# Instructions 1

## Elevation of Privilege Instructions

Draw a diagram of the system you want to threat model before you deal the cards.

Deal the deck to 3–6 players. Play starts with the 3 of Tampering. Play clockwise, and each player in turn continues using the suit if they have a card in that suit. If the player doesn't have a card from that suit, the player can use another suit. Each round is won by the highest card played in the suit that was led, unless an Elevation of Privilege (EoP) card is played. In that case the high value EoP card wins.

To play a card, read the card, announce your threat and record it. If the player can't link the threat to the system, play proceeds.

The winner of a hand selects the card (and suit) to lead the next hand. Take a few minutes between hands to think about threats.

**Points:**
1 for a threat on your card, +1 for taking the trick

Instructions

# Elevation of Privilege Instructions

Threats should be articulated clearly, testable, and addressable. In the event that a threat leads to an argument, you can resolve it by asking the question: "Would we take an actionable bug, feature request or design change for that?" If the answer is yes, it is a real threat. (This doesn't mean that threats outside of that aren't real, it's simply a way to focus discussion on actionable threats.)  Questions that start with "There's a way" should be read as "There's a way...and here's how... "while questions that start with "Your code" should be read "The code we're collectively creating...and here's how."

The deck contains a number of special cards: trumps and open threats. EoP cards are trumps: They take the trick even if they have a lower value than the suit that was led. The ace of each suit is an open threat card. When played, the player must identify a threat not listed on another card.

When all the cards have been played, whoever has the most points wins.

Remember to have fun!

Instructions

# Instructions 2

## Elevation of Privilege Variants

**Optional variants:**

- You may pass cards after the third trick. This is helpful if you have cards that you can't tie to the system. Someone else may be able to.
- Double the number of points, and give one point for threats on other people's cards.
- Other players may "riff" on the threat and if they do, they get one point per additional threat.
- Limit riffing to no more than 60 seconds.
- Mark up the diagram where the threat occurs.

**Questions are listed on the threat cards to help with the aces.**

Thanks to Laurie Williams for inspiration.

Instructions

## Contents:

- **2** Instruction cards
- **1** Strategy Diagram card
- **6** STRIDE Threat cards 'suits':
  1. Spoofing:  2-K, Ace
  2. Tampering:  3-K, Ace
  3. Repudiation: 2-K, Ace
  4. Information Disclosure: 2-K, Ace
  5. Denial of Service: 2-K, Ace
  6. Elevation of Privilege:  5-K, Ace (Trump cards)
- **6** STRIDE Threat Reference cards
- **1** About Threat Modeling and SDL card



# Instructions

## Context

Share the rules

↓

Deal the deck to start play

↓

Play

↓

Wrap up

## Play

Whoever has 3 of Tampering starts

**Whoever has 3 of Tampering:**

Play card

↓

Document issue

↓

Have all players played in this hand?

**If no:**
Play proceeds to next (clockwise) player

**If yes:**
Play starts with winner of the just-ended hand

(Taking 3 minutes to consider cards may improve flow)

Strategy: see reverse

**yes**

Record hand

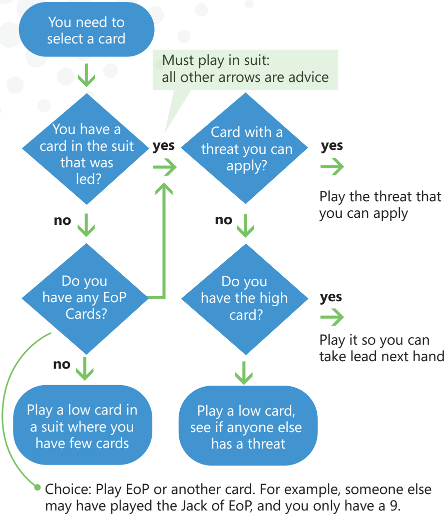
↓

Is there time for another hand?

↓

Wrap up

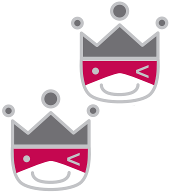
# Strategy


You need to select a card
Must play in suit: all other arrows are advice
You have a card in the suit that was led?
yes
Card with a threat you can apply?
yes
Play the threat that you can apply
no
no
Do you have any EoP Cards?
Do you have the high card?
yes
Play it so you can take lead next hand
no
Play a low card in a suit where you have few cards
Play a low card, see if anyone else has a threat
Choice: Play EoP or another card. For example, someone else may have played the Jack of EoP, and you only have a 9.

2

# Spoofing

An attacker could squat on the random port or socket that the server normally uses.



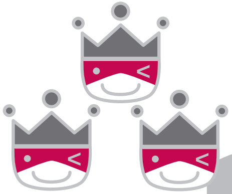
2

Microsoft

# elevation of privilege

# 3 Spoofing

An attacker could try one credential after another and there's nothing to slow them down (online or offline).



3

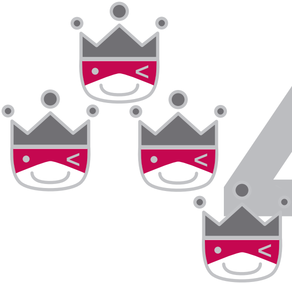
Microsoft

# elevation of privilege

4

# Spoofing

An attacker can anonymously connect, because we expect authentication to be done at a higher level.



