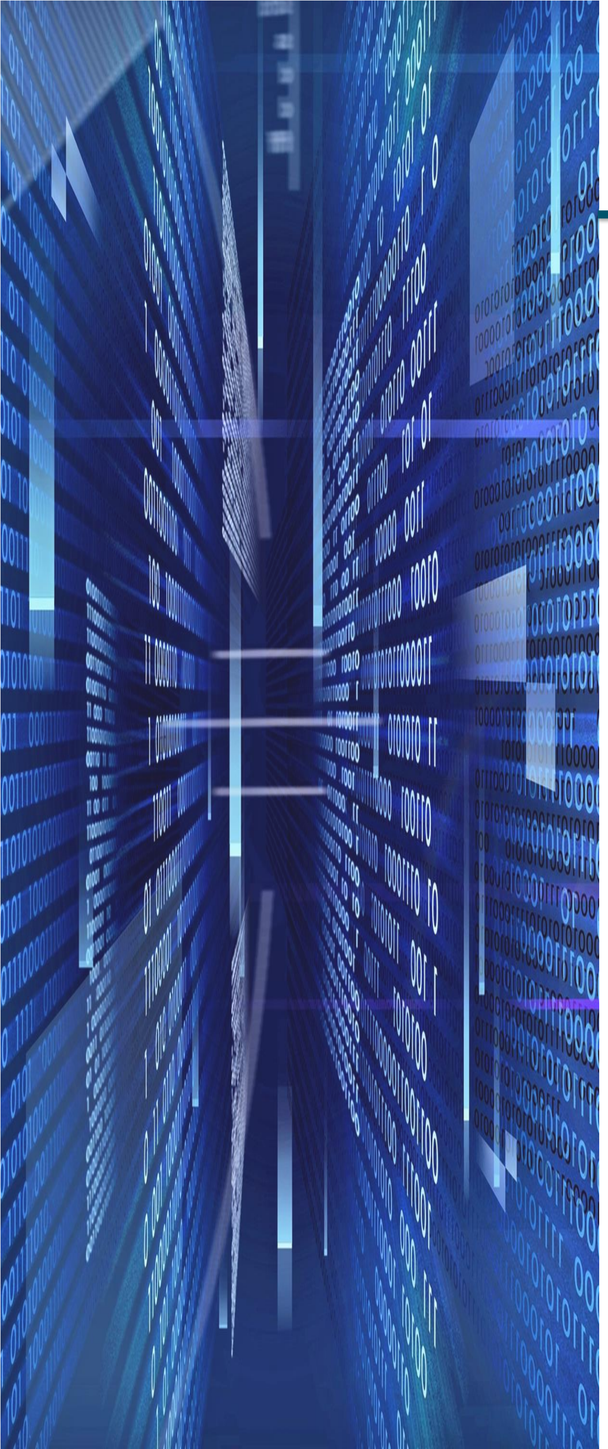


Threat Modeling
Microsoft STRIDE

Prof Federica Paci

Threat Modeling

- Techniques used
  - to model and analyze technology systems and services
  - to understand how that system or service might be attacked,
  - the measures or controls needed to manage the risk posed by such attacks

- Threat modelling techniques are best applied to inform the design and development phases of a technology system or service life cycle

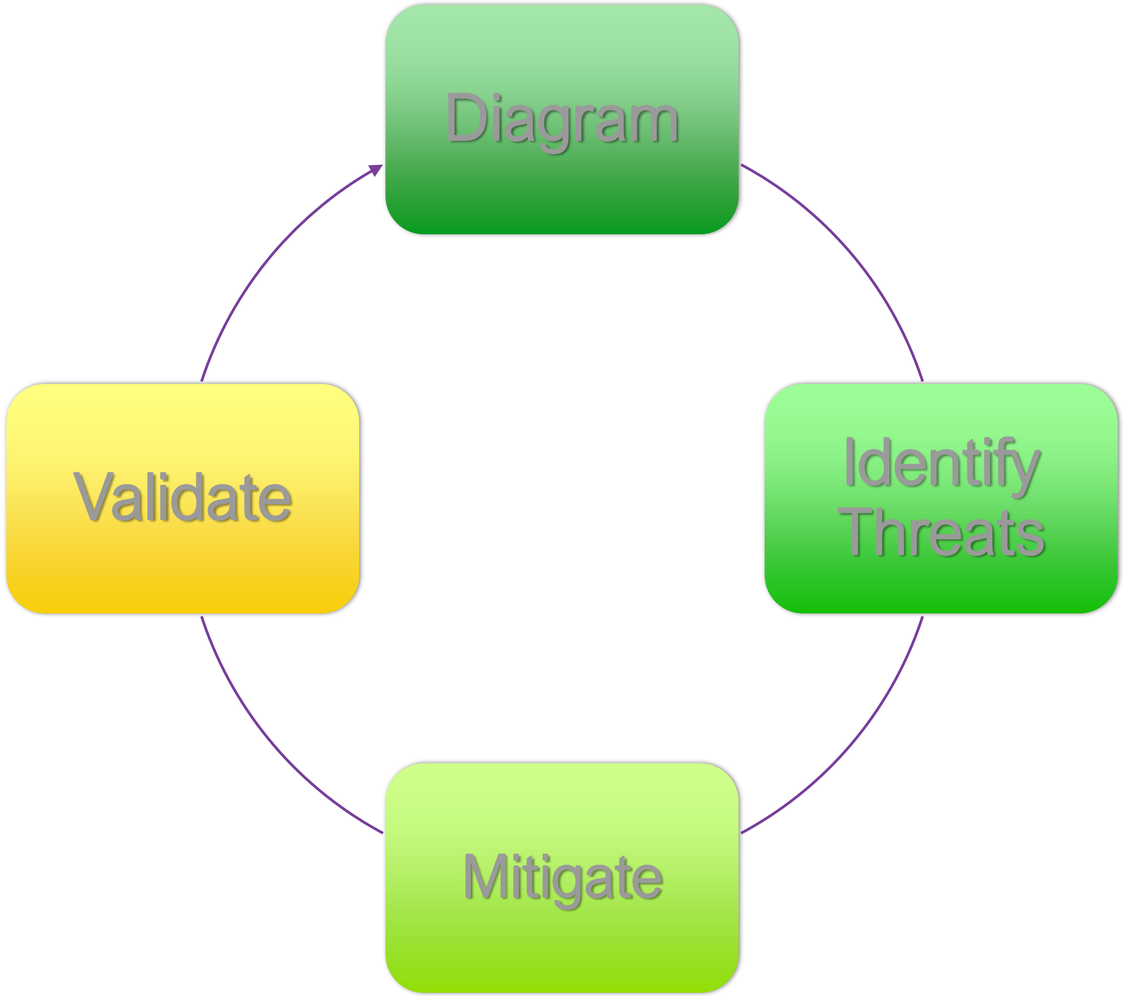
Threat Modeling

- What are we working on?
- What can go wrong?
- What are we going to do about it?
- Did we do a good enough job?

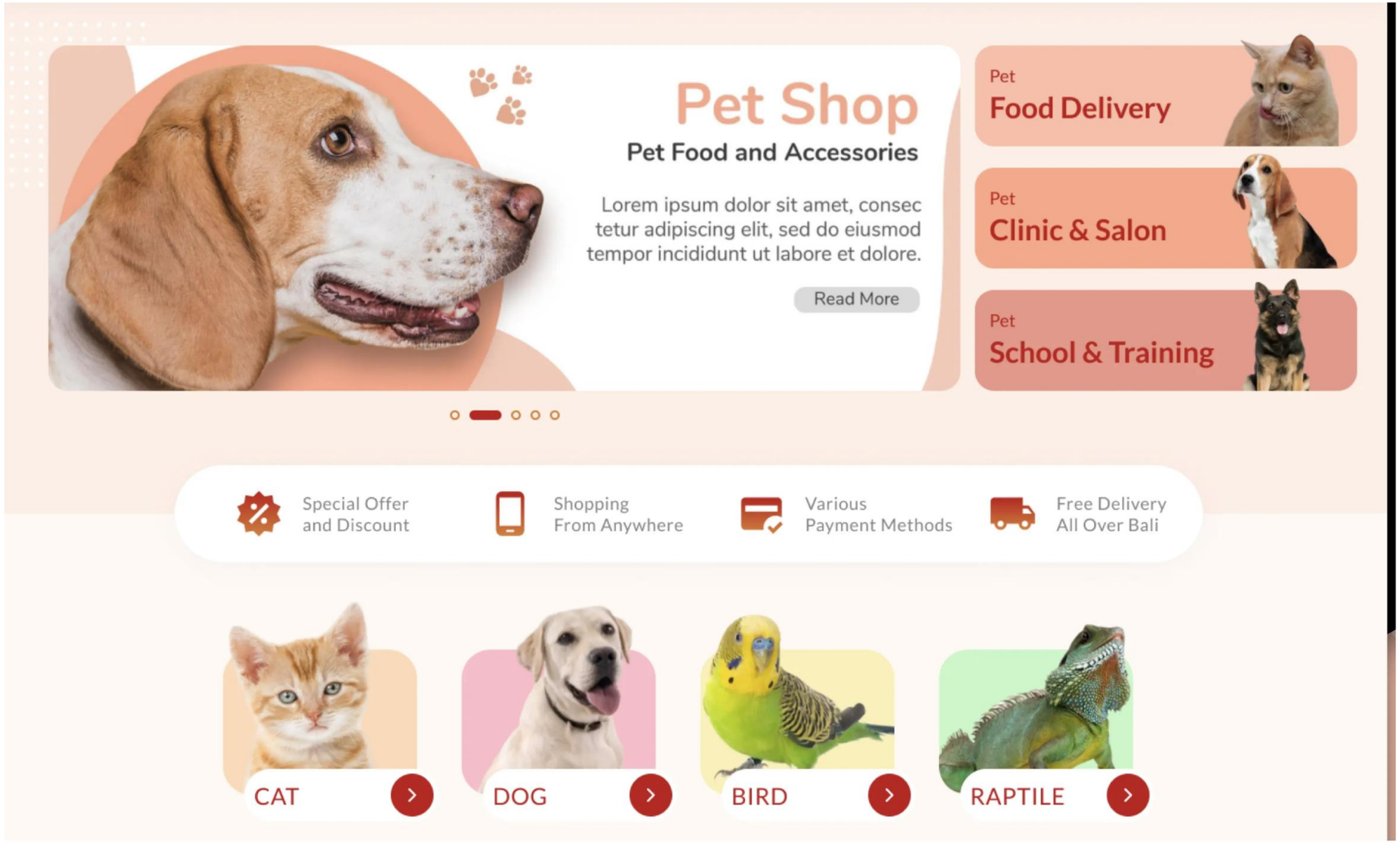
STRIDE

- Popular threat modeling technique by Microsoft
- Focus on what an attacker is trying to achieve
- Endorsed by Security Touchpoints, OWASP's CLASP and Microsoft's SDL
- Taught in security certification programs like CSSLP
- Widely used in industry
- Require little security expertise

