Software Security Engineering Lecture 8 (Threat Modeling material from David Ladd at Microsoft)

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Outline

I. How to Threat Model

II. The STRIDE per Element Approach to Threat Modeling

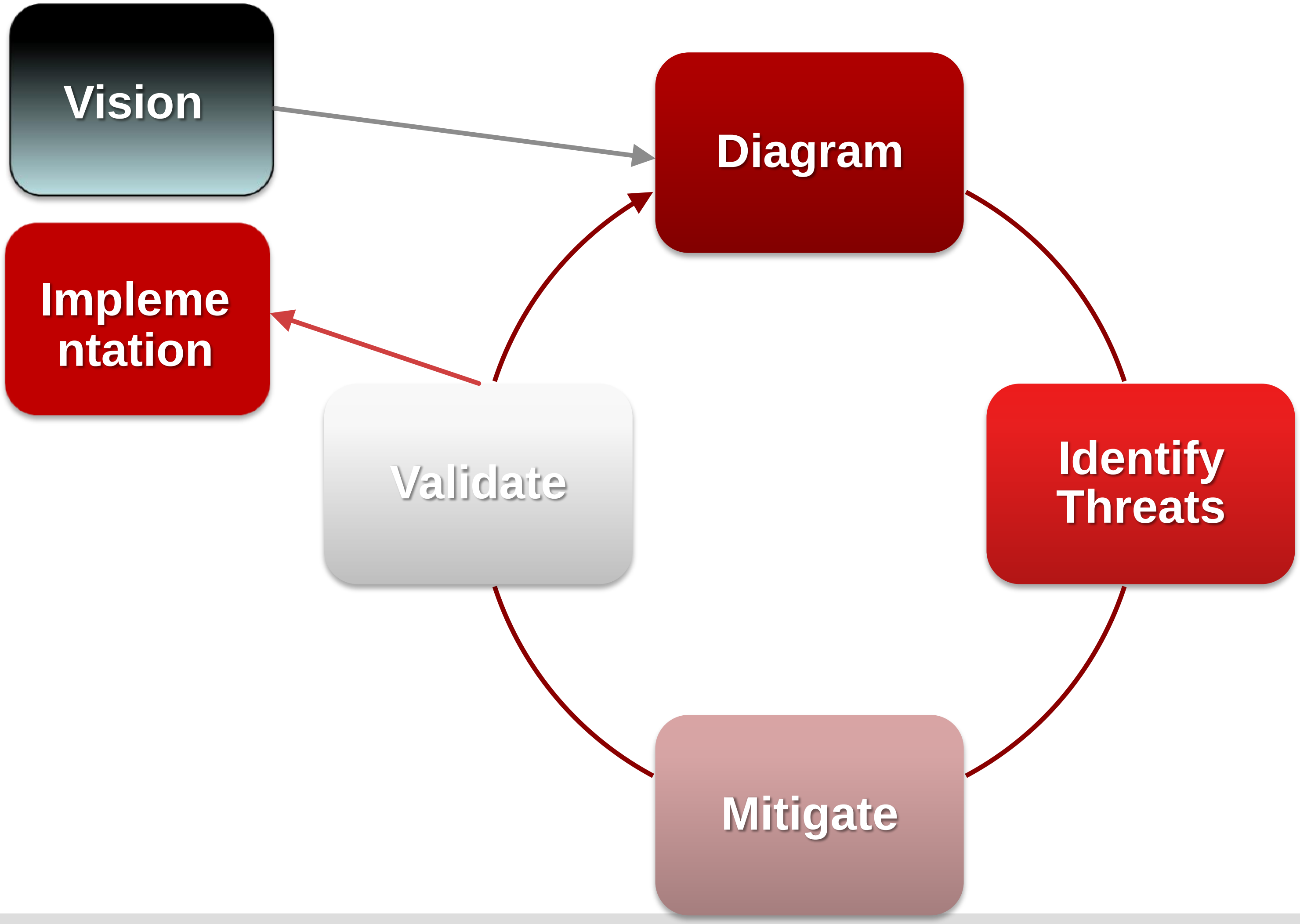
III. Diagram Validation Rules of Thumb

IV. Exercise

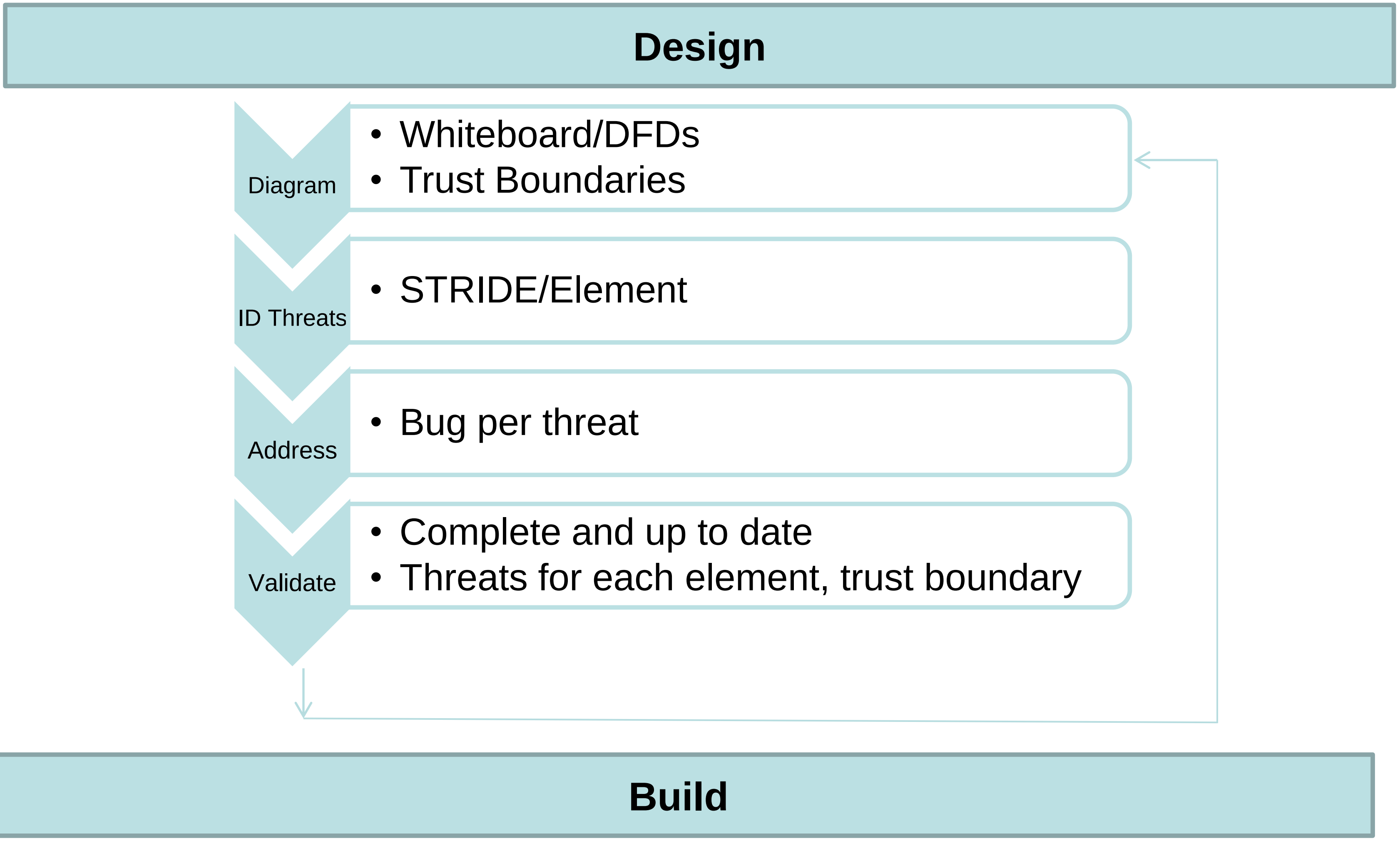
V. Demo Video

How to Threat Model

The Process in a Nutshell

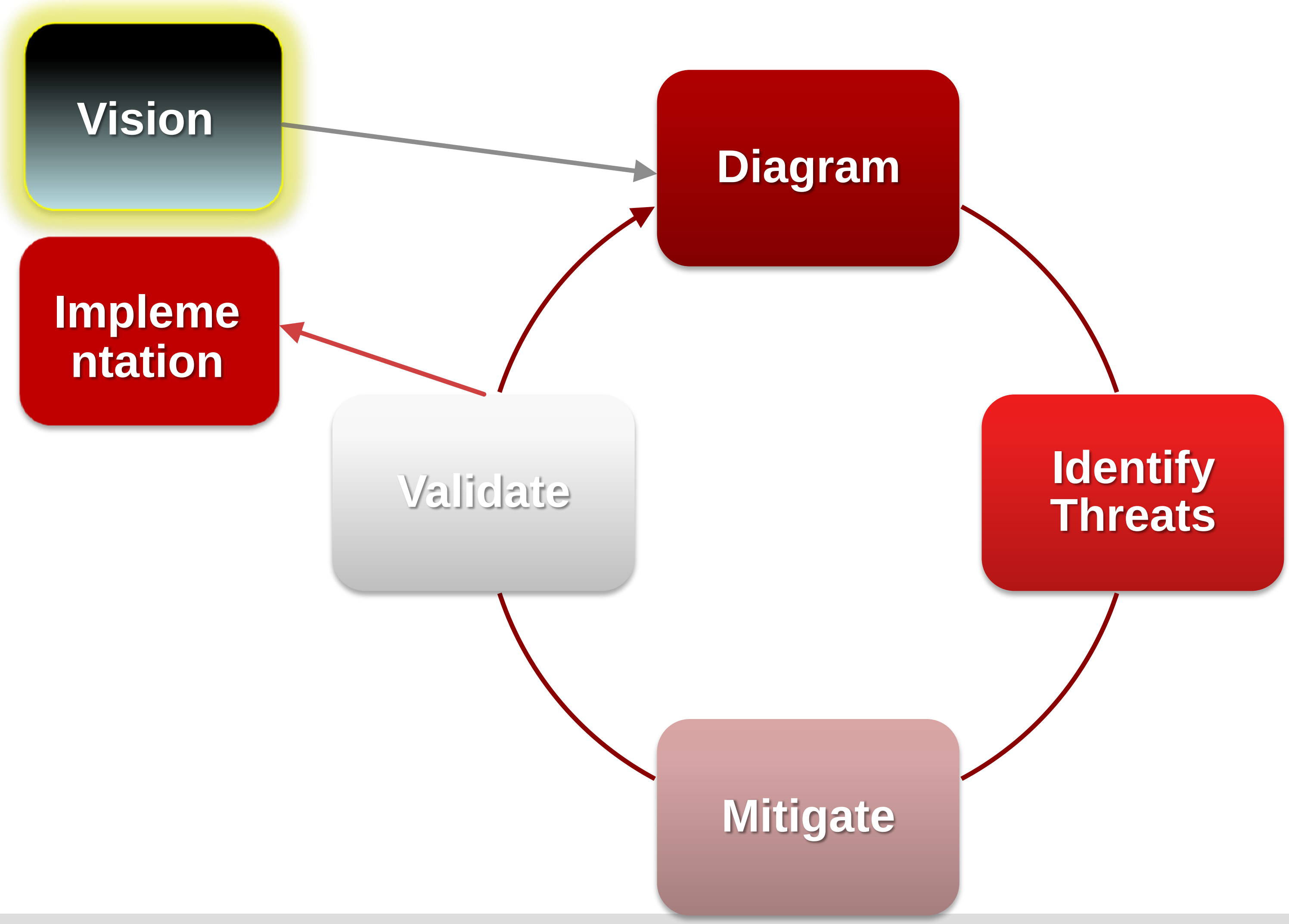


The Process at a glance



Microsoft Confidential

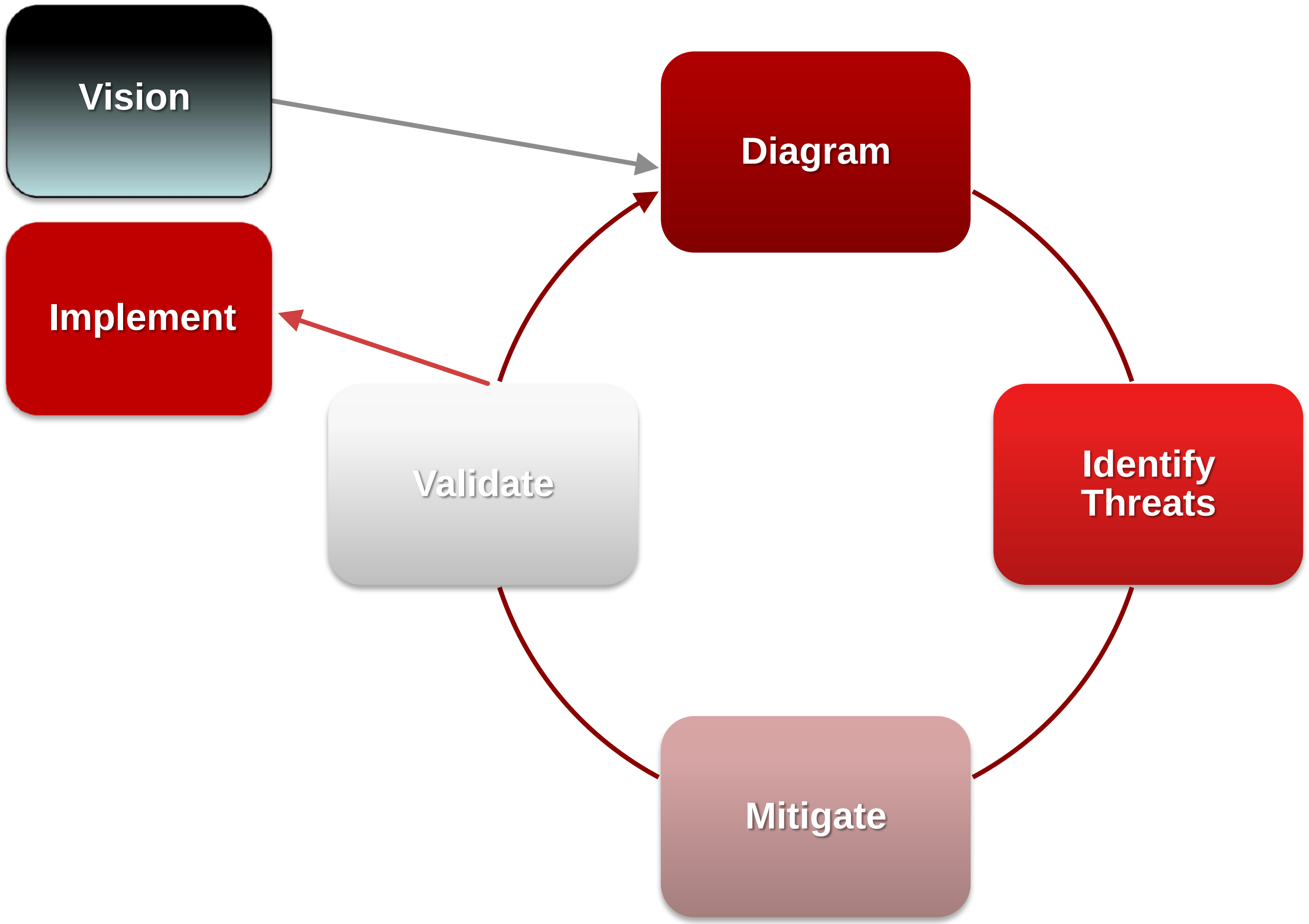
The Process in a Nutshell



Vision

- Scenarios
  - Where do you expect the product to be used?
  - Live.com is different from Windows Vista
- Use cases / personas
- Add security to scenarios, use cases
  - Think about what are you telling customers about the product’s security…

The Process: Diagramming