4

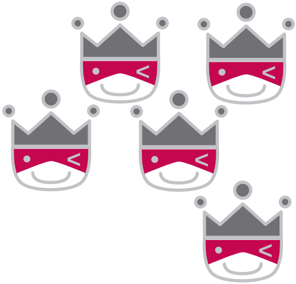
Microsoft

# elevation of privilege

5

# Spoofing

An attacker can confuse a client because there are too many ways to identify a server.



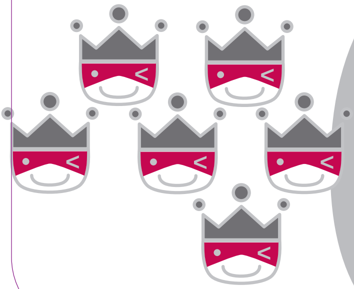
Microsoft

# elevation of privilege

6

# Spoofing

An attacker can spoof a server because identifiers aren't stored on the client and checked for consistency on re-connection (that is, there's no key persistence).



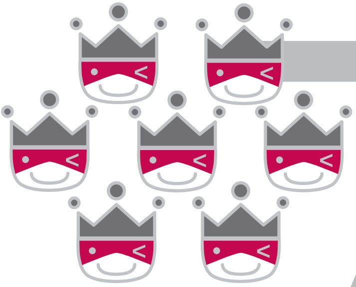
Microsoft

# elevation of privilege

7

# Spoofing

An attacker can connect to a server or peer over a link that isn't authenticated (and encrypted).



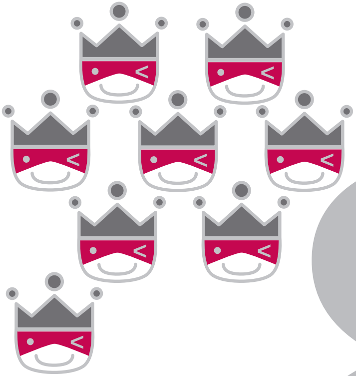
Microsoft

# elevation of privilege

**8**

# Spoofing

An attacker could steal credentials stored on the server and reuse them (for example, a key is stored in a world readable file).



8

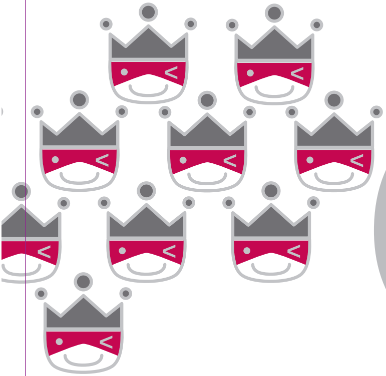
Microsoft

# elevation of privilege

**9**

# Spoofing

An attacker who gets a password can reuse it (use stronger authenticators).

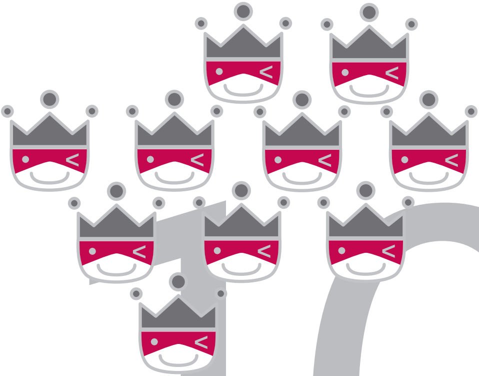


Microsoft

# elevation of privilege

# 10 Spoofing

An attacker can choose to use weaker or no authentication.



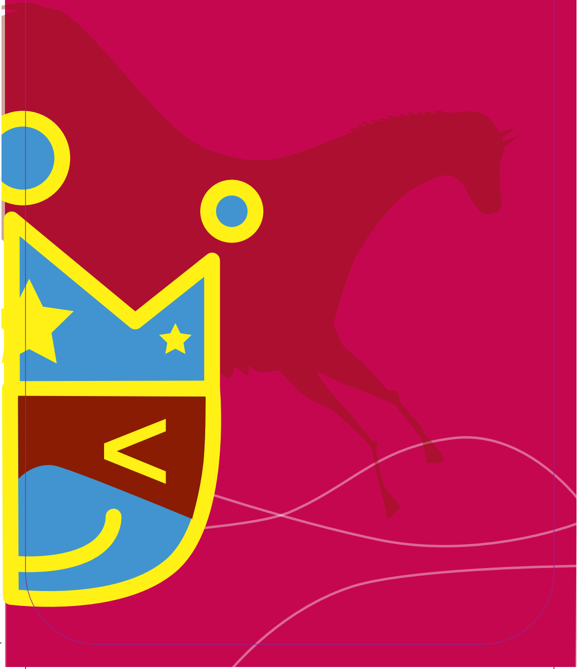
Microsoft

# elevation of privilege

J

# Spoofing

An attacker could steal credentials stored on the client and reuse them.



Microsoft

# elevation of privilege

**Q**

# Spoofing

An attacker could go after the way credentials are updated or recovered (account recovery doesn’t require disclosing the old password).