The Process in a Nutshell



Illustrative Example: PetShop



Use Case: Famebook social network

- Famebook is social network, where online users share personal information such as relationship status, pictures, and comments with their friends.
- Alice is a registered user of Famebook
- Each time Alice updates her friends list, she first connects to the social network's web portal
- The portal communicates with the social network's server, and eventually, the friendship information of Alice and all other users of that social network is stored in a database

Step 1: Create Data Flow Diagrams

- A DFD is a graphical representation of the system under review
  - Model how data enters, leaves and traverses software components
  - Shows all data sources and destinations
  - Show all relevant processes that the data goes through
- Good DFDs are critical to threat modeling!!

Diagram Elements

External Entity

- People
- Other systems
- Microsoft.com

- DLLs
- EXEs
- COM object
  - Components
    - Services
- Web Services
  - Assemblies

- Function call
- Network traffic
- Remote Procedure Call (RPC)

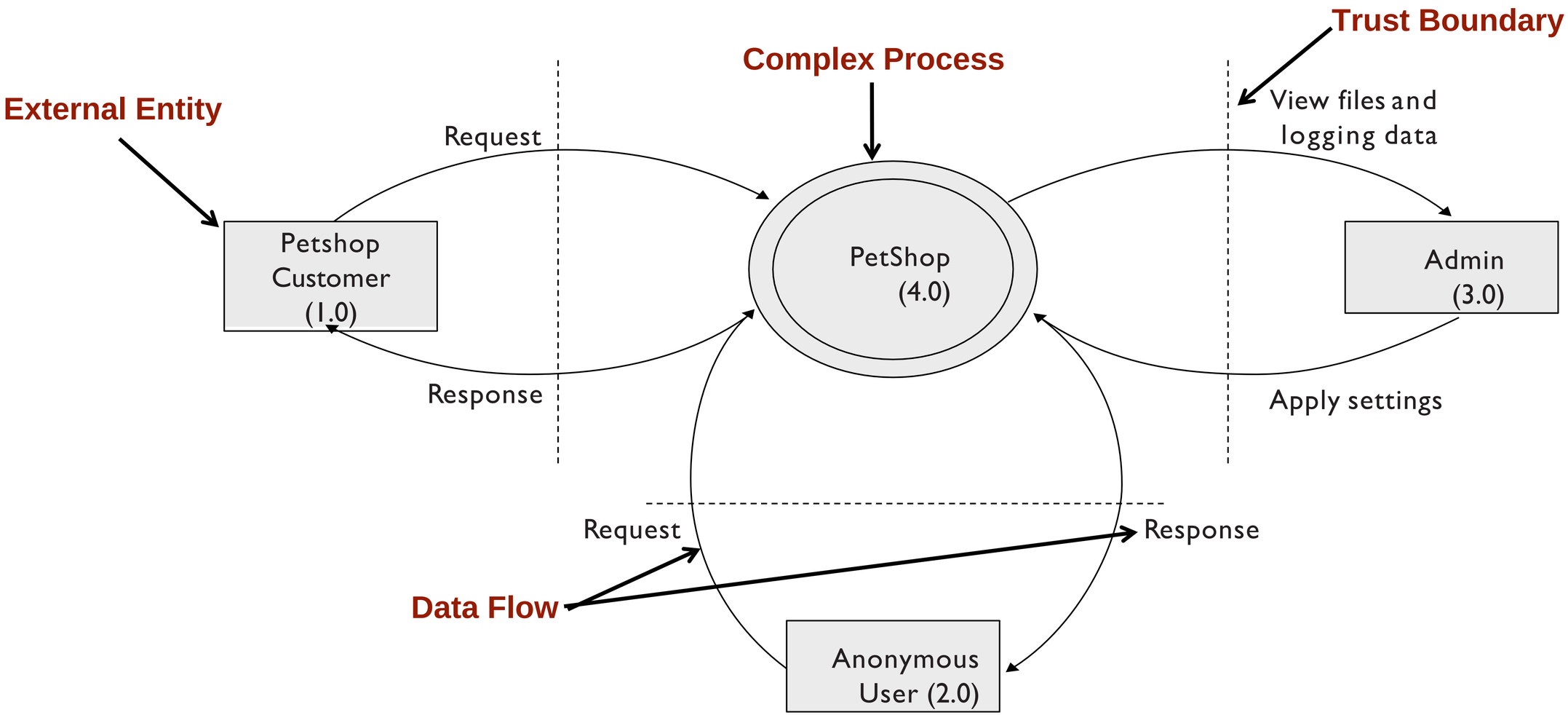
Data Store

- Database
- File
- Registry
- Shared Memory
- Queue / Stack

Trust Boundary

- Process boundary
- File system

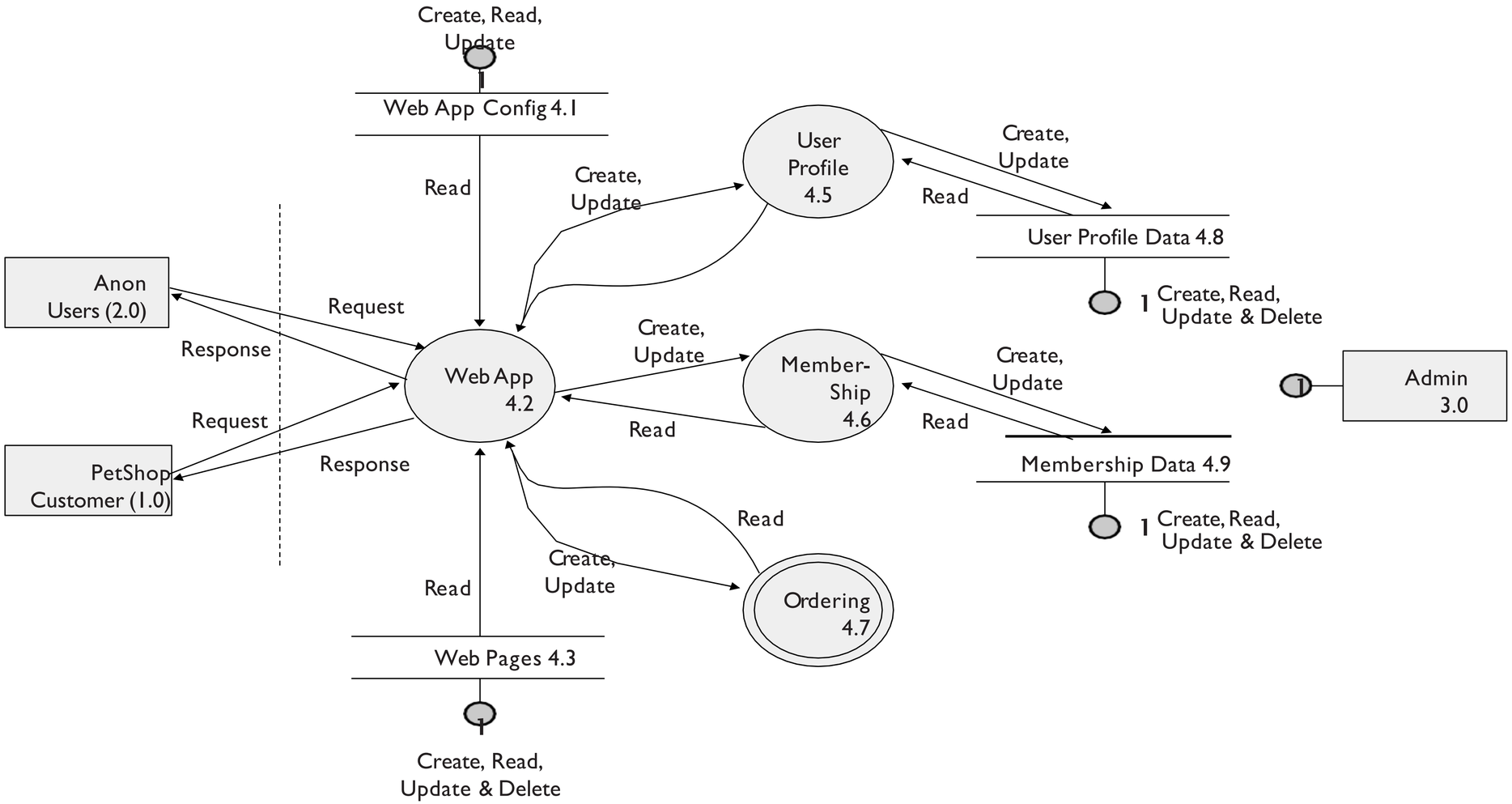
Pet Shop Context Diagram



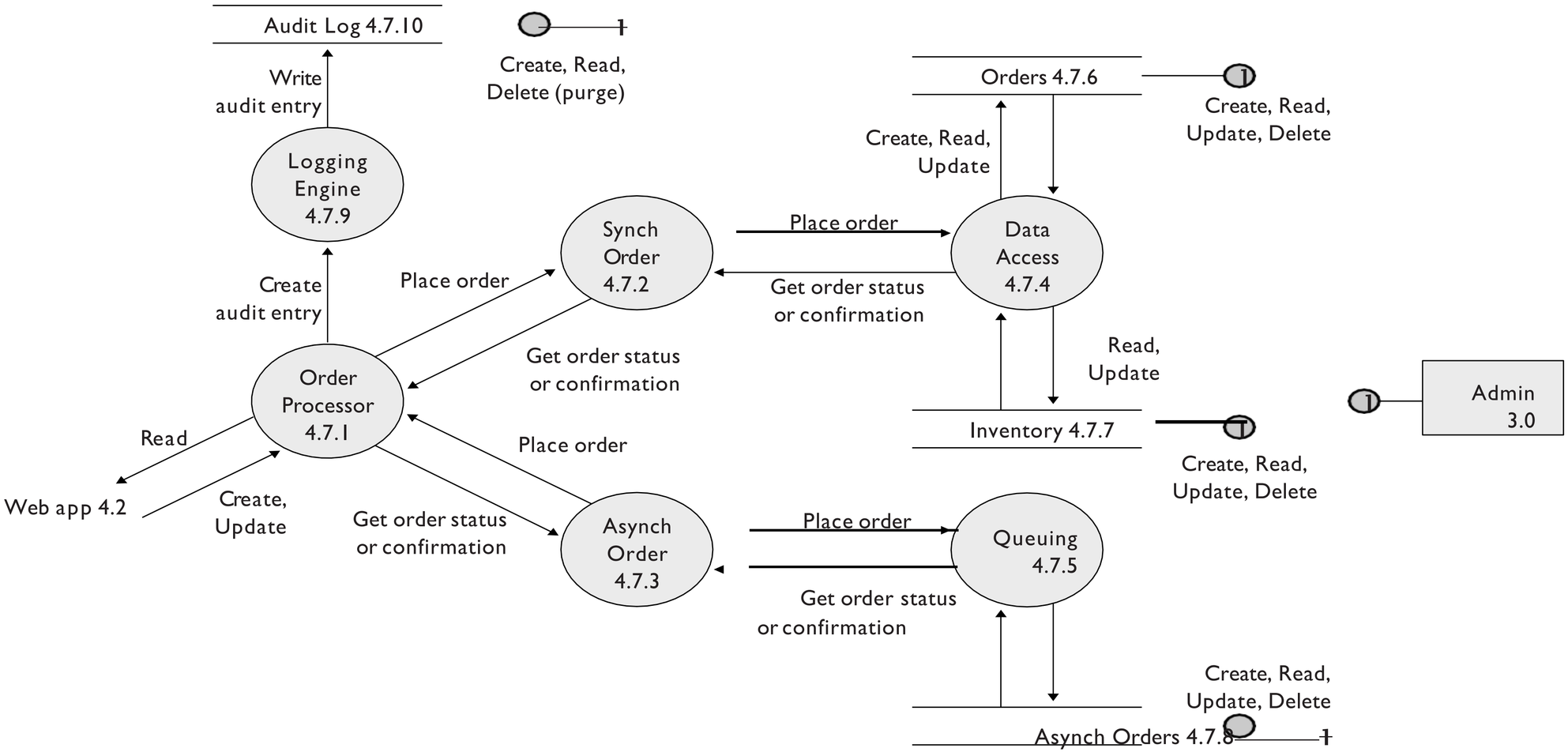
DFDs Decomposition

- Iterate over processes, data stores, and see where they need to be broken down
- Initially draw a **context** diagram
  - Very high-level; software and external entities interacting with it
- Then, draw a **level 1** diagram
  - High level; major business processes
- Then processes can be further decomposed in **level 2** diagrams
- And so on till no further decomposition is possible

Pet Shop Level 1 Diagram



Pet Shop Level 2 Diagram



Exercise 1 – Step 1- Create the data flow diagram

- Build the DFD of the Famebook social network
- Time: 10 minutes

Step 2: Identify Threats

Experts can brainstorm

How to do this without being an expert?

- Use STRIDE to step through the diagram elements
- Get specific about threat manifestation

Threat	Property we want
Spoofing	Authentication
Tampering	Integrity