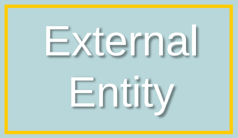
How to Create Diagrams

- Go to the whiteboard
- Start with an overview which has:
  - A few external interactors
  - One or two processes
  - One or two data stores (maybe)
  - Data flows to connect them
- Check your work
  - Can you tell a story without edits?
  - Does it match reality?

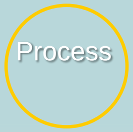
Diagramming

- Use DFDs (Data Flow Diagrams)
  - Include processes, data stores, data flows
  - Include *trust boundaries*
  - Diagrams per scenario may be helpful
- Update diagrams as product changes
- Enumerate assumptions, dependencies
- Number everything (if manual)

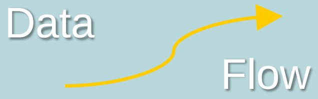
Diagram Elements: Examples



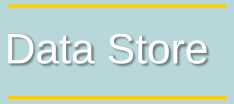
- People
- Other systems
- Microsoft.com



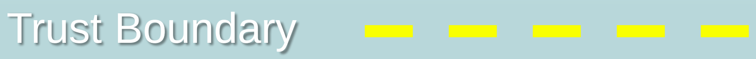
- DLLs
- EXEs
- COM object
- Components
- Services
- Web Services
- Assemblies