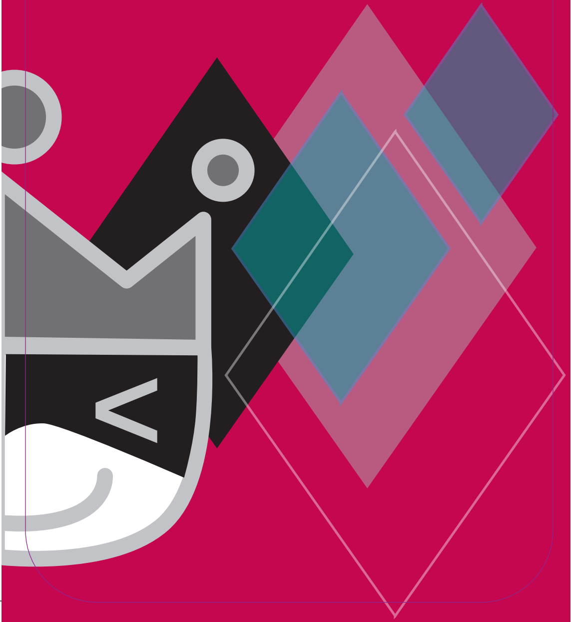
Microsoft

# elevation of privilege

K

# Spoofing

Your system ships with a default admin password and doesn't force a change.



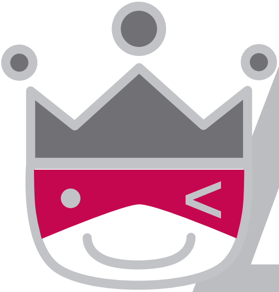
Microsoft

elevation of privilege

**A**

# Spoofing

You've invented a new Spoofing attack.

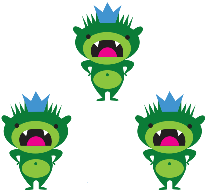


Microsoft

# elevation of privilege

# 3 Tampering

An attacker can take advantage of your custom key exchange or integrity control which you built instead of using standard crypto.



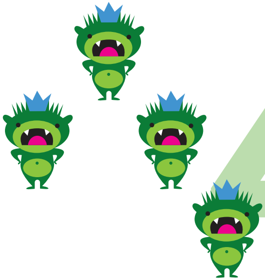
Microsoft

# elevation of privilege

4

# Tampering

Your code makes access control decisions all over the place, rather than with a security kernel.



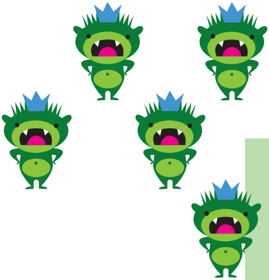
Microsoft

# elevation of privilege

5

# Tampering

An attacker can replay data without detection because your code doesn't provide timestamps or sequence numbers.



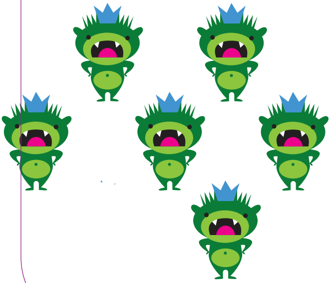
Microsoft

# elevation of privilege

6

# Tampering

An attacker can write to a data store your code relies on.



6

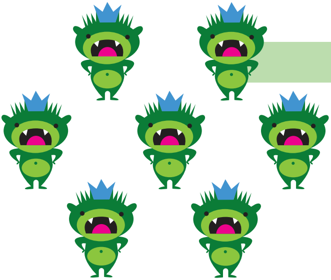
Microsoft

# elevation of privilege

7

# Tampering

An attacker can bypass permissions because you don’t make names canonical before checking access permissions.



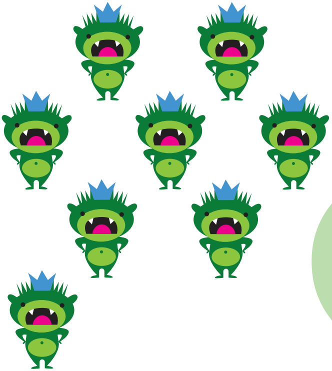
Microsoft

elevation of privilege

8

# Tampering

An attacker can manipulate data because there’s no integrity protection for data on the network.

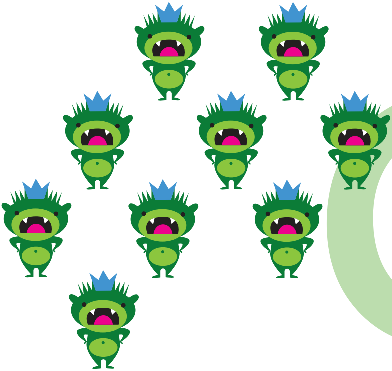


Microsoft

# elevation of privilege

# 9 Tampering

An attacker can provide or control state information.



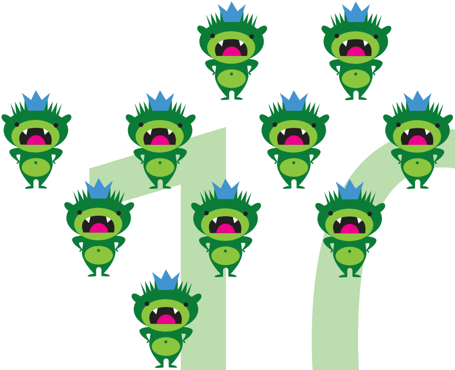
Microsoft

# elevation of privilege

10

# Tampering

An attacker can alter information in a data store because it has weak ACLs or includes a group which is equivalent to everyone ("all Live ID holders").



Microsoft

# elevation of privilege

# J Tampering

An attacker can write to some resource because permissions are granted to the world or there are no ACLs.

Microsoft®

# elevation of privilege

# Q

# Tampering

An attacker can change parameters over a trust boundary and after validation (for example, important parameters in a hidden field in HTML, or passing a pointer to critical memory).