Repudiation	Nonrepudiation
Information Disclosure	Confidentiality
Denial of Service	Availability
Elevation of Privilege	Authorization

Threat: Spoofing

Threat	**S**poofing
Property	Authentication
Definition	Impersonating something or someone else
Example	Pretending to be any of billg, microsoft.com, or ntdll.dll

Threat: Tampering

Threat	Tampering
Property	Integrity
Definition	Modifying data or code
Example	Modifying a DLL on disk or DVD, or a packet as it traverses the LAN

Threat: Repudiation

Threat	**R**epudiation
Property	Non-Repudiation
Definition	Claiming to have not performed an action
Example	“I didn’t send that email,” “I didn’t modify that file,” “I certainly didn’t visit that Web site, dear!”

Threat: Information Disclosure

Threat	Information Disclosure
Property	Confidentiality
Definition	Exposing information to someone not authorized to see it
Example	Allowing someone to read the Windows source code; publishing a list of customers to a Web site

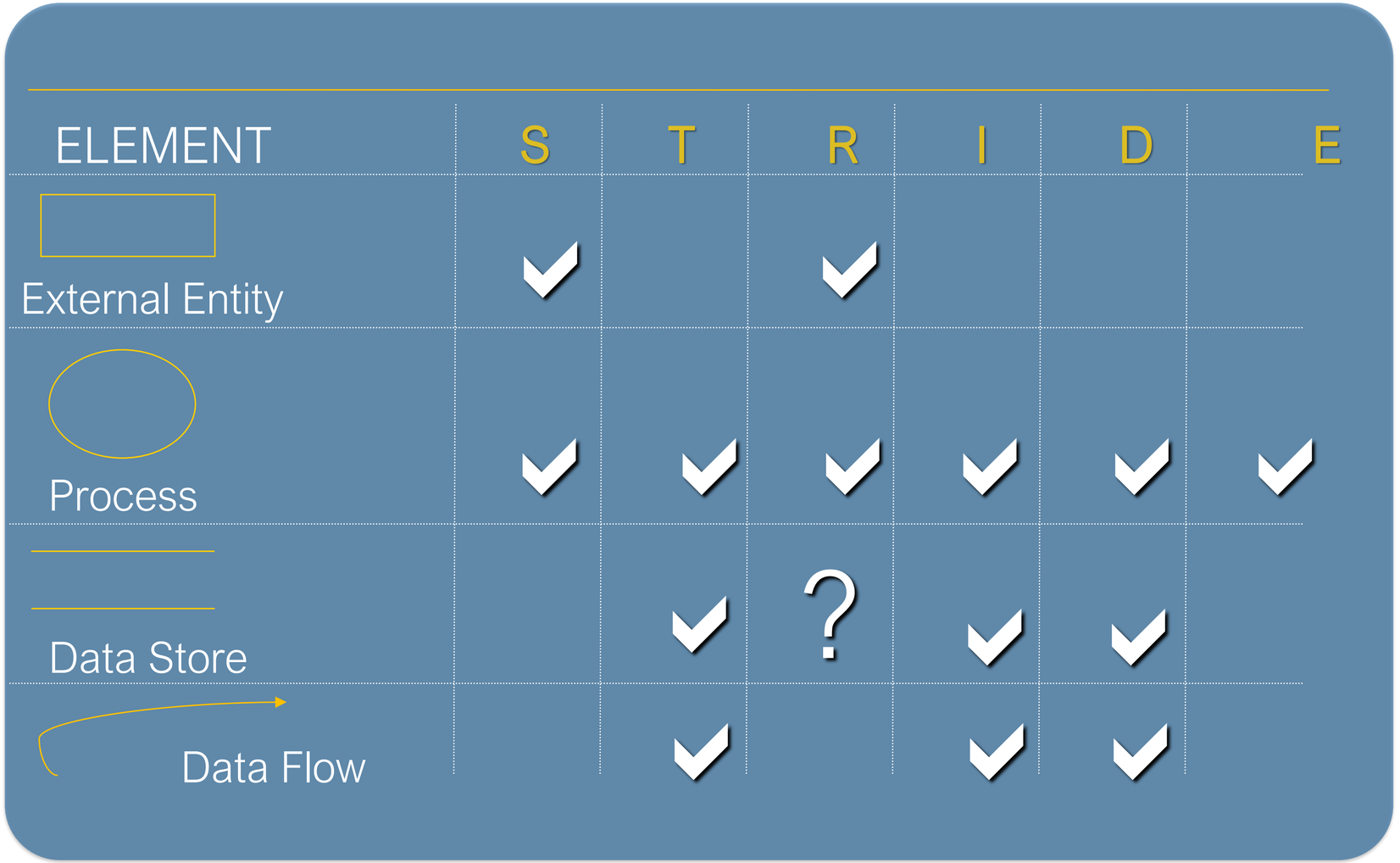
Threat: Denial of Service

Threat	Denial of Service
Property	Availability
Definition	Deny or degrade service to users
Example	Crashing Windows or a Web site, sending a packet and absorbing seconds of CPU time, or routing packets into a black hole

Threat: Elevation of Privilege

Threat	Elevation of Privilege (EoP)
Property	Authorization
Definition	Gain capabilities without proper authorization
Example	Allowing a remote Internet user to run commands is the classic example, but going from a “Limited User” to “Admin” is also EoP

Map STRIDE to DFD Elements



Map STRIDE to DFD Elements: An Example

Threat Type	DFD Elements
Spoofing	**External Entities**: Pet Shop Customer… **Processes**: Web application, Order processor
Tampering	**Processes**: Web application, Order processor **Data stores**: Audit-log data,… **Data Flows**: Pet Shop Customer to Web application,….
Repudiation	**External Entities**: Pet Shop Customer…
Information Disclosure	**Data stores**: Audit-log data,… **Data Flows**: Pet Shop Customer to Web application,…
Denial of Service	**Data stores**: Audit-log data,… **Data Flows**: Pet Shop Customer to Web application,….
Elevation of Privileges	**Processes**: Web application, Order processor