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



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



- Process boundary
- File system

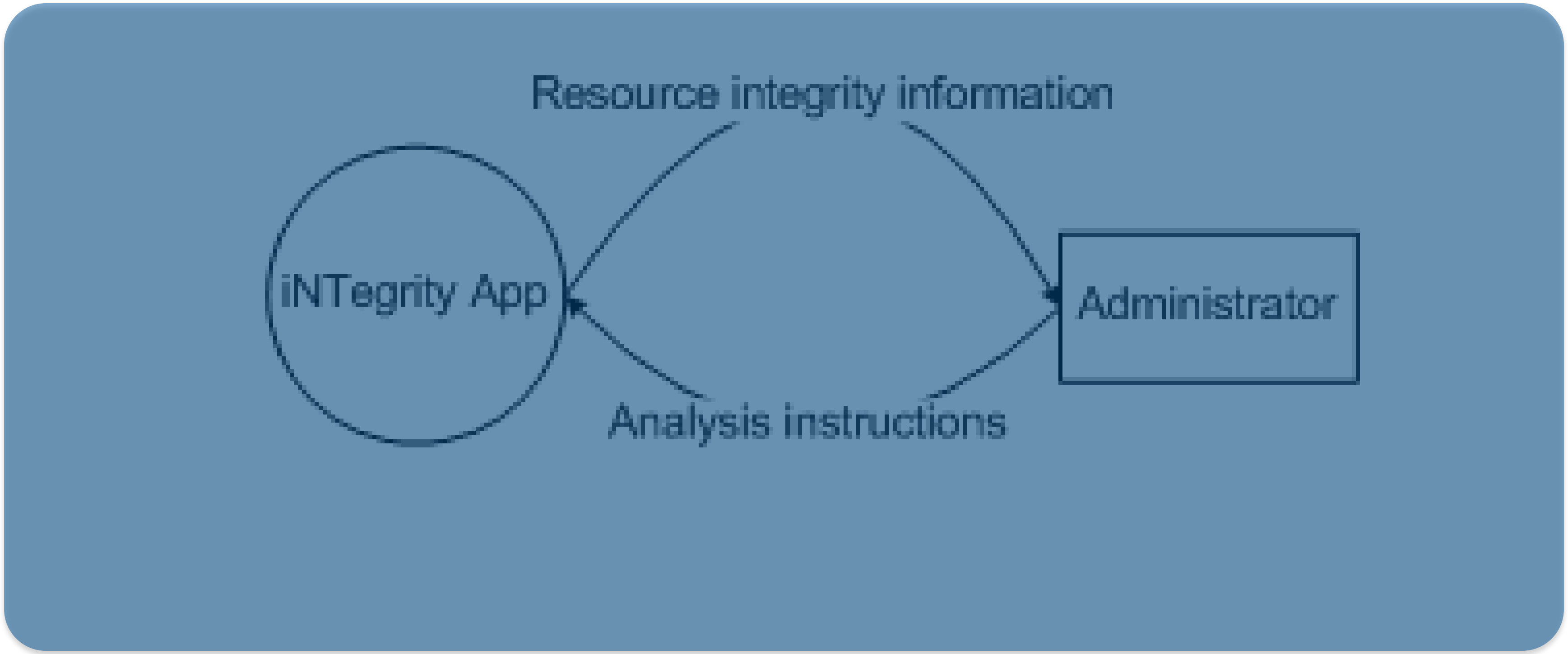
Diagrams: Trust Boundaries

- Add trust boundaries that intersect data flows
- Points/surfaces where an attacker can interject
  - Machine boundaries, privilege boundaries, integrity boundaries are examples of trust boundaries
  - Threads in a native process are often inside a trust boundary, because they share the same privs, rights, identifiers and access
- Processes talking across a network always have a trust boundary
  - They may create a secure channel, but they’re still distinct entities
  - Encrypting network traffic is an ‘instinctive’ mitigation
    - But doesn’t address tampering or spoofing

Diagram Iteration

- Iterate over processes, data stores, and see where they need to be broken down
- How to know it “needs to be broken down?”
  - More detail is needed to explain security impact of the design
  - Object crosses a trust boundary
  - Words like “sometimes” and “also” indicate you have a combination of things that can be broken out
    - “Sometimes this datastore is used for X”…probably add a second datastore to the diagram

Context Diagram



Level 1 Diagram

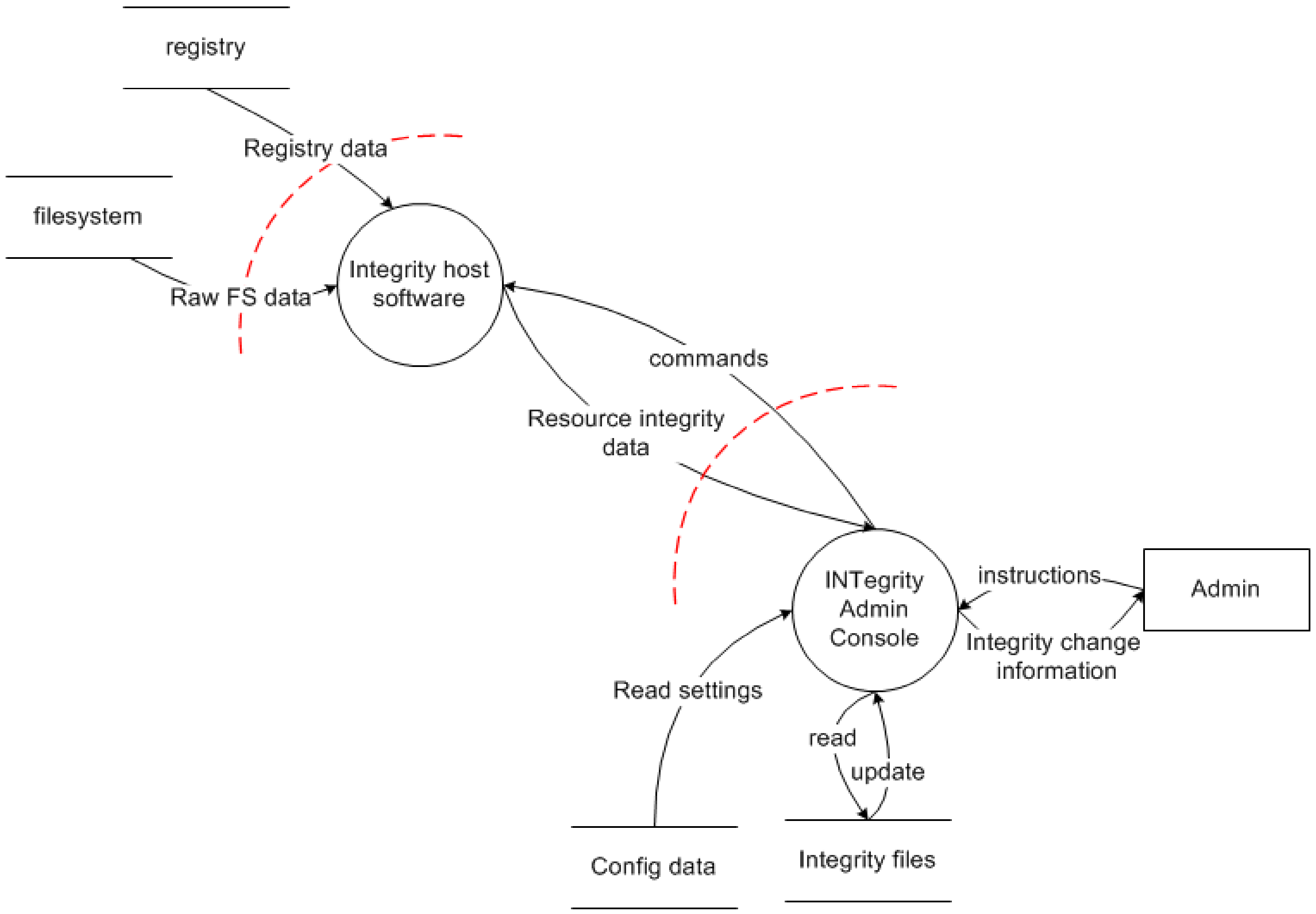


Diagram Layers

- Context Diagram
  - Very high-level; entire component / product / system
- Level 1 Diagram
  - High level; single feature / scenario
- Level 2 Diagram
  - Low level; detailed sub-components of features
- Level 3 Diagram
  - More detailed
  - Rare to need more layers, except in huge projects or when you're drawing more trust boundaries

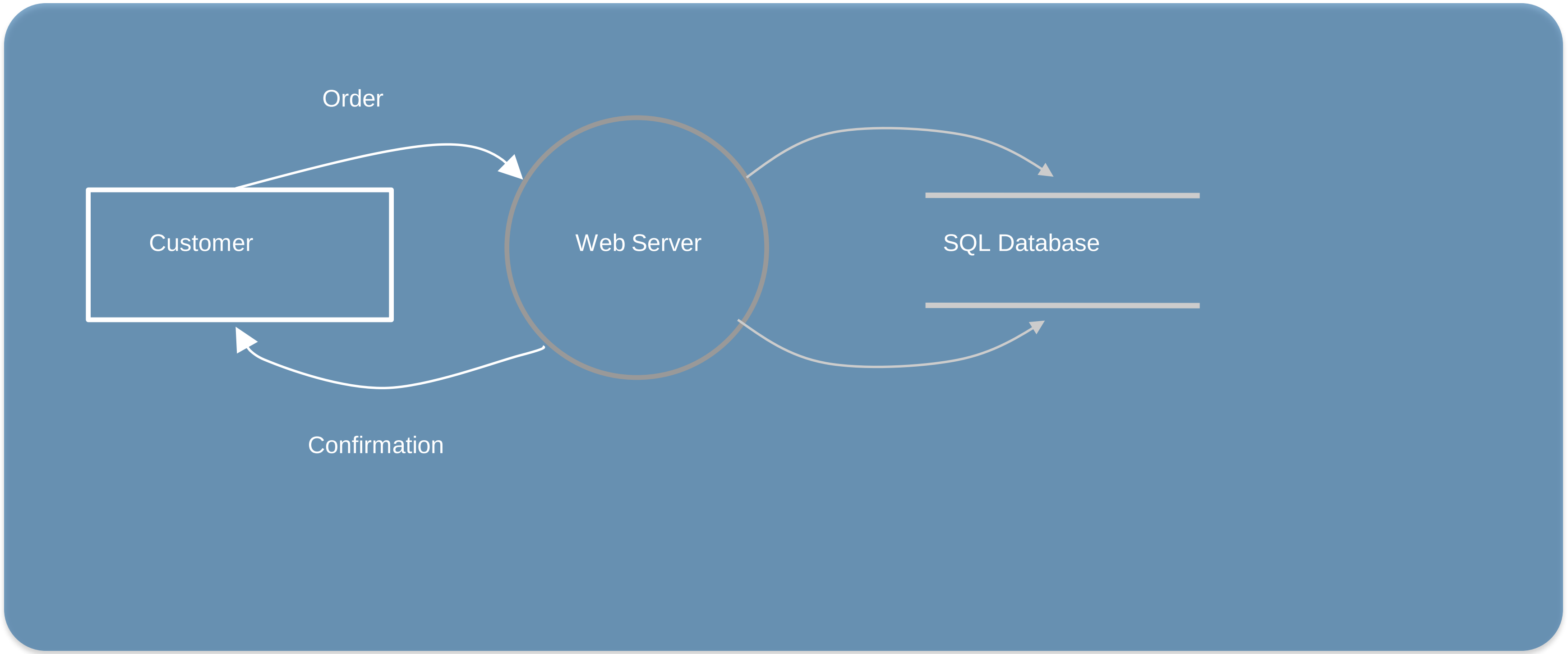
Creating Diagrams: analysis or synthesis?