Microsoft

# elevation of privilege

K

# Tampering

An attacker can load code inside your process via an extension point.

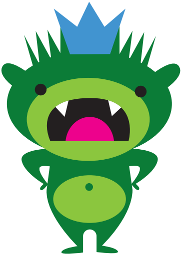
Microsoft

# elevation of privilege

A

# Tampering

You’ve invented a new Tampering attack.



Microsoft

# elevation of privilege

2

# Repudiation

An attacker can pass data through the log to attack a log reader, and there’s no documentation of what sorts of validation are done.

2

Microsoft

# elevation of privilege

3

# Repudiation

A low privilege attacker can read interesting security information in the logs.

Microsoft®

# elevation of privilege

4

# Repudiation

An attacker can alter files or messages because the digital signature system you're implementing is weak, or uses MACs where it should use a signature.

Microsoft

# elevation of privilege

# 5 Repudiation

An attacker can alter log messages on a network because they lack strong integrity controls.

Microsoft

# elevation of privilege

6

# Repudiation

An attacker can create a log entry without a timestamp (or no log entry is timestamped).

Microsoft

elevation of privilege

7

# Repudiation

An attacker can make the logs wrap around and lose data.

Microsoft

# elevation of privilege

8

# Repudiation

An attacker can make a log lose or confuse security information.

Microsoft

# elevation of privilege

**9**

# Repudiation

An attacker can use a shared key to authenticate as different principals, confusing the information in the logs.

Microsoft

# elevation of privilege

**10**

# Repudiation

An attacker can get arbitrary data into logs from unauthenticated (or weakly authenticated) outsiders without validation.

Microsoft

# elevation of privilege

**J**

# Repudiation

An attacker can edit logs and there’s no way to tell (perhaps because there’s no heartbeat option for the logging system).

Microsoft®

# elevation of privilege

Q

# Repudiation

An attacker can say “I didn’t do that,” and you would have no way to prove them wrong.

# elevation of privilege

K

# Repudiation

The system has no logs.

logs = 0

Microsoft

# elevation of privilege

A

# Repudiation

You've invented a new Repudiation attack.

Microsoft

# elevation of privilege

2

# Information Disclosure

An attacker can brute-force file encryption because there's no defense in place (example defense: password stretching).

2

Microsoft

# elevation of privilege

3

# Information Disclosure

An attacker can see error messages with security-sensitive content.

3

Microsoft

# elevation of privilege

**4**

# Information Disclosure

An attacker can read content because messages (for example, an email or HTTP cookie) aren't encrypted even if the channel is encrypted.

Microsoft

# elevation of privilege

5

# Information Disclosure

An attacker may be able to read a document or data because it's encrypted with a non-standard algorithm.

Microsoft

# elevation of privilege

6

# Information Disclosure

An attacker can read data because it’s hidden or occluded (for undo or change tracking) and the user might forget that it’s there.

6

Microsoft

# elevation of privilege

7

# Information Disclosure

An attacker can act as a “man in the middle” because you don’t authenticate endpoints of a network connection.

7

Microsoft

# elevation of privilege

8

# Information Disclosure

An attacker can access information through a search indexer, logger, or other such mechanism.

Microsoft

# elevation of privilege

**9**

# Information Disclosure

An attacker can read sensitive information in a file with bad ACLs.

Microsoft

# elevation of privilege

10

# Information Disclosure

An attacker can read information in files with no ACLs.

10

Microsoft

# elevation of privilege

J

# Information Disclosure

An attacker can discover the fixed key being used to encrypt.

Microsoft

# elevation of privilege

# Q Information Disclosure

An attacker can read the entire channel because the channel (for example, HTTP or SMTP) isn't encrypted.

Microsoft

elevation of privilege

K

# Information Disclosure

An attacker can read network information because there's no cryptography used.

Microsoft

# elevation of privilege

A

# Information Disclosure

You've invented a new Information Disclosure attack.

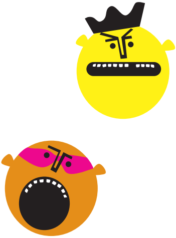
Microsoft

# elevation of privilege

2

# Denial of Service

An attacker can make your authentication system unusable or unavailable.



2

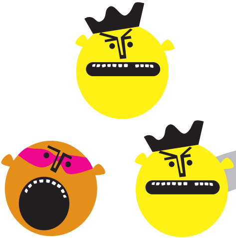
Microsoft

# elevation of privilege

**3**

# Denial of Service

An attacker can make a client unavailable or unusable but the problem goes away when the attacker stops **(client, authenticated, temporary)**.



3

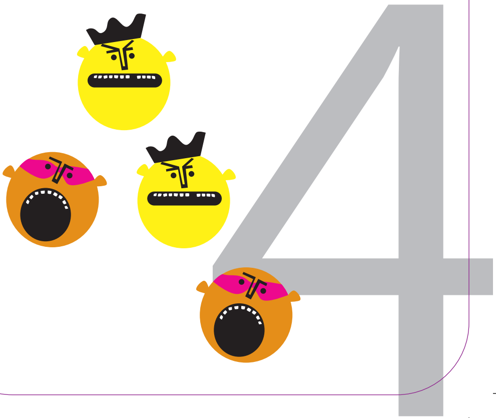
Microsoft

# elevation of privilege

4

# Denial of Service

An attacker can make a server unavailable or unusable but the problem goes away when the attacker stops **(server, authenticated, temporary)**.



