# Systemic Risk & Vulnerability Analysis of Multi-Cloud Environments

This presentation was given at the 2023 National Cybersecurity Education Colloquium

**Program Name: INSuRE+C**

**Teams**: Mississippi State University, Rochester Institute of Technology
**Technical Directors**: National Security Agency

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# Team Members

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**NSA**

- Dr. Josiah Dykstra
- Dr. Andy Sampson

**RIT**

- Dr. Nidhi Rastogi
- Matthew Stoffolano - MS Student

**MSU**

- Dr. Sudip Mittal
- Morgan Reece - PhD Student
- Teddy Lander - MS Student

# Agenda

- Introduction
  - Problem Motivation
  - Industry Modeling
- Modeling Framework
- Risk Analysis & Explanation
- Attack Implementation
- Results & Future opportunities

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# Introduction

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**Problem Statement**: Multi-Cloud application deployment has caused highly fragmented approach toward security, leading to a constant rise of new attack vectors and potential vulnerabilities.

**Project Phases:**

1) **Systemic Risk & Vulnerability Analysis of Multi-cloud Environments**
2) **Identify Novel Attacks Patterns & Risk Mitigation in Multi-cloud Environments**
3) **Develop & Evaluate Defensive Strategies to Secure Multi-cloud Environments**

# Phase 1 - **Systemic Risk & Vulnerability Analysis of Multi-cloud Environments**

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Architecture definition

3-tier mutli-cloud architecture

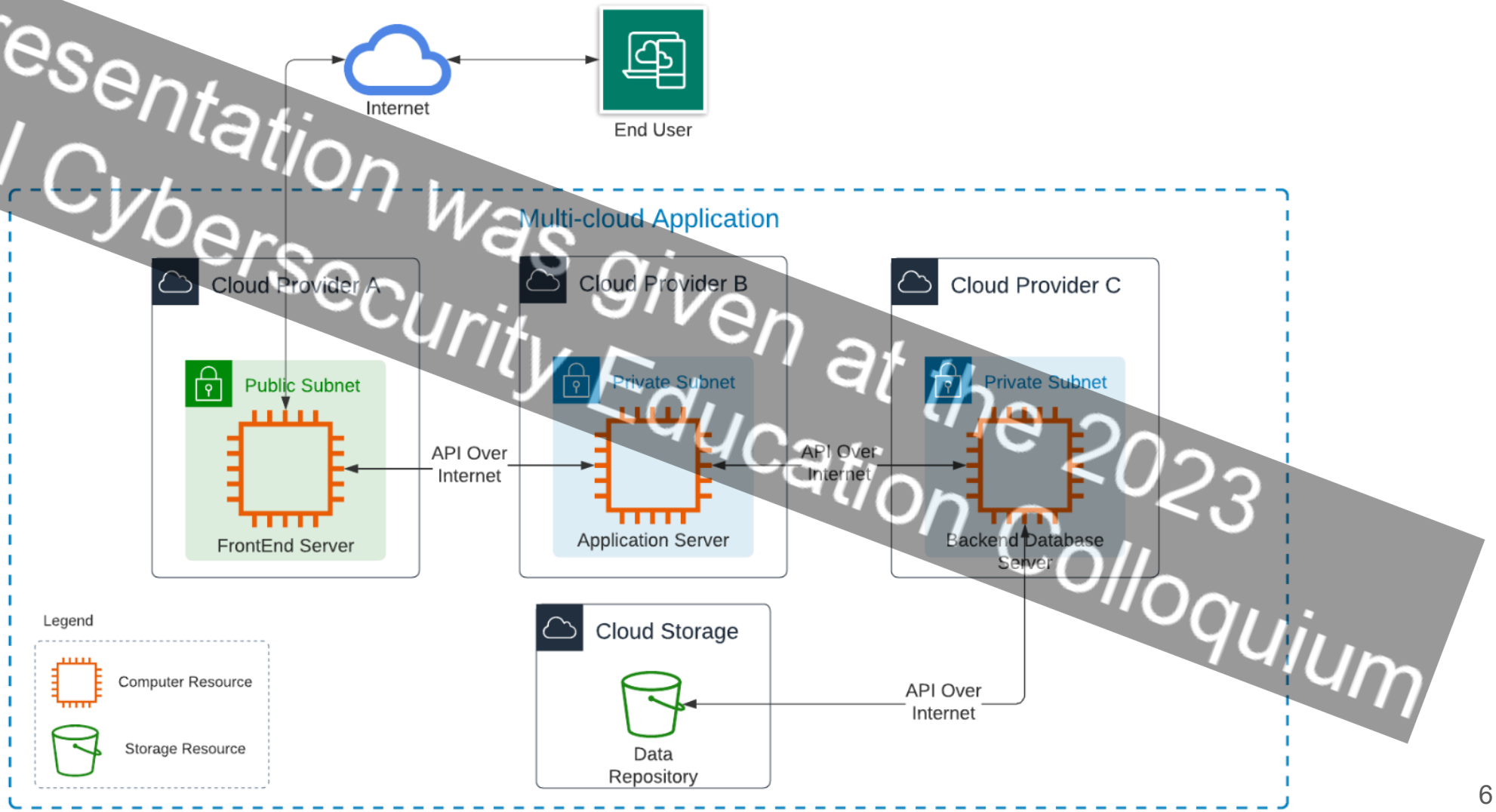
Identify industry for modeling and analysis