- Top down
  - Gives you the “context” in context diagram
  - Focuses on the system as a whole
  - More work at the start
- Bottom up
  - Feature crews know their features
  - Approach not designed for synthesis
  - More work overall

Diagram Validation Rules of Thumb

Diagram Validation Rules of Thumb

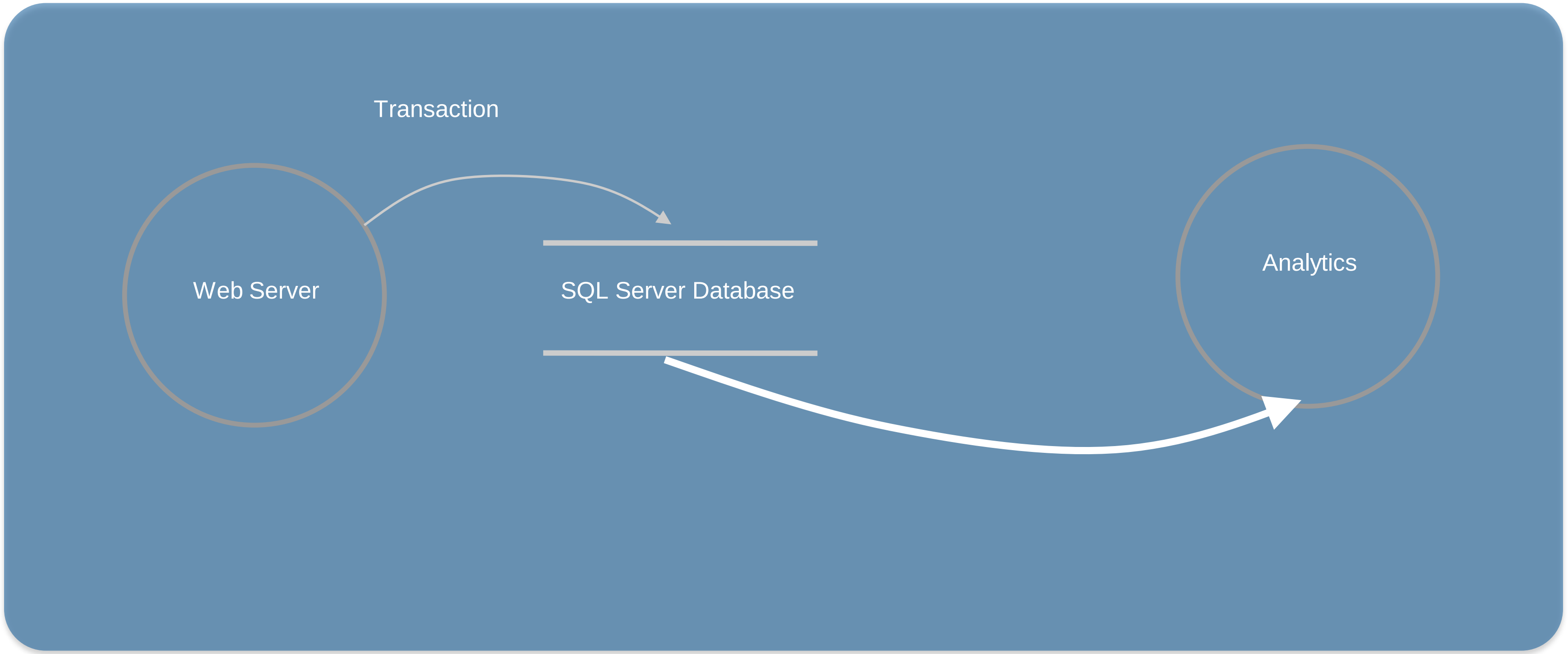
Does data magically appear?



Data comes from external entities or data stores

Diagram Validation Rules of Thumb

Are there data sinks?



You write to a store for a reason: Someone uses it.

Diagram Validation Rules of Thumb

Data doesn't flow magically

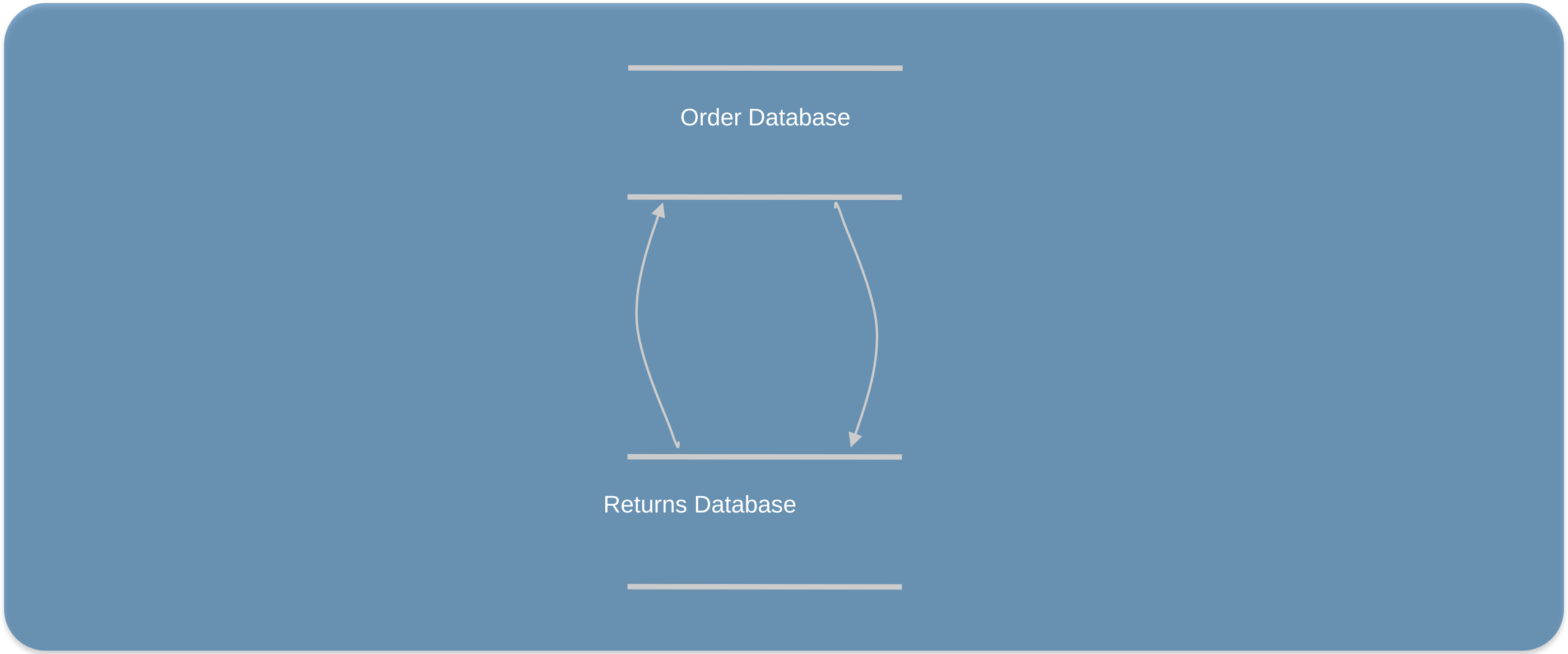
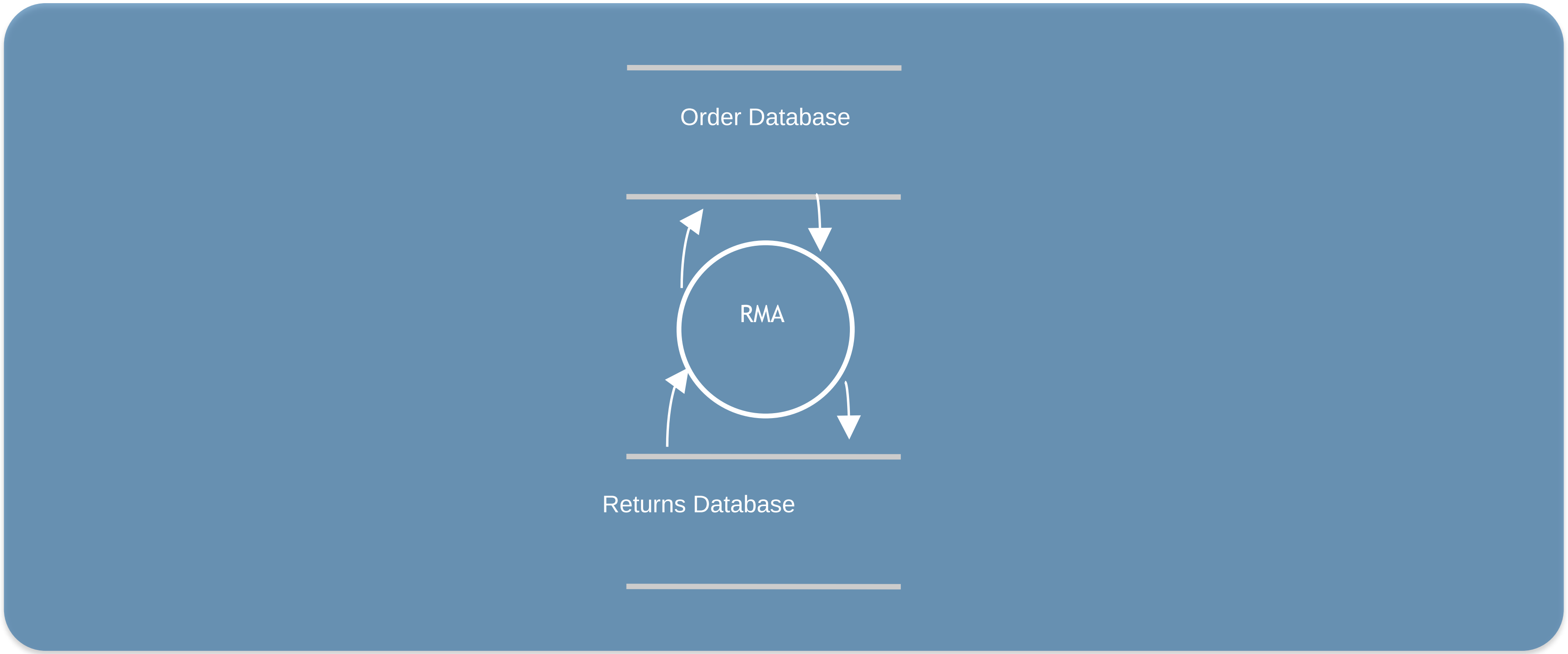