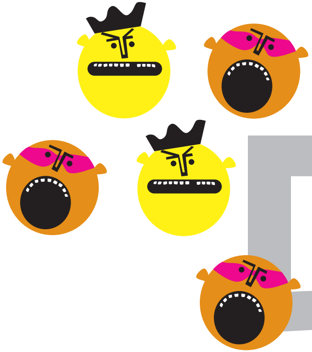
Microsoft

# elevation of privilege

5

# Denial of Service

An attacker can make a client unavailable or unusable without ever authenticating, but the problem goes away when the attacker stops **(client, anonymous, temporary)**.



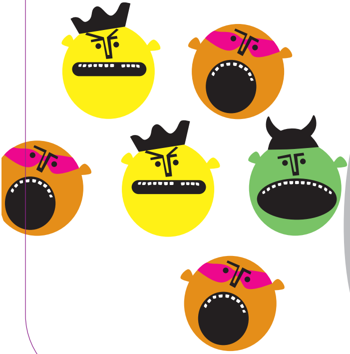
Microsoft

# elevation of privilege

**6**

# Denial of Service

An attacker can make a server unavailable or unusable without ever authenticating, but the problem goes away when the attacker stops **(server, anonymous, temporary)**.



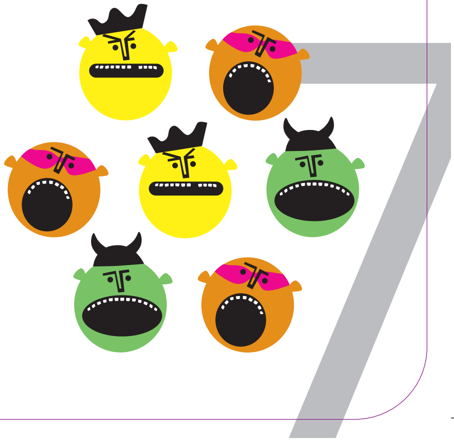
Microsoft

# elevation of privilege

7

# Denial of Service

An attacker can make a client unavailable or unusable and the problem persists after the attacker goes away **(client, authenticated, persistent)**.



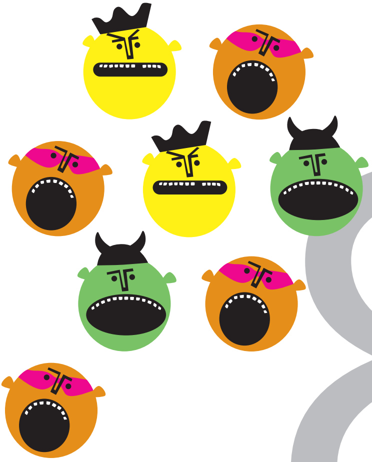
Microsoft

# elevation of privilege

**8**

# Denial of Service

An attacker can make a server unavailable or unusable and the problem persists after the attacker goes away **(server, authenticated, persistent)**.



8

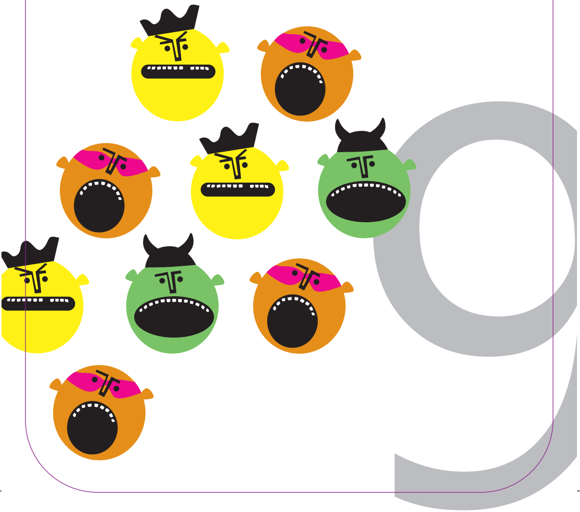
Microsoft

# elevation of privilege

# 9

# Denial of Service

An attacker can make a client unavailable or unusable without ever authenticating, and the problem persists after the attacker goes away **(client, anonymous, persistent)**.



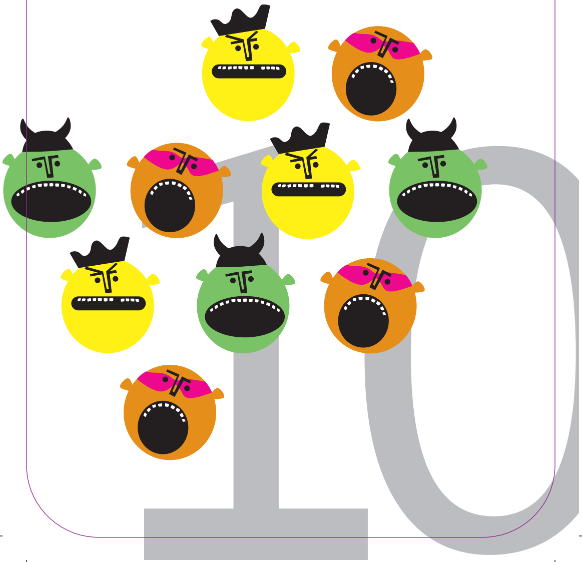
Microsoft

# elevation of privilege

10

# Denial of Service

An attacker can make a server unavailable or unusable without ever authenticating, and the problem persists after the attacker goes away **(server, anonymous, persistent)**.