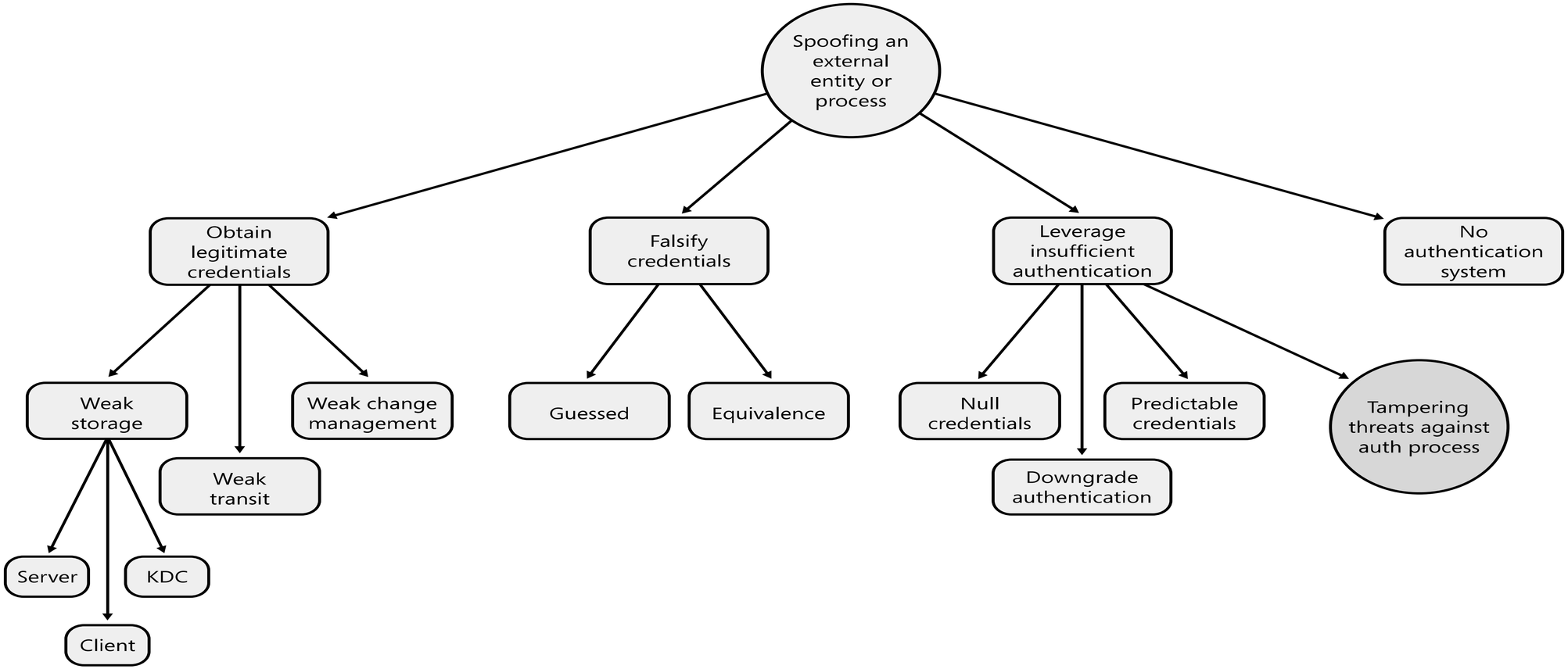
Exercise 2 – Step 2 - Identify Threats

- Work in pairs
- List the elements of the following DFD diagram
- Use the table to map elements to STRIDE threat types
  - The table is meant to support you in the identification of the threat that apply to a specific DFD element type
  - Ask yourself if a threat type is applicable to the DFD element in the system you are analysing
- Time: 10 min

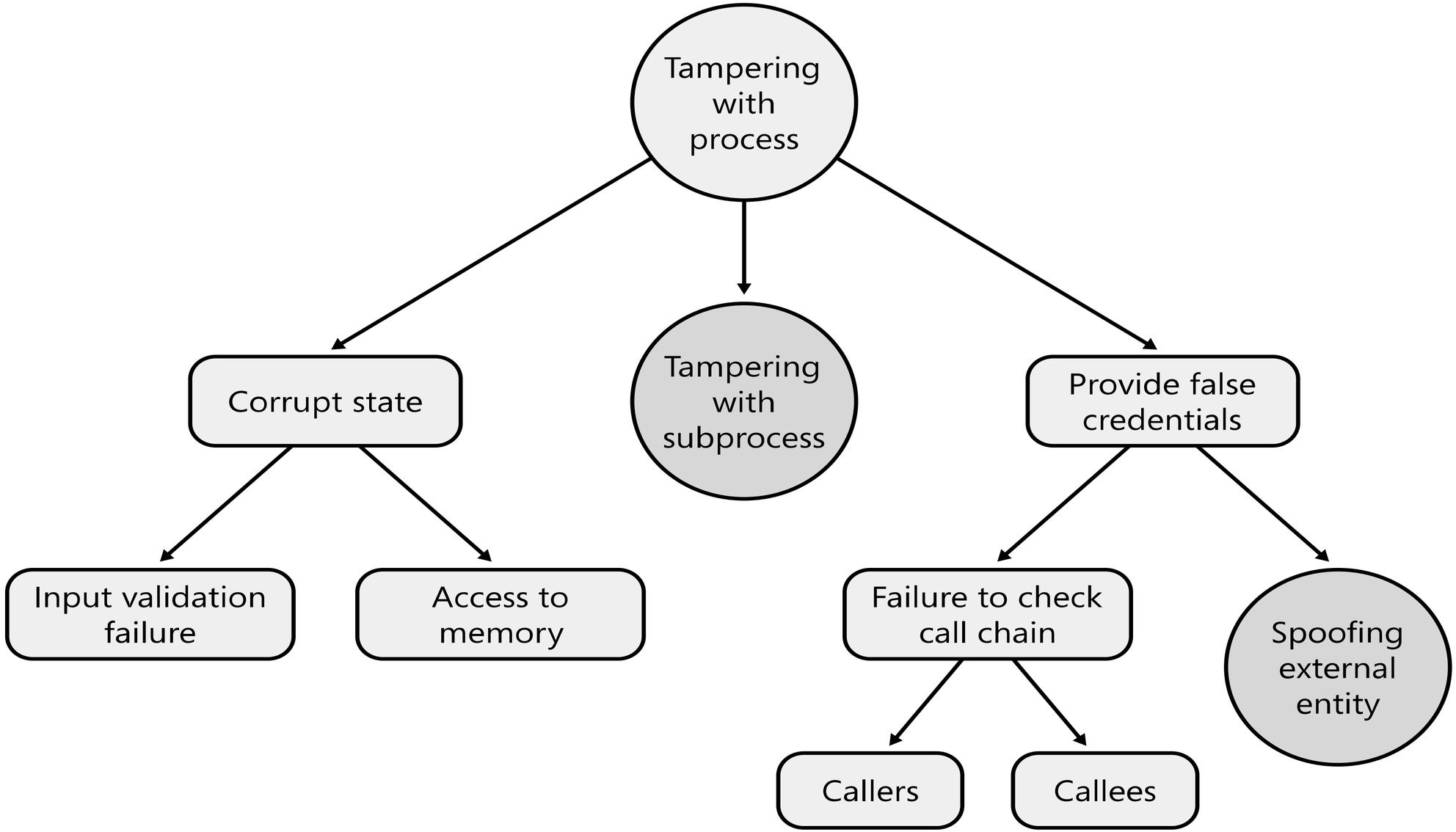
Step 2: Refine threats with tree threat patterns

- Generic threat types are refined into concrete threats via trees
- AND/OR composition of threats
- STRIDE provides 12 threat tree patterns
  - 1 threat tree for Spoofing
  - 3 threat trees for Tampering
  - 1 threat trees for Repudiation
  - 3 threat trees for Information Disclosure
  - 3 threat trees for Denial of Service
  - 1 threat tree for Elevation of Privileges