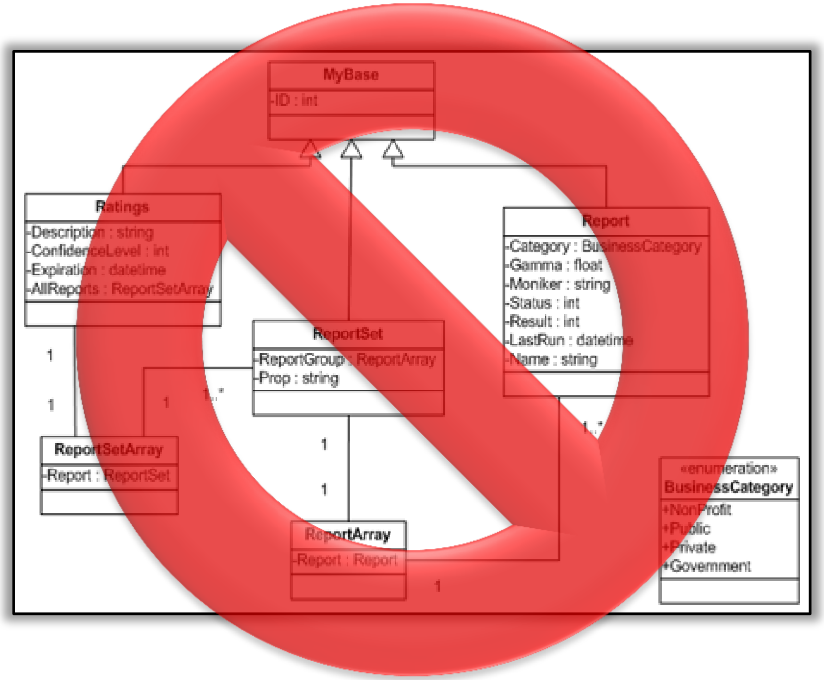
Diagram Validation Rules of Thumb

It goes through a process



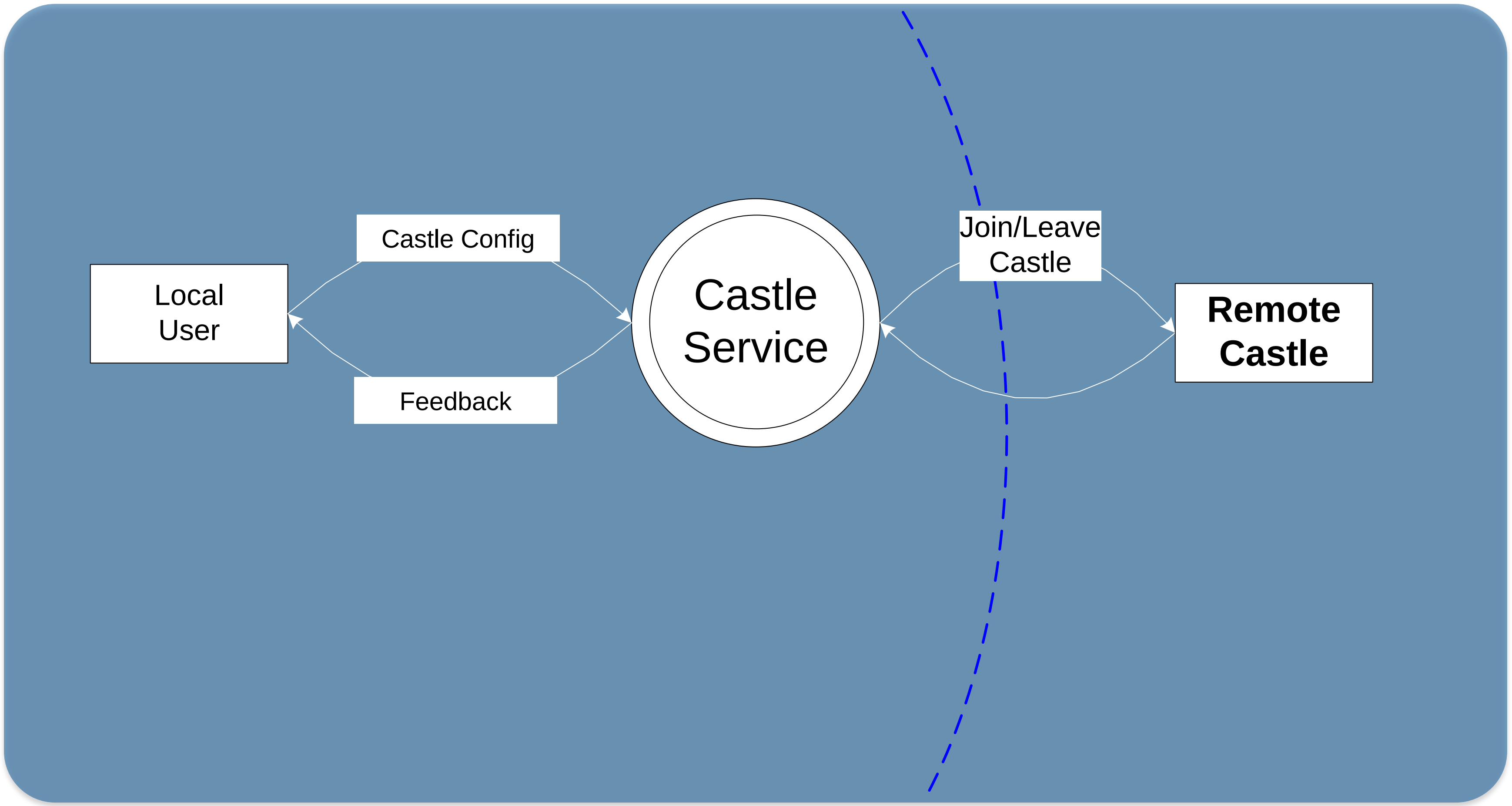
Diagrams Should Not Resemble

- Flow charts
- Class diagrams
- Call graphs

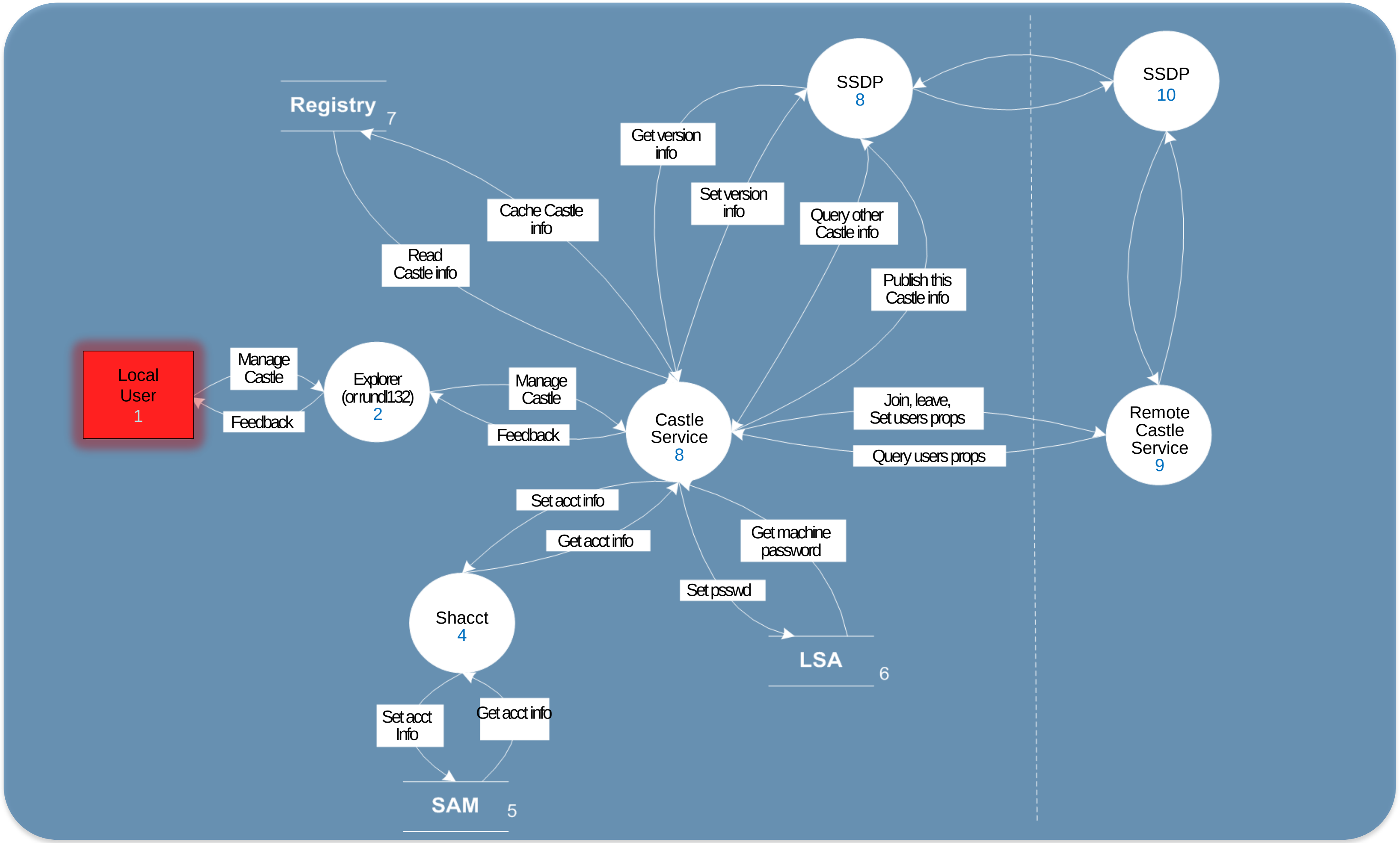


SQL Server Security Flowchart
Are you using replication?
Are you using remote data access (RDA)?
STOP

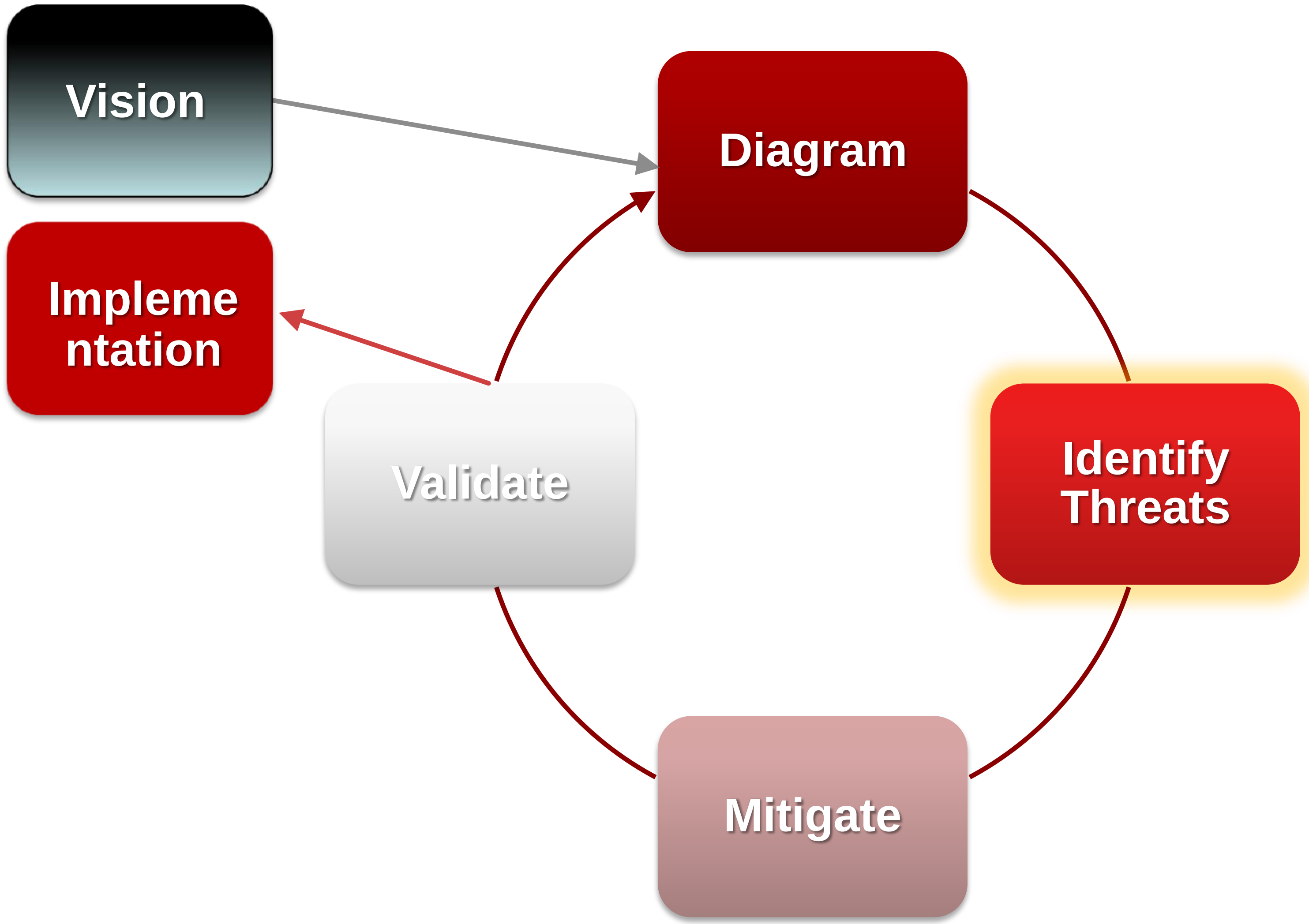
Real Context Diagram ("Castle")



Castle Level 1 Diagram



The Process: Identifying Threats



Identifying 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	**T**ampering
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	**I**nformation 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	**D**enial 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	**E**levation 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

Different Threats Affect Each Element Type

ELEMENT	S	T	R	I	D	E
External Entity	✓		✓			
Process	✓	✓	✓	✓	✓	✓
Data Store		✓	?	✓	✓	
Data Flow		✓		✓	✓	

Apply STRIDE Threats to Each Element

- For each item on the diagram:
  - Apply relevant parts of STRIDE
  - Process: STRIDE
  - Data store, data flow: TID
    - Data stores that are logs: TID+R
  - External entity: SR
  - Data flow inside a process:
    - Don’t worry about T, I, or D
- This is why you number things