Microsoft

# elevation of privilege

J

# Denial of Service

An attacker can cause the logging subsystem to stop working.

Microsoft

# elevation of privilege

Q

# Denial of Service

An attacker can amplify a Denial of Service attack through this component with amplification on the order of 10:1.

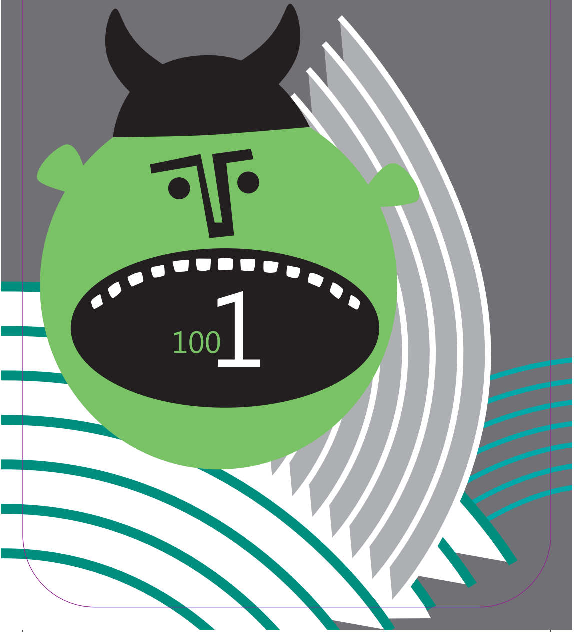
Microsoft

# elevation of privilege

K

# Denial of Service

An attacker can amplify a Denial of Service attack through this component with amplification on the order of 100:1.



Microsoft

# elevation of privilege

A

# Denial of Service

You’ve invented a new Denial of Service attack.

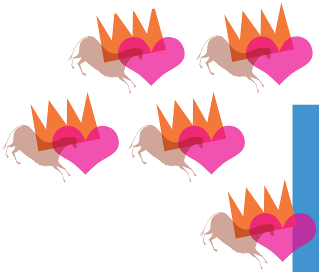
Microsoft

# elevation of privilege

5

# Elevation of Privilege

An attacker can force data through different validation paths which give different results.



5

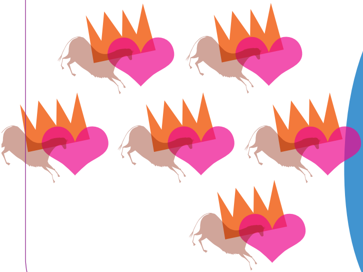
Microsoft

# elevation of privilege

**6**

# Elevation of Privilege

An attacker could take advantage of .NET permissions you ask for, but don't use.



6

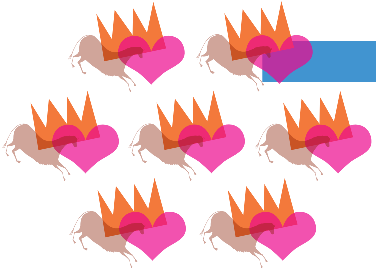
Microsoft

# elevation of privilege

# 7

# Elevation of Privilege

An attacker can provide a pointer across a trust boundary, rather than data which can be validated.



7

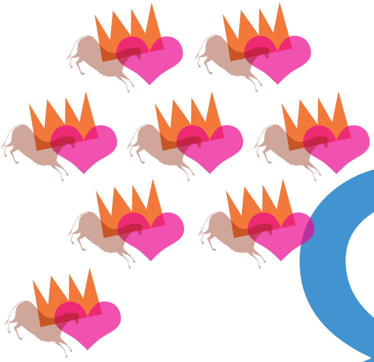
Microsoft®

# elevation of privilege

8

# Elevation of Privilege

An attacker can enter data that is checked while still under the attacker's control and used later on the other side of a trust boundary.



8

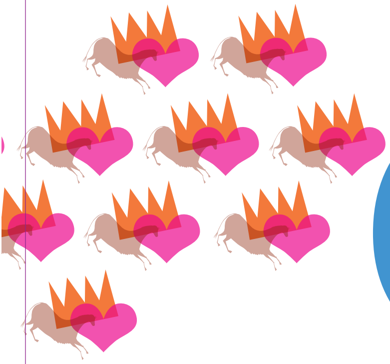
Microsoft

# elevation of privilege

9

# Elevation of Privilege

There’s no reasonable way for callers to figure out what validation of tainted data you perform before passing it to them.



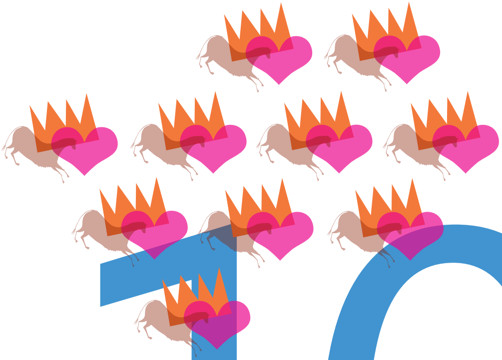
Microsoft

# elevation of privilege

**10**

# Elevation of Privilege

There’s no reasonable way for a caller to figure out what security assumptions you make.



