application level

- checks if application traffic is valid
- protects from simple port changes
- may provide payload inspection to detect malicious payload
- proxy servers
  - call-out
  - in-line (transparent)

Address-translation between internal numbering and external addresses

- using NAPT provides same as prohibiting incoming TCP
- internal topology can be hidden

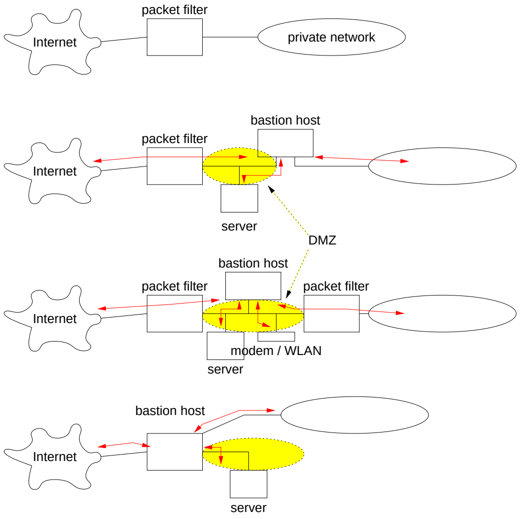
Host-based or software firewalls add on application security

- completes application security and access control
- possibly user- and application-level control

Hybrid use combination of different types for performance

- check start of connection with application gateway, switch to stateful filtering ⇒ better performance as bulk of traffic is handled by fast path.

Firewall topologies



Building firewall rules

- Defining default policy
  - "everything not prohibited is allowed"
    - ∗ "router" ACL
    - ∗ enumerate vulnerable services and protect them
  - "everything not allowed is prohibited"
    - ∗ enumerate needed and safe services and allow them
  - both policies need continuous updating
- There should be one rule for one packet
  - multiple overlapping rules

  - order of rules matters
  - performance issues: hardware-based routers/firewalls can handle certain number of rules without significant performance penalty. For software-based firewalls order of rules does matter.
- Possibility to oversight
- High-level languages not solution

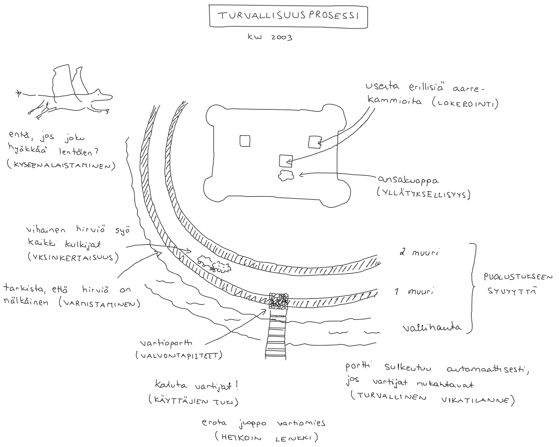
Deploying multiple firewalls

- Helps to limit the impact of attack
- Protection by diversity
  - on other hand, multiple systems to update
- Designing rules even more complicated

What firewall protects and what not

- Protects
  - from known, vulnerable protocols
  - static network configuration
- Does *not* protect for / from
  - executable/active content
  - malicious insider
  - loopholes: modems, WLAN, mobile networks
  - carry-in attacks such as notebooks, mass storage
  - new attacks
  - most DoS attacks
- May result "hard perimeter, mellow inside"
  - failure to update internal systems
  - selecting insecure protocols and applications

Security in organisation


TURVALLISUUS PROSESSI
KW 2003
entä, jos joku hyökkää lentäen? (KYSEENALAISTAMINEN)
useita erillisiä aarre-kammioita (LOKEROINTI)
ansakuoppa (YLLÄTYKSELLISYYS)
vihainen hirviö syö kaikki kulkijat (YKSINKERTAISUUS)
tarkista, että hirviö on nälkäinen (VARMISTAMINEN)
2. muuri
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vallihauta
PUOLUSTUKSEEN SYVYYTTÄ
vartioportti (VALVONTAPISTEET)
portti sulkeutuu automaattisesti, jos vartijat nukahtavat (TURVALLINEN VIKATILANNE)
Koulutа vartijat! (KÄYTTÄJIEN TUKI)
erota juoppo vartiomies (HEIKOIN LENKKI)

How secure are firewalls

- Common Vulnerabilities and Exposures: 110 matches on “firewall”

  Check Point FireWall-1 34 entries

  Cisco 13 entries

  Juniper 1 entry

  Linux 6

  Symantec 17

  WatchGuard 11 entries

- More features (VPN, virus checks, QoS protection)
  ⇒ more code
  ⇒ more bugs
  ⇒ more vulnerabilities