Use the Trust boundaries

Trusted/ high code reading from untrusted/low

- Validate everything for specific and defined uses

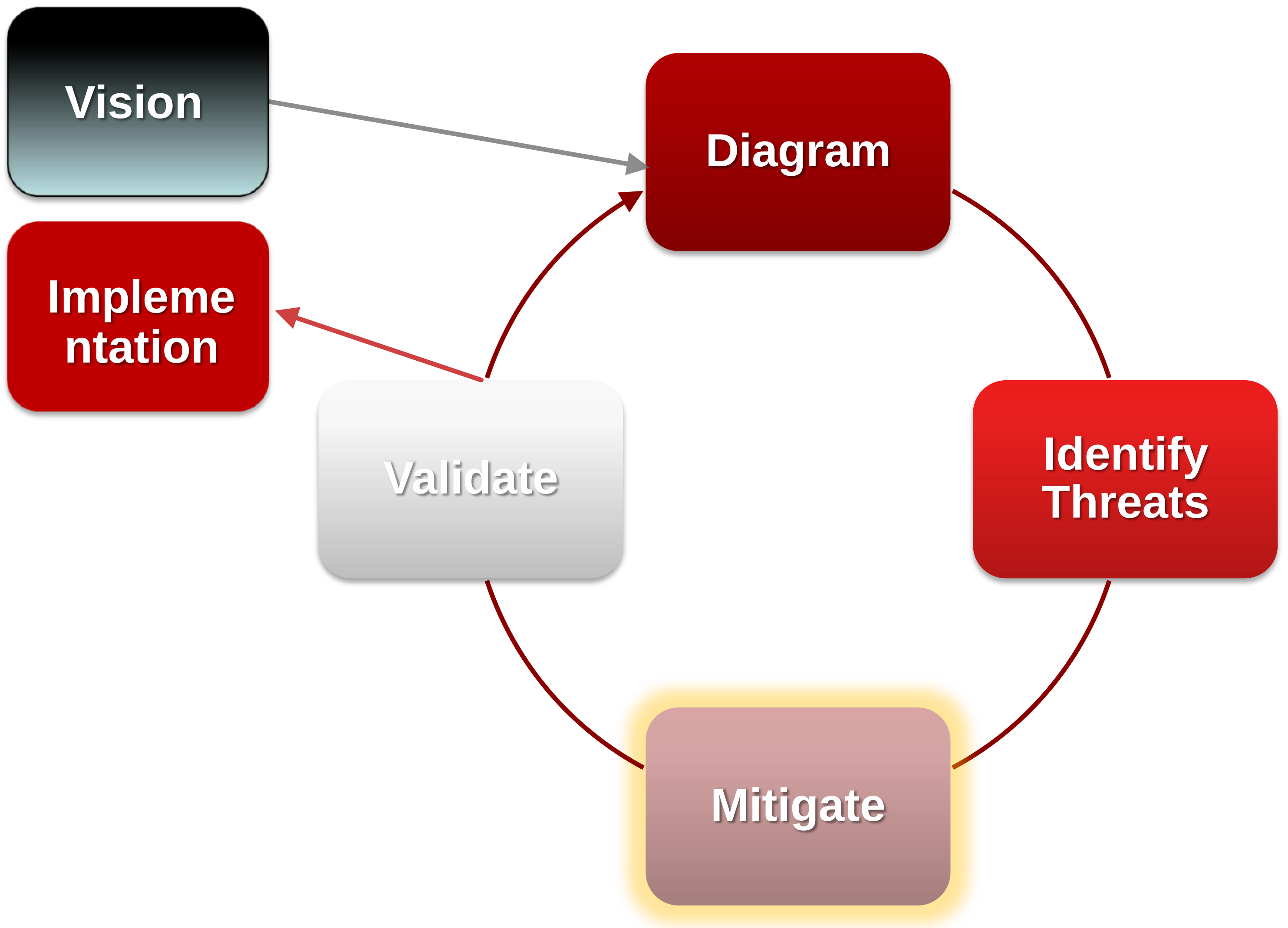
High code writing to low

- Make sure your errors don’t give away too much

Threats and Distractions

- Don’t worry about these threats
  - The computer is infected with malware
  - Someone removed the hard drive and tampers
  - Admin is attacking user
  - A user is attacking himself
- You can’t address any of these (unless you’re the OS)

The Process: Mitigation



Mitigation Is the Point of Threat Modeling

- Mitigation
  - To address or alleviate a problem
- Protect customers
- Design secure software
- Why bother if you:
  - Create a great model
  - Identify lots of threats
  - Stop
- So, find problems and fix them

Mitigate

- Address each threat
- Four ways to address threats
  1. Redesign to eliminate
  2. Apply standard mitigations
     - What have similar software packages done and how has that worked out for them?
  3. Invent new mitigations (riskier)
  4. Accept vulnerability in design
     - SDL rules about what you can accept
- Address each threat

Standard Mitigations

Spoofing	Authentication	To authenticate principals: • Cookie authentication • Kerberos authentication • PKI systems such as SSL/TLS and certificates To authenticate code or data: • Digital signatures
Tampering	Integrity	• Windows Vista Mandatory Integrity Controls • ACLs • Digital signatures
Repudiation	Non Repudiation	• Secure logging and auditing • Digital Signatures
Information Disclosure	Confidentiality	• Encryption • ACLS
Denial of Service	Availability	• ACLs • Filtering • Quotas
Elevation of Privilege	Authorization	• ACLs • Group or role membership • Privilege ownership • Input validation

Inventing Mitigations Is Hard: Don’t do it

- Mitigations are an area of expertise, such as networking, databases, or cryptography
- Amateurs make mistakes, but so do pros
- Mitigation failures will appear to work
  - Until an expert looks at them
  - We hope that expert will work for us
- When you need to invent mitigations, get expert help

Sample Mitigation

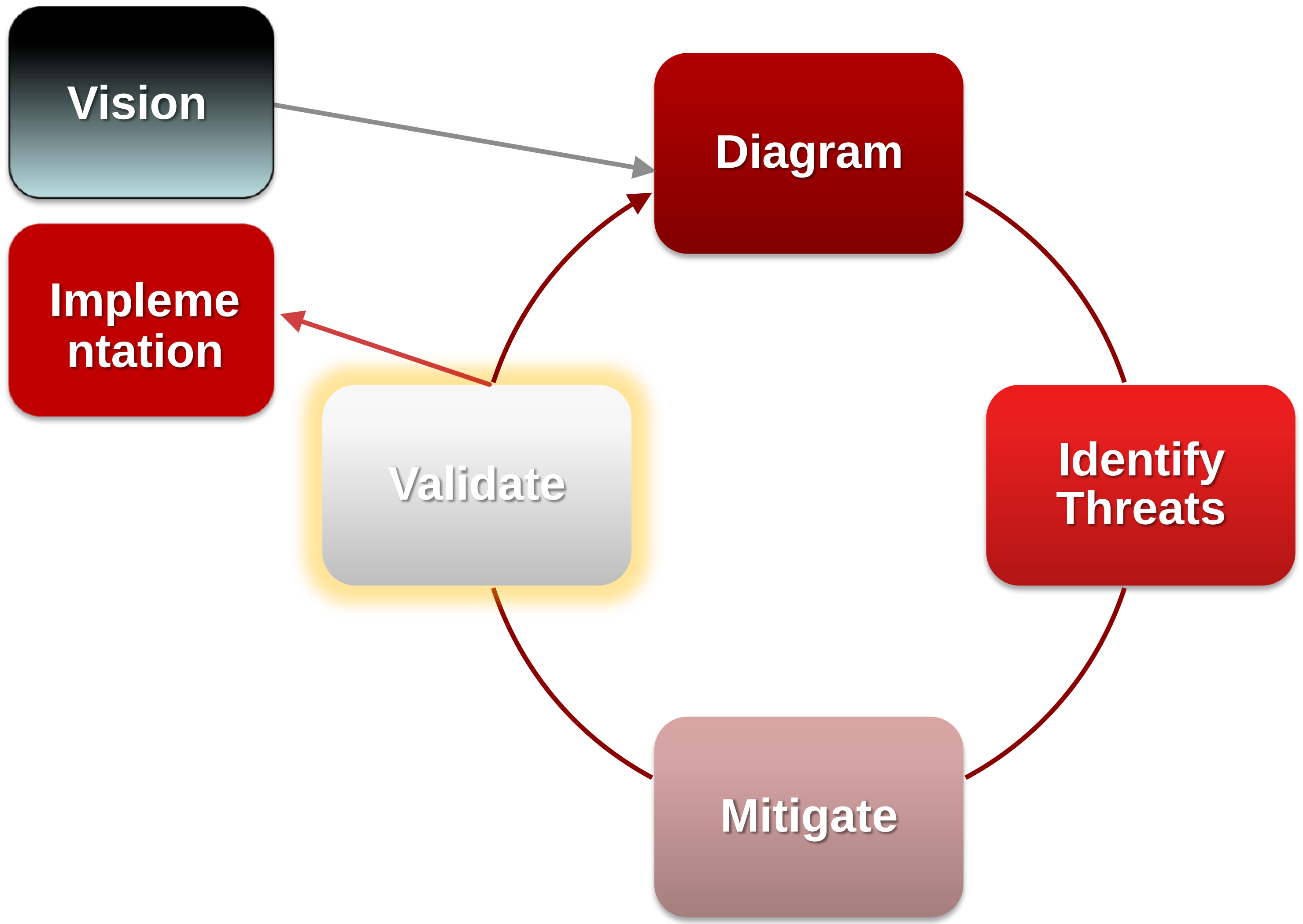
- Mitigation #54, Rasterization Service performs the following mitigation strategies:
  1. OM is validated and checked by (component) before being handed over to Rasterization Service
  2. The resources are decoded and validated by interacting subsystems, such as [foo], [bar], and [boop]
  3. Rasterization ensures that if there are any resource problems while loading and converting OM to raster data, it returns a proper error code
  4. Rasterization Service will be thoroughly fuzz tested

(Comment: Fuzzing isn't a mitigation, but it's a great thing to plan as part 4)

Improving Sample Mitigation: Validated-For

- "OM is validated and checked by [component] before being handed over to Rasterization Service"
- Validated for what? Be specific!
  - "…validates that each element is unique."
  - "…validates that the URL is RFC-1738 compliant, but note URL may be to http://evil.com/ownme.html"
  - (Also a great external security note)

The Process: Validation



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
  - Has Test / QA reviewed the model?
    - Tester approach often finds issues with threat model or details
  - Is each threat mitigated?
  - Are mitigations done right?
- Did you check these before Final Security Review?
  - Shipping will be more predictable

Validate Quality of Threats and Mitigations

- Threats: Do they:
  - Describe the attack
  - Describe the context
  - Describe the impact
- Mitigations
  - Associate with a threat
  - Describe the mitigations
  - File a bug
    - ✗ Fuzzing is a test tactic, not a mitigation

Validate Information Captured

Dependencies

- What other code are you using?
- What security functions are in that other code?
- Are you sure?

Assumptions

- Things you note as you build the threat model
  - ✗ "HTTP.sys will protect us against SQL Injection"
  - ✗ "LPC will protect us from malformed messages"
  - ✓ GenRandom will give us crypto-strong randomness

More Sample Mitigations

- Mitigation #3: The Publish License is created by RMS, and we've been advised that it's only OK to include an unencrypted e-mail address if it's required for the service to work. Even if it is required, it seems like a bad idea due to easy e-mail harvesting.
- Primary Mitigation: Bug #123456 has been filed against the RMS team to investigate removing the e-mail address from this element. If that's possible, this would be the best solution to our threat.
- Backup Mitigation: It's acceptable to mitigate this by warning the document author that their e-mail address may be included in the document. If we have to ship it, the user interface will be updated to give clear disclosure to the author when they are protecting a document.