10

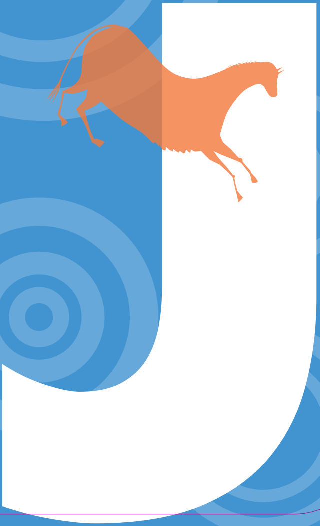
Microsoft

# elevation of privilege

J

# Elevation of Privilege

An attacker can reflect input back to a user, like cross-site scripting.



Microsoft

# elevation of privilege

Q

# Elevation of Privilege

You include user-generated content within your page, possibly including the content of random URLs.

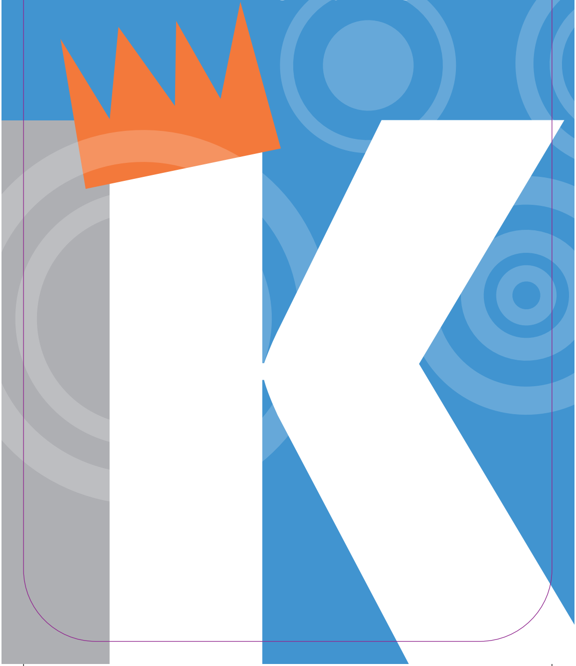
Microsoft

# elevation of privilege

K

# Elevation of Privilege

An attacker can inject a command that the system will run at a higher privilege level.



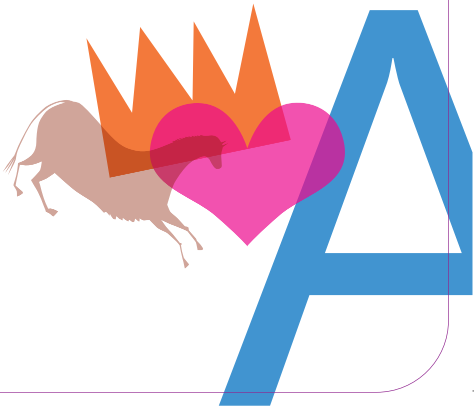
Microsoft

# elevation of privilege

A

# Elevation of Privilege

You’ve invented a new Elevation of Privilege attack.



Microsoft

# elevation of privilege

# Spoofing

**2**. An attacker could squat on the random port or socket that the server normally uses.

**3**. An attacker could try one credential after another and there's nothing to slow them down (online or offline).

**4**. An attacker can anonymously connect because we expect authentication to be done at a higher level.

**5**. An attacker can confuse a client because there are too many ways to identify a server.

**6**. An attacker can spoof a server because identifiers aren't stored on the client and checked for consistency on re-connection (that is, there's no key persistence).

**7**. An attacker can connect to a server or peer over a link that isn't authenticated (and encrypted).

**8**. An attacker could steal credentials stored on the server and reuse them (for example, a key is stored in a world readable file).

**9**. An attacker who gets a password can reuse it (use stronger authenticators).

continued on back

Spoofing

## Spoofing cont.

**10**. An attacker can choose to use weaker or no authentication.

**J**. An attacker could steal credentials stored on the client and reuse them.

**Q**. An attacker could go after the way credentials are updated or recovered (account recovery doesn't require disclosing the old password).

**K**. Your system ships with a default admin password and doesn't force a change.

**A**. You've invented a new Spoofing attack.

Spoofing

# Tampering

**3**. An attacker can take advantage of your custom key exchange or integrity control which you built instead of using standard crypto.

**4**. Your code makes access control decisions all over the place, rather than with a security kernel.

**5**. An attacker can replay data without detection because your code doesn't provide timestamps or sequence numbers.

**6**. An attacker can write to a data store your code relies on.

**7**. An attacker can bypass permissions because you don't make names canonical before checking access permissions.

**8**. An attacker can manipulate data because there's no integrity protection for data on the network.

**9**. An attacker can provide or control state information.

**10**. An attacker can alter information in a data store because it has weak ACLs or includes a group which is equivalent to everyone ("all Live ID holders").

continued on back

Tampering

# Tampering cont.

**J**. An attacker can write to some resource because permissions are granted to the world or there are no ACLs.

**Q**. An attacker can change parameters over a trust boundary and after validation (for example, important parameters in a hidden field in HTML, or passing a pointer to critical memory).

**K**. An attacker can load code inside your process via an extension point.

**A**. You've invented a new Tampering attack.

Tampering

R

# Repudiation

2. An attacker can pass data through the log to attack a log reader, and there's no documentation of what sorts of validation are done.

3. A low privilege attacker can read interesting security information in the logs.

4. An attacker can alter files or messages because the digital signature system you're implementing is weak, or uses MACs where it should use a signature.