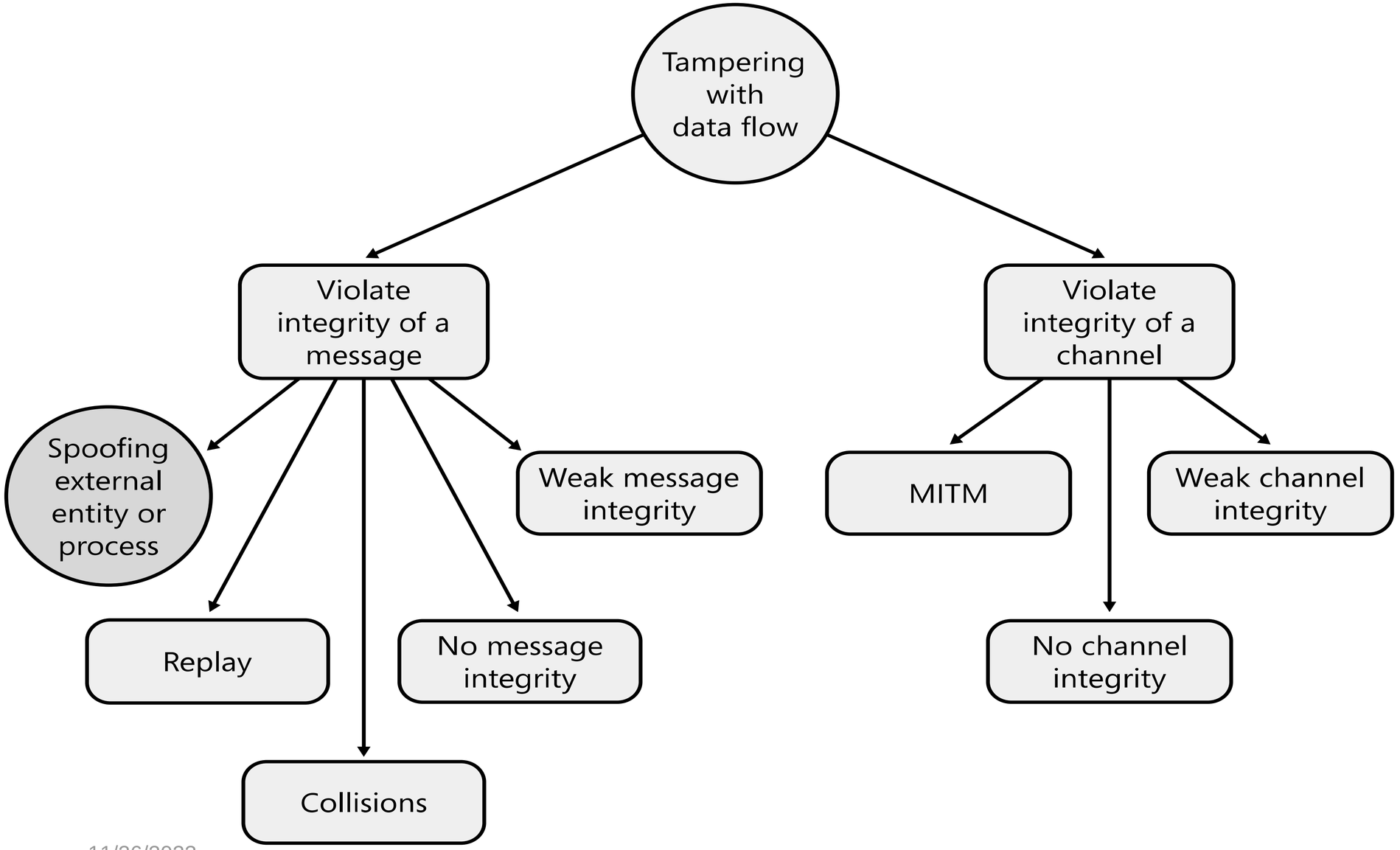
Spoofing an External Entity or Process



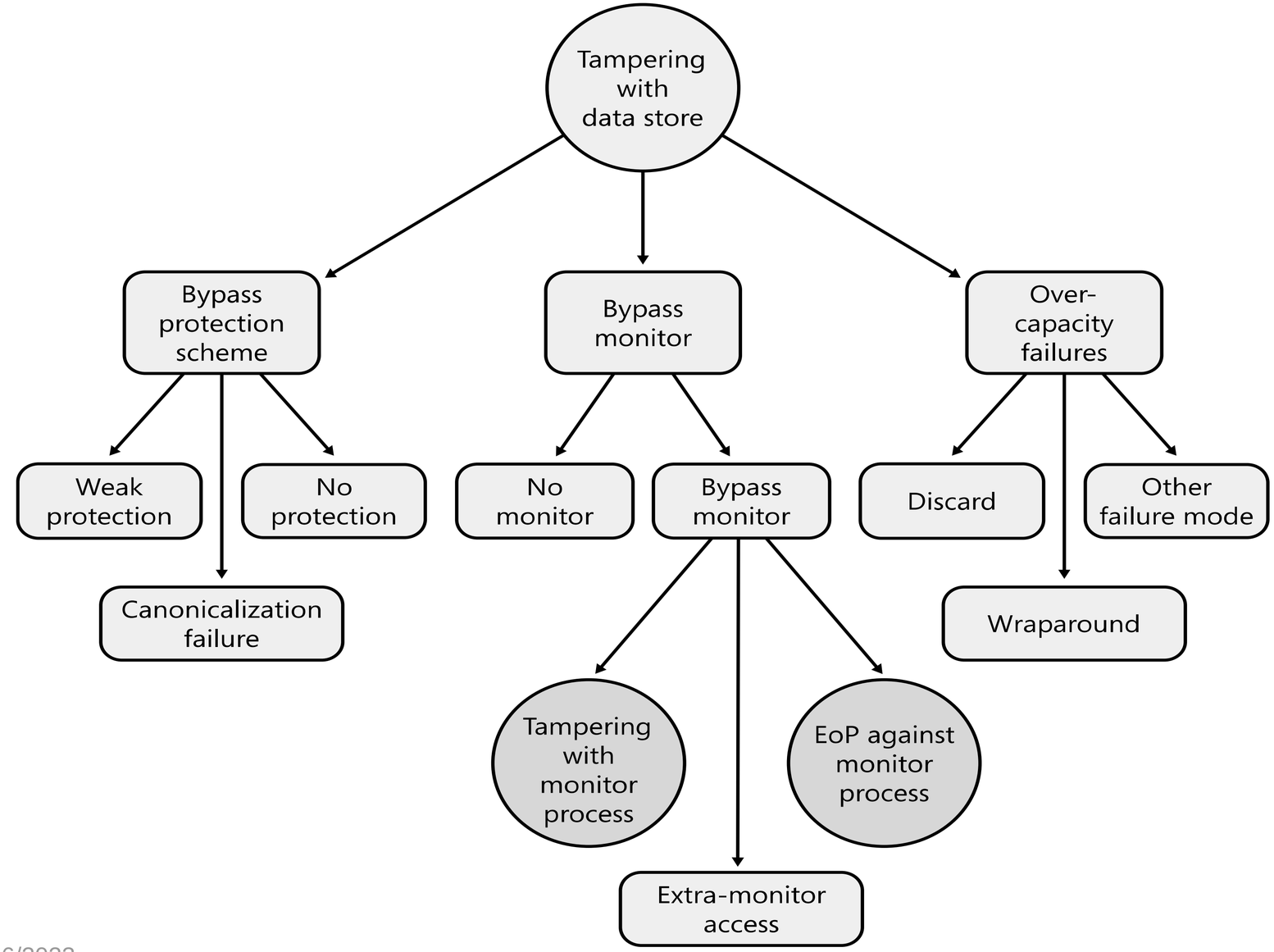
Tampering with a Process



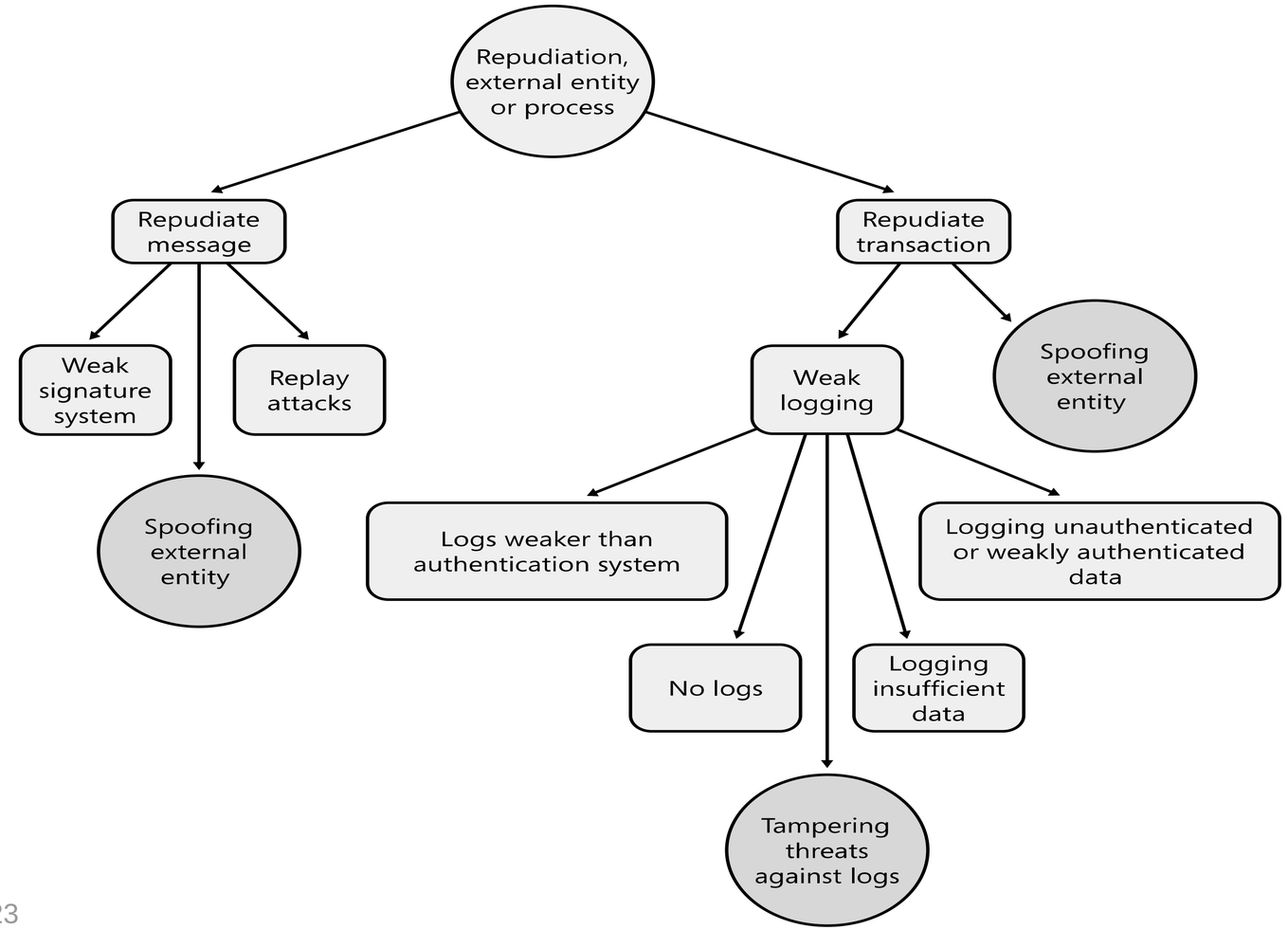
Tampering with a Data Flow



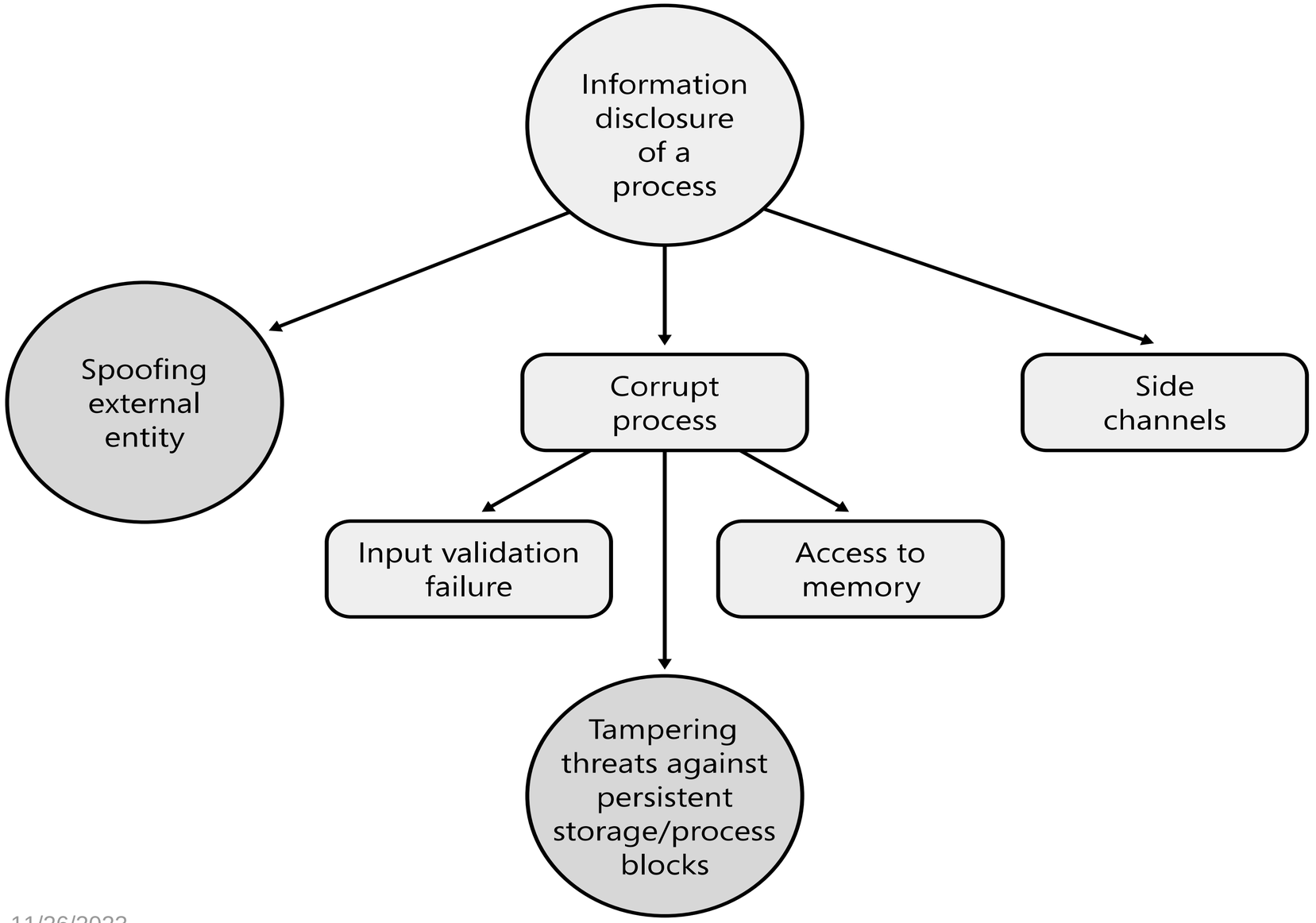
Tampering with a Data Store



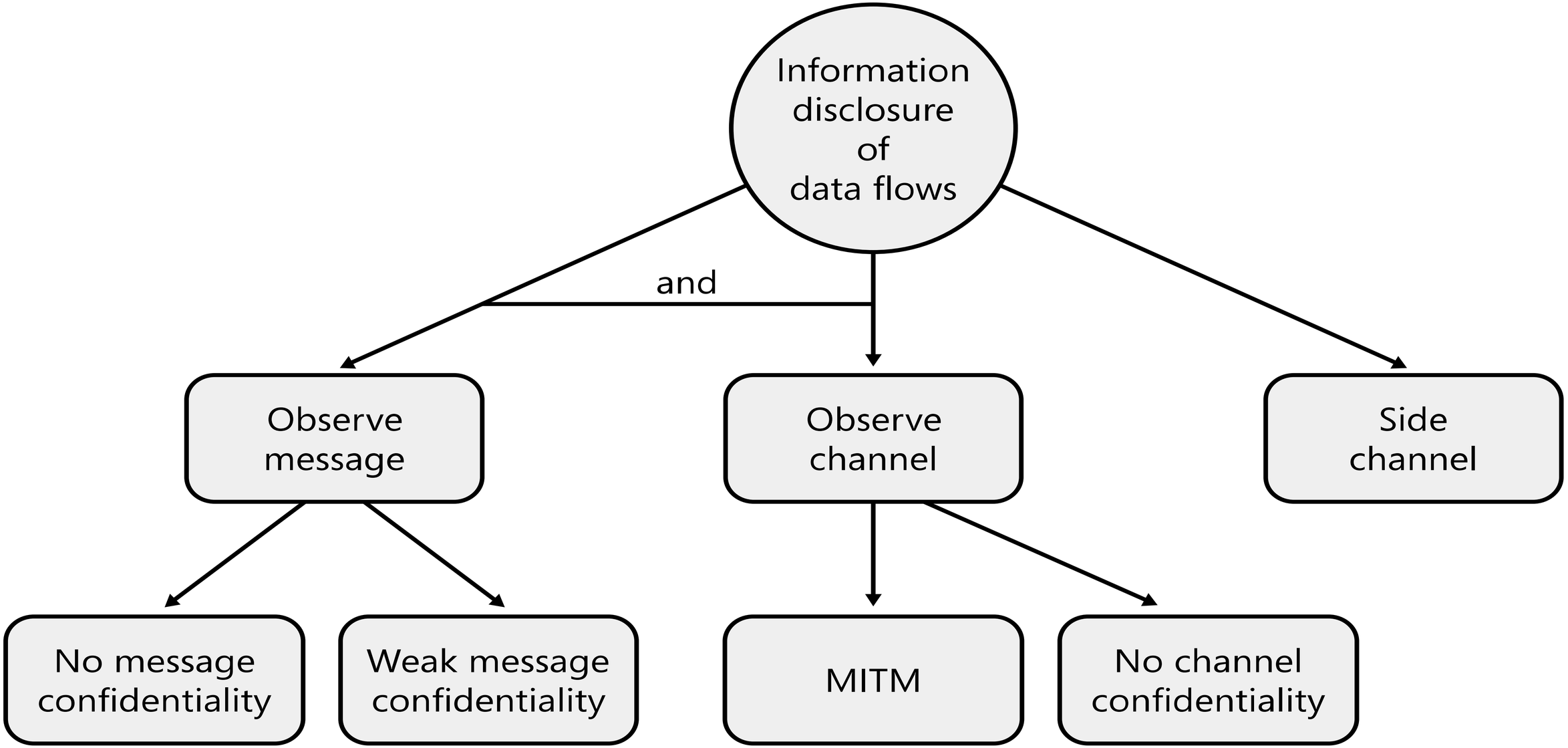
Repudiation



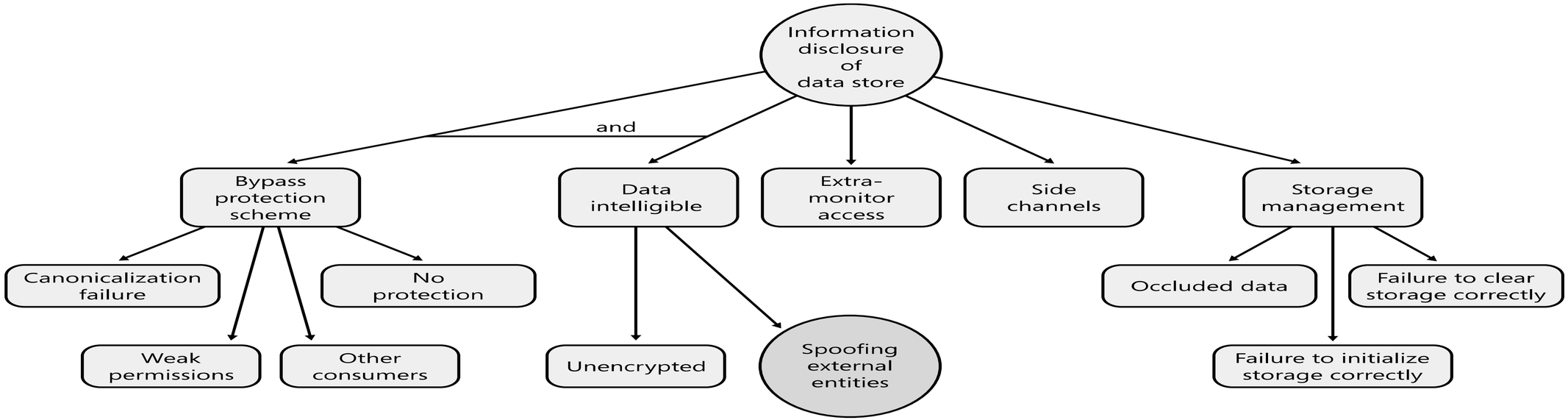
Information Disclosure of a Process



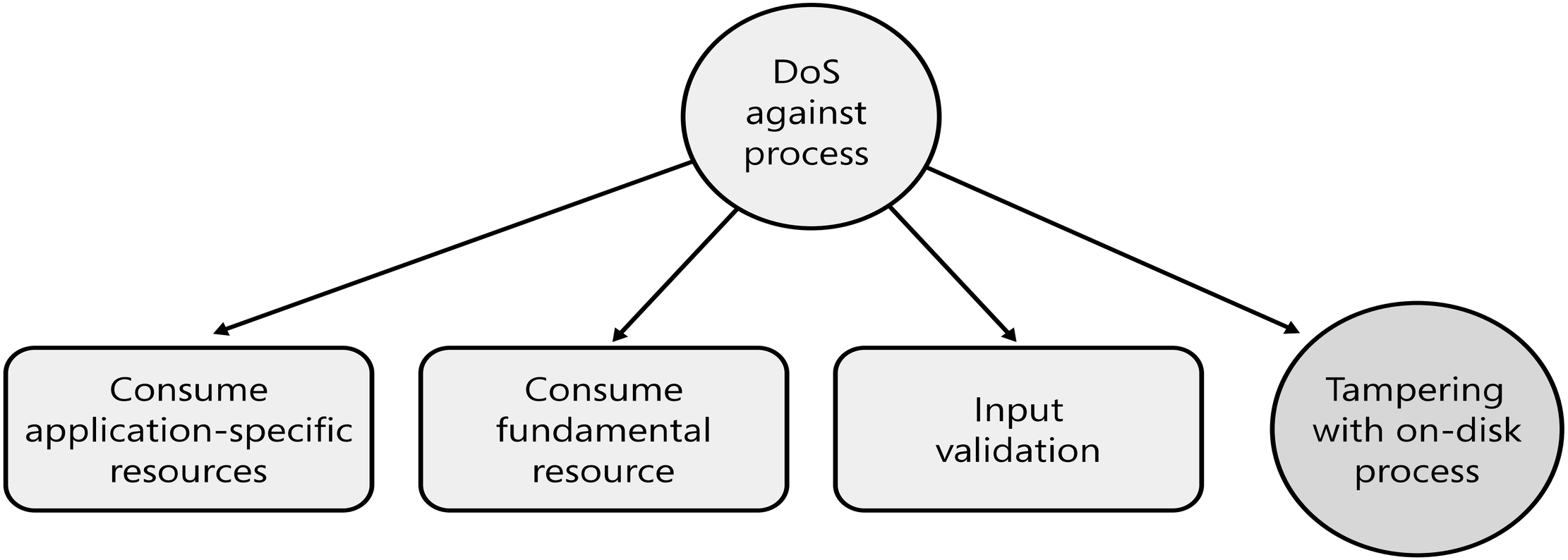
Information Disclosure of a Data Flow



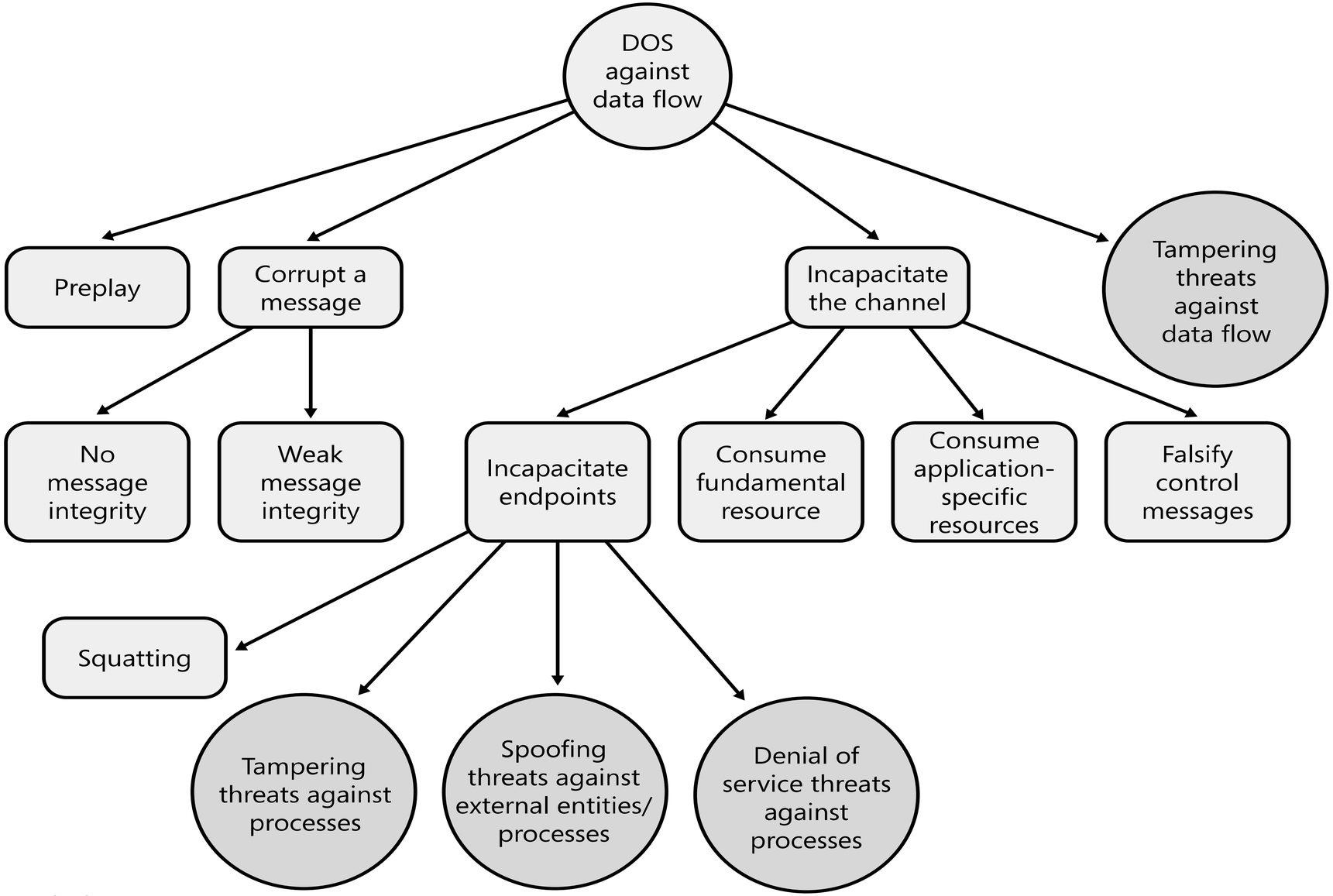
Information Disclosure of a Data Store



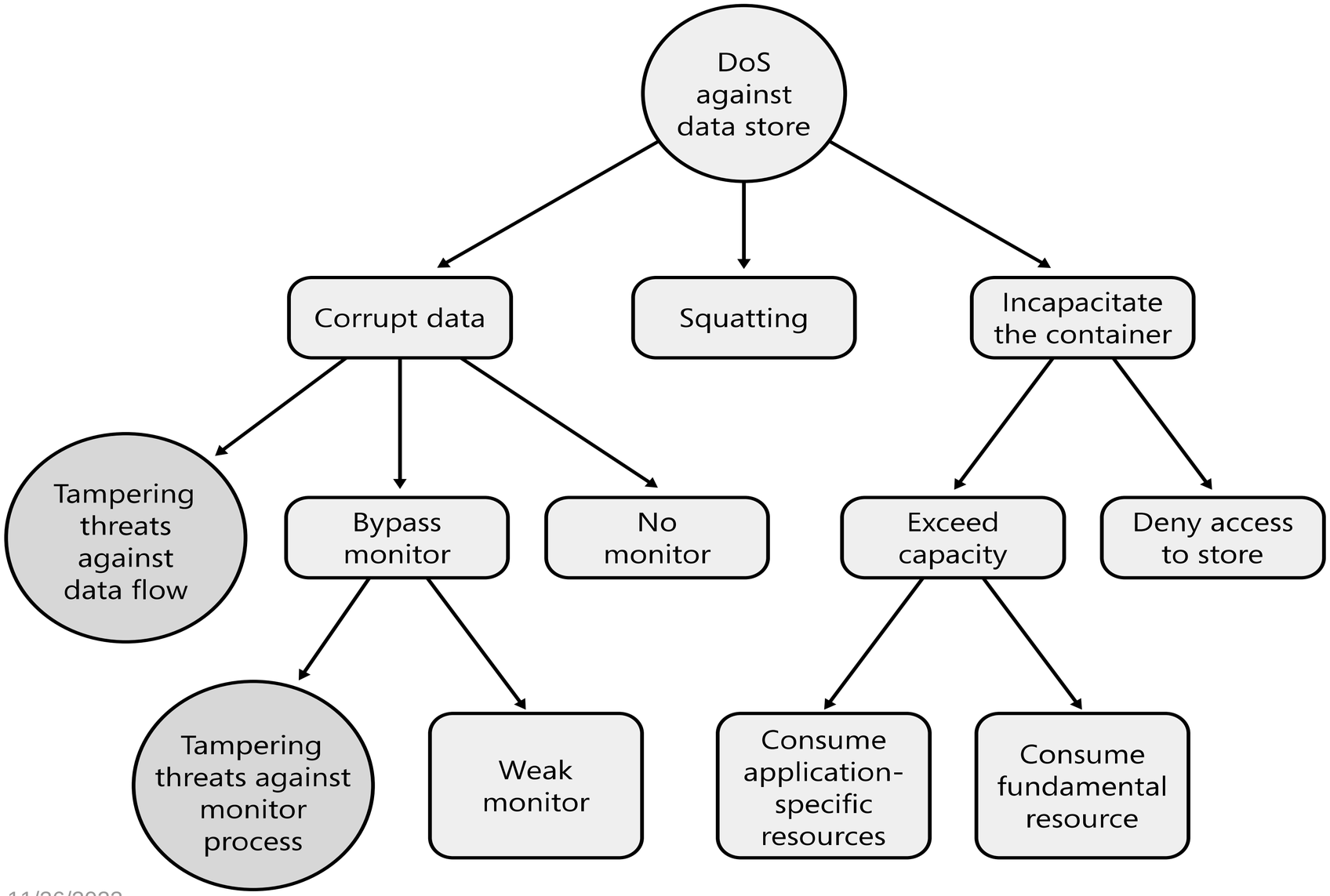
DoS against a Process



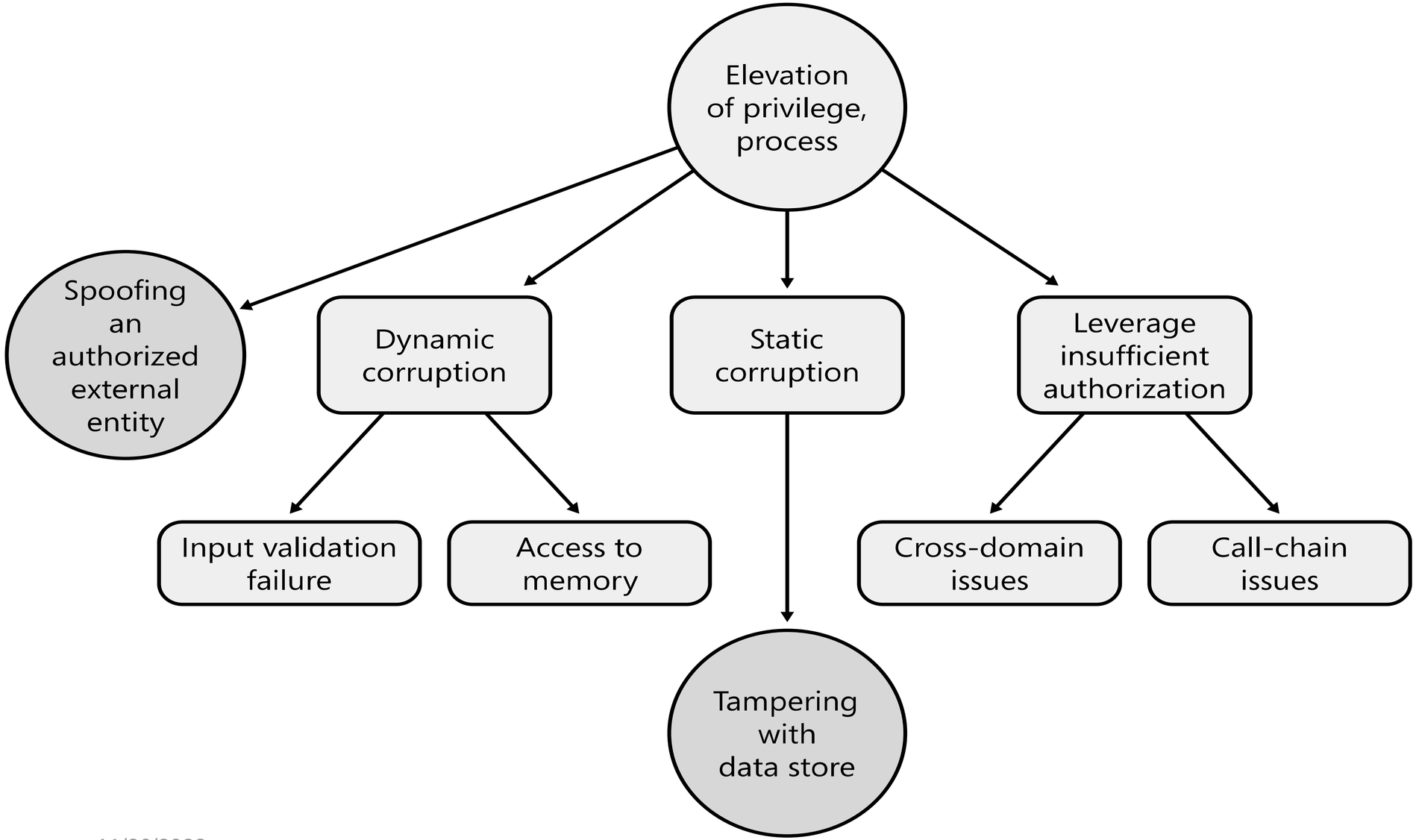
DoS against a Data Flow



DoS against a Data Store



Elevation of Privilege



Refining threats – An Example

DFD Element	Threat Type	Threat
Pet Shop Customer to Web application	Information Disclosure (I)	Observe message – No Message Confidentiality
Audit Log Data Store	Tampering (T)	Tampering with Data Store – Weak Protection
Order Processor	Elevation of Privileges (EoP)	Leverage Insufficient Authorization

Step 2: Assess the Risks

- Risk level given by the combination of likelihood and impact
- 4 Possible Risk Levels
  - 1 very high must be fixed during development phase
  - 2 high must be fixed during development phase
  - 3 medium must be fixed before the product becomes a release candidate
  - 4 low should be fixed only if time permits

How do you assess the risks?

- Microsoft SDL Requirement phase requires to specify **bug bars**
- A ***bug bar*** classifies threats based on the impact that they have
- First the bug is assigned a STRIDE threat category
- Then a risk level is associated with the threat based on
  - Server application versus client application.
  - Local versus remote accessibility
  - Accessibility to anonymous versus authenticated users
  - Accessibility to authenticated users versus administrators
  - The degree of user interaction required