Effective Threat Modeling Meetings

- Develop draft threat model before the meeting
  - Use the meeting to discuss
- Start with a DFD walkthrough
- Identify most interesting elements
  - Assets (if you identify any)
  - Entry points/trust boundaries
- Walk through STRIDE against those elements
- Threats that cross elements/recur
  - Consider library, redesigns

Threat Modeling Video

Call to Action

- Threat model your work!
  - Start early
  - Track changes
- Work with a Security Advisor!
- Talk to your “dependencies” about security assumptions
- Learn mores

Threat Modeling Learning Resources

- MSDN Magazine
  - Reinvigorate your Threat Modeling Process
  - Threat Modeling: Uncover Security Design Flaws Using The STRIDE Approach
- Article
  - Experiences Threat Modeling at Microsoft
- SDL Blog
  - All threat modeling posts
- Books
  - *The Security Development Lifecycle: SDL: A Process for Developing Demonstrably More Secure Software*
    (Howard, Lipner, 2006) “Threat Modeling” chapter

Resources

Microsoft Security Development Lifecycle
Secure Software Made Easier
Home
About
Process Guidance
Tools
Forums
Support

Highlights

» **SDL Guidance Updated for Agile Development Methodologies** Download the latest SDL process guidance that includes SDL for Agile Development, a streamlined approach that melds Agile methods and security.

» **Security Considerations for Client and Cloud Applications** Download a whitepaper about how Microsoft addresses potential security vulnerabilities during the development of "client and cloud" applications using the SDL.

» **Microsoft Silverlight 1.0: An SDL Implementation Story** Learn how the Microsoft Silverlight team met and exceeded the Security Development Lifecycle (SDL) requirements for every phas of the Silverlight 1.0 release.

» **Preventing Security Development Errors** Read a whitepaper about how the Windows Live Team applied the Security Development Lifecycle (SDL) to the development of new Windows Live services with ASP.NET MVC.

» **Manual Integration of the SDL Process Template**

Recent Posts

Introducing the InfoSec Assessment & Protection Suite
Announcing SDL for Agile Development Methodologies
SDL at TechEd Europe and Platforma
SIR Volume 7 Released
Ninjas are cool, but engineers build bridges

Introducing the InfoSec Assessment & Protection Suite

The Information Security Tools (IST) team has released the InfoSec Assessment & Protection (A&P) Suite. It's a suite made up of protection and assessment tools which include:

- **Web Protection Library (WPL)** - an umbrella for several libraries and runtime modules incl V3.1) and S when downl

Best Practices for the Security API
Certificate Enrollment API
Cryptography
Cryptography API: Next Generatio
Parental Controls
SDL - Process Guidance
SDL Process
Introduction
Pre-SDL Requirements: Se
Phase 1: Requirements
Phase 2: Design
Phase 3: Implementation
Phase 4: Verification
Phase 5: Release
Post-SDL Requirement: Re
SDL for Agile Development
SDL Process for Line-of-Busin
SDL Process – Appendix
Security Devices

MSDN › MSDN Library › Win32 and COM Development › Security › SDL - Process

Microsoft Security Development Lifecycle (SI

Introduction
Pre-SDL Requirements: Security Training
Phase 1: Requirements
Phase 2: Design
Phase 3: Implementation
Phase 4: Verification
Phase 5: Release
Post-SDL Requirement: Response
Content Disclaimer

The following documentation on the Microsoft Security Development Lifecycle, version
This documentation is not an exhaustive reference on the SDL process as practiced at M

Microsoft

Microsoft® Security Development Lifecycle

Version 4.1a
November 10, 2009
For the latest information, please see http://www.microsoft.com/sdl.

SDL Portal

http://www.microsoft.com/sdl

SDL Blog

http://blogs.msdn.com/sdl/

SDL Process on MSDN (Web)

http://msdn.microsoft.com/en-us/library/cc307748.aspx

SDL Process on MSDN (MS Word)

http://www.microsoft.com/downloads/details.aspx?FamilyID=d045a05a-c1fc-48c3-b4d5-b20353f97122&displaylang=en

Questions?

Looking Ahead: Lecture # 9

- Attack Surface
- Measurement Extensions
- Inspecting for Security

Case Study Assignment # 5

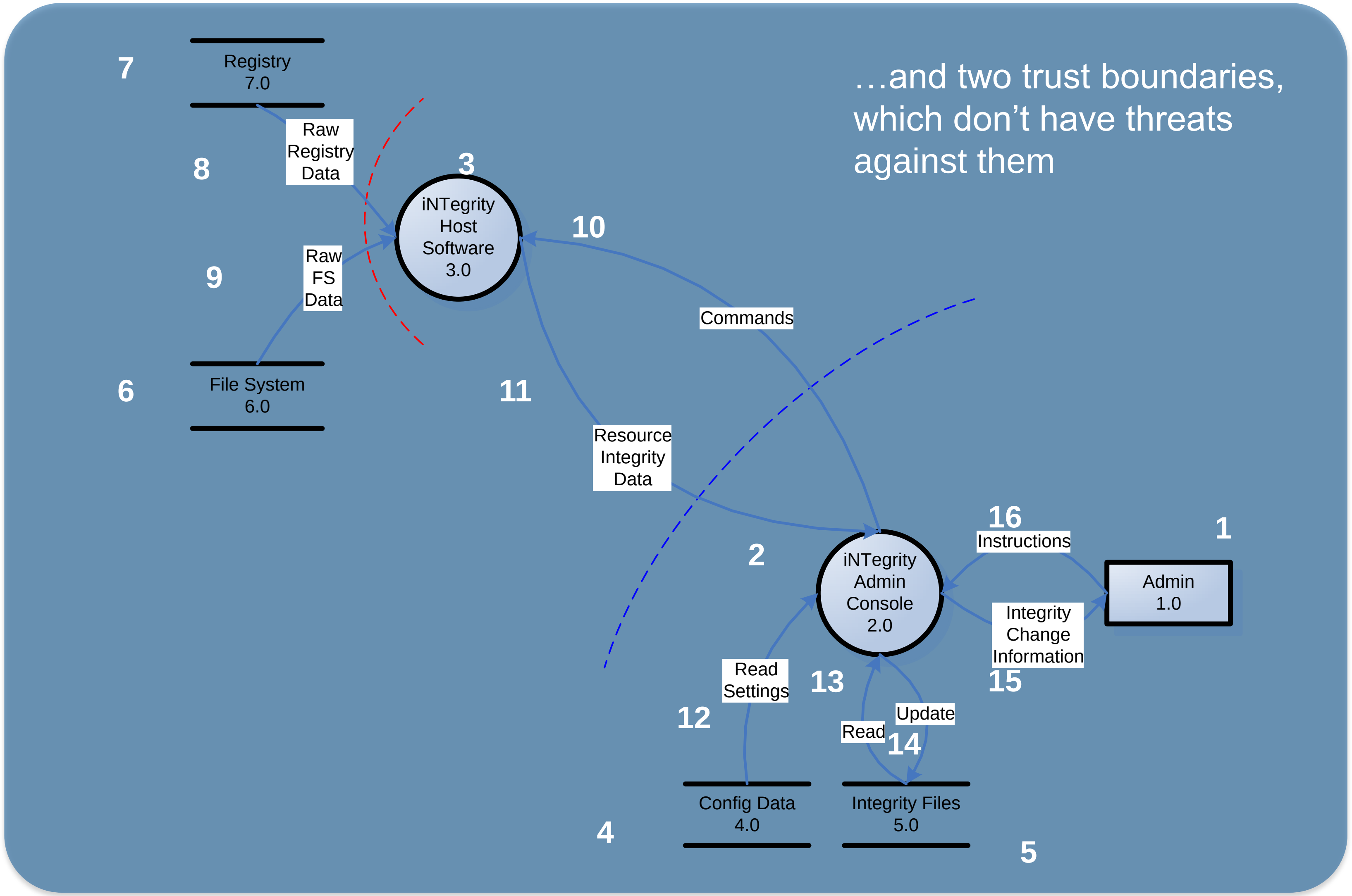
- Develop a threat model for your case study project. You may optionally download and use the Microsoft tool to support this activity. (90%)
- Did the threat model provide any new insights beyond the work you had already done? (10%)
- Collate all the case study assignments into a single report, with a project introduction and all of the assignments following it. You can feel free to make changes if you want.

Turn the assignment in on Blackboard BEFORE Saturday August 4 at 12:00 noon.

Support notes for Assignment

- Work with your team to:
  - Identify all diagram elements
  - Identify threat types to each element
  - Identify at least three threats
  - Identify first order mitigations
  - Improve the diagram

Identify All Elements (16 Elements)



…and two trust boundaries, which don't have threats against them

Identify Threat Types to Each Element

Identify STRIDE threats by element type

Threats Elements

ELEMENT	S	T	R	I	D	E	
External Entity	✓		✓				Administrator (1)
Process	✓	✓	✓	✓	✓	✓	Admin console (2) , Host SW (3)
Data Store		✓	✓	✓	✓		Config data (4), Integrity data (5), Filesystem data (6), registry (7)
Data Flow		✓		✓	✓		8. raw reg data 9. raw filesystem data 10. commands 16

Identify Threats!

- Be specific
- Understand threat and impact
- Identify first order mitigations

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Backup Slides

Standard Mitigations

S T R I D E

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

Standard Mitigations

S T R I D E

Threat	Property	
Spoofing	Authentication	To authenticate principals: • Basic authentication • Digest authentication • Cookie authentication • Windows authentication (NTLM) • 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

S T R I D E

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

Standard Mitigations

S T R I D E

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

Standard Mitigations

S T R I D E

Threat	Property	
Information Disclosure	Confidentiality	• Encryption • ACLs

Standard Mitigations

S T R I D E

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

Standard Mitigations

S T R I D E

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