Intrusion Detection Systems

- How to make sure that firewall is not leaking
- How to detect internal attacks
- IDS is designed to
  - detect,
  - identify, and
  - report malicious activity
- IDS can be located different places
  - application
  - host
  - network

Application and host IDS

- Application instrumented to identify abnormal actions
  - high level of abstraction
  - user actions monitored
  - policy violations
  - application log analysis
  - access to encrypted data
  - may not protect application flaws
- Host instrumented
  - reference monitor
  - actions by user and application
  - host log analysis
- Log analysis best on separate host
  - provides after-the-fact analysis
  - vulnerable to network attacks

Network IDS

- Monitors traffic
  - best done with signal splitters
- Large volume of data
  - low level of abstraction
  - encrypted traffic problematic
- Mostly misuse detection
  - recorded patterns of misuse (signatures)
  - frequent updates (like virus scanners)

```
alert tcp $EXTERNAL_NET any -> $HOME_NET 22
 ( msg:"EXPLOIT ssh CRC32 overflow /bin/sh";
   flow:to_server,established;
   content:"/bin/sh";  )
```

- Anomaly detection
  - detecting differences to normal
    - ∗ threshold detection
    - ∗ statistical profile
    - ∗ rule-based detection
  - learning system
- Large number of alerts
  - 3700 alerts from corporate network per day
  - 48 should be studied in detail
  - 2 warrant an action

IDS in large network

- One should monitor every link
  ⇒ very expensive
- Select important links
  - full census on those
- Do random sampling on other links
  - if one samples every 512th packet
    ⇒ not a big increase in traffic
  - large problems notified immediately

Honeypots

- A false system similar to production system
  - all access illegal
    ⇒ any accessing is potential intruder
- Used as part of IDS
  - a connection results monitoring
- How to keep attacker from telling difference from real system
  - should be not too weak
  - should have "real" data and traffic
  - if virtual host, should not be visible

IDS reaction too slow

- IDS identifies attack
  - analysis may not be real-time
  - corrective actions may take time
- Epidemic security problem may be instant [4]
- System can be scanned, attacked, and compromised in a minute or less
  ⇒ Need for automation

Intrusion Prevention Systems (IPS)

- IDS with automatic response
- Suffers from large number of false alerts
- A firewall with automatic ACL update
- Virus scanners are host-based IPS
- Still at early stages
  - does not stop vendors from marketing…

Traffic traceback

- Problem: where incoming attack traffic originates
- Source IP cannot be trusted
  - sender can put it to any address
  - ingress filtering not deployed universally
- Should not need additional hardware or load on routers
- Scalability problems, few proposals [1, 2, 3]

Security in Ad-hoc networks

- Ad-hoc networks interesting topic
  - self-building topology
  - extending network coverage
- Must rely on other hosts
  - no central authority, block lists
  - no trusted core network
  - routing done by devices
- Public key-based per-packet authentication too heavy
  - modern PC throughput few ten kbit/s
- How to communicate trustfulness?

Challenges in All-IP world

- Large number of non-technical users
  - the "`--:--`" generation
  - rightful ignorance: I want to watch movies — fixing security problems does not match to my idea of relaxing.
- Service provider responsibility
- Multi-vendor environment

Summary

- Firewall and IDS are good tools
- Must know their limitations
- Future challenges
  - accurate detection of malicious activity
  - security in ubiquitous computing
  - trust in autonomous systems

Easter holiday 2005-03-29, no lecture

References

[1] Stefan Savage, David Wetherall, Anna Karlin, and Tom Anderson. Practical network support for IP traceback. In *Proceedings of the 2000 ACM SIGCOMM Conference*, August 2000. An early version of the paper appeared as techreport UW-CSE-00-02-01 available at: `http://www.cs.washington.edu/homes/savage/traceback.html`.

[2] Alex C. Snoeren, Craig Partridge, Luis A. Sanchez, Christine E. Jones, Fabrice Tchakountio, Stephen T. Kent, and W. Timothy Strayer. Hash-Based IP traceback. In Roch Guerin, editor, *Proceedings of the ACM SIGCOMM 2001 Conference (SIGCOMM-01)*, volume 31, 4 of *Computer Communication Review*, pages 3–14, New York, August 27–31 2001. ACM Press.

[3] Alex C. Snoeren, Craig Partridge, Luis A. Sanchez, Christine E. Jones, Fabrice Tchakountio, Beverly Schwartz, Stephen T. Kent, and W. Timothy Strayer. Single-packet ip traceback. *IEEE/ACM Trans. Netw.*, 10(6):721–734, 2002.

[4] Stuart Staniford, Vern Paxson, and Nicholas Weaver. How to 0wn the internet in your spare time. In *Proceedings of the 11th USENIX Security Symposium (Security '02).* To be appear. URL:`http://www.cs.berkeley.edu/~nweaver/cdc.web/`.