  - In the case of an information disclosure threat, whether the data is personally identifiable information (PII) or is sensitive data
  - In the case of a DoS attack, whether the application continues service or is non func- tional once an attack stops

Assessing the risk level

STRIDE Threat Type	Client/Server	Scope	Risk Level
Spoofing	Client	Ability for attacker to present a UI that is different from but visually identical to the UI that users must rely on to make valid trust decisions in a default/common scenario	2
	Server	Computer connecting to server is able to masquerade as a different user or computer of his or her choice *using a protocol* that is designed and marketed to provide strong authentication.	2

Assessing the risk level

STRIDE Threat Type	Client/Server	Scope	Risk Level
Spoofing	Client	Ability for attacker to present a UI that is different from but visually identical to the UI that users are accustomed to trust in a specific scenario.	3
	Server	Client user or computer is able to masquerade as a different, random user or computer using a protocol that is designed and marketed to provide strong authentication.	3

Assessign the risk level

STRIDE Threat Type	Client/Server	Scope	Risk Level
Tampering/Repudiation	Client/Server	Permanent modification of any user data or data used to make trust decisions in a common or default scenario that persists after restarting the OS/application.	2
	Server	Temporary modification of data in a common or default scenario that does not persist after restarting the OS/application.	3
	Client	Temporary modification of any data that does not persist after restarting the OS/application.	4

Assessing the risk level

STRIDE Threat Type	Client/Server	Scope	Risk Level
Information Disclosure	Client/Server	Disclosure of PII (email addresses, phone numbers, credit card information)	2
	Client/Server	Attacker can locate and read information from anywhere on the system	2
	Client/Server	Attacker can locate and read information from known locations	3