5. An attacker can alter log messages on a network because they lack strong integrity controls.

6. An attacker can create a log entry without a timestamp (or no log entry is timestamped).

7. An attacker can make the logs wrap around and lose data.

8. An attacker can make a log lose or confuse security information.

9. An attacker can use a shared key to authenticate as different principals, confusing the information in the logs.

continued on back

Repudiation

# R

## Repudiation cont.

**10**. An attacker can get arbitrary data into logs from unauthenticated (or weakly authenticated) outsiders without validation.

**J**. An attacker can edit logs and there's no way to tell (perhaps because there's no heartbeat option for the logging system).

**Q**. An attacker can say "I didn't do that," and you would have no way to prove them wrong.

**K**. The system has no logs.

**A**. You've invented a new Repudiation attack.

# Information Disclosure

**2**. An attacker can brute-force file encryption because there's no defense in place (example defense: password stretching).

**3**. An attacker can see error messages with security-sensitive content.

**4**. An attacker can read content because messages (for example, an email or HTTP cookie) aren't encrypted even if the channel is encrypted.

**5**. An attacker may be able to read a document or data because it's encrypted with a non-standard algorithm.

**6**. An attacker can read data because it's hidden or occluded (for undo or change tracking) and the user might forget that it's there.

**7**. An attacker can act as a "man in the middle" because you don't authenticate endpoints of a network connection.

**8**. An attacker can access information through a search indexer, logger, or other such mechanism.

continued on back

Information Disclosure

# Information Disclosure cont.

**9**. An attacker can read sensitive information in a file with bad ACLs.

**10**. An attacker can read information in files with no ACLs.

**J**. An attacker can discover the fixed key being used to encrypt.

**Q**. An attacker can read the entire channel because the channel (for example, HTTP or SMTP) isn't encrypted.

**K**. An attacker can read network information because there's no cryptography used.

**A**. You've invented a new Information Disclosure attack.

Information Disclosure

# Denial of Service

**2**. An attacker can make your authentication system unusable or unavailable.

**3**. An attacker can make a client unavailable or unusable but the problem goes away when the attacker stops **(client, authenticated, temporary)**.

**4**. An attacker can make a server unavailable or unusable but the problem goes away when the attacker stops **(server, authenticated, temporary)**.

**5**. An attacker can make a client unavailable or unusable without ever authenticating, but the problem goes away when the attacker stops **(client, anonymous, temporary).**

**6**. An attacker can make a server unavailable or unusable without ever authenticating, but the problem goes away when the attacker stops **(server, anonymous, temporary)**.

**7**. An attacker can make a client unavailable or unusable and the problem persists after the attacker goes away **(client, authenticated, persistent)**.

continued on back

Denial of Service

# Denial of Service cont.

**8**. An attacker can make a server unavailable or unusable and the problem persists after the attacker goes away **(server, authenticated, persistent)**.

**9**. An attacker can make a client unavailable or unusable without ever authenticating, and the problem persists after the attacker goes away **(client, anonymous, persistent)**.

**10**. An attacker can make a server unavailable or unusable without ever authenticating, and the problem persists after the attacker goes away **(server, anonymous, persistent)**.

**J**. An attacker can cause the logging subsystem to stop working.

**Q**. An attacker can amplify a Denial of Service attack through this component with amplification on the order of 10:1.

**K**. An attacker can amplify a Denial of Service attack through this component with amplification on the order of 100:1.

**A**. You've invented a new Denial of Service attack.

Denial of Service

# Elevation of Privilege (EoP)

**5**. An attacker can force data through different validation paths which give different results.

**6**. An attacker could take advantage of .NET permissions you ask for, but don’t use.

**7**. An attacker can provide a pointer across a trust boundary, rather than data which can be validated.

**8**. An attacker can enter data that is checked while still under the attacker’s control and used later on the other side of a trust boundary.

**9**. There’s no reasonable way for callers to figure out what validation of tainted data you perform before passing it to them.

**10**. There’s no reasonable way for a caller to figure out what security assumptions you make.

**J**. An attacker can reflect input back to a user, like cross-site scripting.

**Q**. You include user-generated content within your page, possibly including the content of random URLs.

**K**. An attacker can inject a command that the system will run at a higher privilege level.

**A**. You’ve invented a new Elevation of Privilege attack.

Elevation of Privilege

# Elevation of Privilege

# About

## Threat Modeling

The Elevation of Privilege game is designed to be the easiest way to start looking at your design from a security perspective. It's one way to threat model, intended to be picked up and used by any development group. Because the game uses STRIDE threats, it gives you a framework for thinking, and specific actionable examples of those threats.

STRIDE stands for:

**Spoofing**: Impersonating something or someone else.

**Tampering**: Modifying data or code.

**Repudiation**: Claiming not to have performed an action.

**Information Disclosure**: Exposing information to someone not authorized to see it.

**Denial of Service**: Denying or degrading service to users.

**Elevation of Privilege**: Gain capabilities without proper authorization.

At **www.microsoft.com/security/sdl/eop** we have videos, score sheets and tips and tricks for playing.

About

# SDL

The Elevation of Privilege game is a fun and easy way to get started understanding the security of your systems by threat modeling. As you discover and correct design-level security problems, it's worth thinking about the other ways security issues can creep into your code. Microsoft has a large collection of free resources available to help you get started with the Security Development Lifecycle (SDL).

To learn more about threat modeling and the Microsoft Security Development Lifecycle, visit our website at **microsoft.com/sdl/**

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Security Development Lifecycle