	Client Server	Any untargeted information disclosure including runtime data	4

Assessing the risk level

STRIDE Threat Type	Client/Server	Scope	Risk Level
Denial of Service	Client	Requires reinstallation of system and/or components	2
	Client	Requires cold reboot or causes Blue Screen/Bug Check	3
	Client	Temporary DoS: restart of application	4
	Server	Anonymous user sends a small amount of data	2
	Server	Authenticated permanent DoS	3

Assessing the risk level

STRIDE Threat Type	Client/Server	Scope	Risk Level
Elevation of Privilege	Client/Server	Remote user with the ability to execute arbitrary code	1
	Client	Local, low-privilege user can elevate himself to another user, administrator or local system	2
	Server	Local authenticated user has the ability to execute arbitrary code or obtain more privilege than intended	2

Assessing Risks: An example

DFD Element	Threat Type	Threat	Risk Level
Pet Shop Customer to Web application	Information Disclosure (I)	Observe message – No Message Confidentiality	1
Audit Log Data Store	Repudiation(R)	Tampering with Data Store – Weak Protection	1
Order Processor	Elevation of Privileges (EoP)	Leverage Insufficient Authorization	1

Exercise4: Part 2 – Refine Threats and Assess Risks

1. For each identified threat type to a DFD element
    1. Refine into a concrete threat
    2. Assess the risk of the threat (from 1 to 4)

Time: 10 minutes

Step 3: Plan for Mitigations

- Four ways to address threats
  1. Do Nothing
  2. Remove the feature
  3. Accept vulnerability in design
  4. Counter the threats with technology
     - ✓ Use list of mitigation technologies

Standard Mitigations

Threat	Property	
Spoofing	Authentication	To authenticate principals: • MFA • Kerberos authentication • PKI systems, such as SSL or TLS and certificates • IPSec • Digitally signed packets To authenticate code or data: • Digital signatures • Message authentication codes • Hashes

Standard Mitigations

Threat	Property	
Tampering	Integrity	• Windows Vista mandatory integrity controls • ACLs • Digital signatures • Message authentication codes

Standard Mitigations

Threat	Property	
Repudiation	Nonrepudiation	• Strong authentication • Secure logging and auditing • Digital signatures • Secure time stamps • Trusted third parties

Standard Mitigations

Threat	Property	
Information Disclosure	Confidentiality	• Encryption • ACLs

Standard Mitigations

Threat	Property	
Denial of Service	Availability	• ACLs • Filtering • Quotas • Authorization • High-availability designs

Standard Mitigations

Threat	Property	
Elevation of Privilege	Authorization	• ACLs • Group or role membership • Privilege ownership • Permissions • Input validation

Example – Step 3 - Plan for Mitigations

DFD Element	Threat Type	Threat	Mitigation
Pet Shop Customer to Web application	I	Observe message	SSL/TLS
Audit Log Data Store	R	Bypass protection scheme	ACL and MAC
Order Processor	EoP	Leverage Insufficient Authorization	ACL

Step 4: Validating Threat Models

- Validate the whole threat model
  - Does diagram match final code?
  - Are threats enumerated?
  - Minimum: STRIDE per element that touches a trust boundary
  - Is each threat mitigated?
  - Are mitigations done right?

Summary

- Threat modeling helps to find and proactively mitigate security design flaws before the system is built
- Microsoft STRIDE is a systematic process to identify and mitigate security design flaws
- It can be use by non security experts
  - taxonomy of threats
  - threats tree patterns
  - standard mitigations for threats

Recommended Readings

- Threat modeling

  https://www.ncsc.gov.uk/collection/risk-management/threat-modelling
- M. Howard and S. Lipner. The Security Development Life Cycle,2006. Chapters 9 and 22
- Threat Modeling Available at: https://www.owasp.org/index.php/Application_Threat_Modeling
- Threat Modeling Lessons from Star Wars (and Elsewhere): Available at: https://www.youtube.com/watch?v=KLpgaoD8ySM