Attack vector identification

Define Risk Analysis Methodology

STRIDE & DREAD to be used in conjunction with each other for full scoped analysis

# Multi-Cloud Architecture

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# Healthcare Industry Modeling and Analysis

- Risk assessment begins with Business Impact Analysis (BIA)
  - BIA requires organizational operations to determine impact
  - Enables defining basis of value of data
- BIA drives organizational risk analysis
- Defined architecture found extensively in healthcare industry
  - Either through internal development or acquisition, 90% of healthcare organizations plan on using multiple cloud service providers[1]

[1] https://www.hitinfrastructure.com/features/pros-cons-and-strategies-for-implementing-healthcare-multicloud/

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# Attack Vector Categories

Identifying attack vectors that are unique to multi-cloud application deployments.

1. Architecture
2. API
3. Authentication
4. Automation
5. Difference in Management
6. Mismatch in Cyber Legislation

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# STRIDE use in Risk Analysis and Mitigation

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**STRIDE Threat Modeling Methodology**

**Objective** - Identify, categorize, and analyze attacks into 6 types of threats: Spoofing, Tampering, Repudiation, Information disclosure (privacy breach or data leak), Denial of service, Elevation of privilege

**Benefits** - Proactive exercise in identifying threats and developing mitigations

**Selection of Methodology** - Used in all scenarios of threat modeling and risk analysis; one of the most commonly used threat modeling framework

# DREAD Methodology

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**DREAD Risk Assessment Methodology**

**Objective** - Quantitatively assess the severity of a cyberthreat using a scaled rating system that assigns numerical values to risk categories

**Benefits** – Very customizable methodology requiring extensive cybersecurity experience to ensure accurate analysis

**Selection of Methodology** - Focuses on impact and operability

# Phase 2 - **Perform risk & vulnerability analysis**

Risk analysis

- Application of STRIDE and DREAD to threat vectors identified in Phase 1

Risk mitigation

- Utilizing MITRE ATT&CK Framework to support mitigation definition

Research and design simulation environment

- Cloud providers and possible applications

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# Architecture Threat Risk Analysis

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Risk Score calculated from DREAD model:

avg_damage = (Legal + Reputation + Productivity)/3

threat_probability = (Reproducibility, Exploitability, Affected Users, Discoverability)

**DREAD Risk Score = (avg_damage) + Σ threat_attributes**

Overall Threat Rating from DREAD Risk Score

- **Critical (40–50):** Critical vulnerability; address immediately.
- **High (25–39):** Severe vulnerability; consider for review and resolution soon.
- **Medium (11–24):** Moderate risk; review after addressing severe and critical risks.
- **Low (1–10):** Low risk to infrastructure and data.

# High Risk Attack Vectors – Risk Analysis Results

| | | | Damage | | | Threat Attributes | | | |
|---|---|---|---|---|---|---|---|---|---|
| Description of Threat | STRIDE Framework Category | Total Risk Score | Legal Damage | Reputation Damage | Productivity Damage | Reproducibility | Exploitability | Affected Users | Discoverability |
| Architecture: CVEs | ALL | 44.00 | 0 | 9 | 9 | 9 | 10 | 10 | 9 |
| Architecture: DoS attacks | Denial of Service | 42.67 | 0 | 10 | 10 | 8 | 8 | 10 | 10 |
| Automation : Data poisoning | Tampering with Data | 34.33 | 0 | 4 | 6 | 10 | 10 | 8 | 3 |
| Authentication : Man-in-the-Middle | Information Disclosure | 32.67 | 0 | 9 | 5 | 7 | 9 | 10 | 2 |
| API : Malformed packets | Denial of Service | 32.00 | 0 | 6 | 9 | 8 | 7 | 3 | 9 |
| Architecture: Differing Encryption Offerings and Capabilities | Information Disclosure | 30.33 | 0 | 6 | 7 | 7 | 8 | 4 | 7 |
| Authentication : Substitution attack | Denial of Service | 29.33 | 0 | 7 | 9 | 10 | 10 | 2 | 2 |
| API : Privilege Elevation | Elevation of Privilege | 28.00 | 0 | 9 | 6 | 8 | 10 | 3 | 2 |
| Automation : Dynamic changes to config causing inconsistency | Denial of Service | 27.33 | 0 | 5 | 8 | 5 | 8 | 7 | 3 |
| Difference in Management: Auto-Scaling | Denial of Service | 25.67 | 0 | 8 | 9 | 6 | 5 | 7 | 2 |
| Authentication : Session hijacking | Spoofing Identity | 25.67 | 4 | 6 | 4 | 7 | 8 | 1 | 5 |
| Architecture: VPN Infiltration | Information Disclosure | 25.33 | 0 | 8 | 5 | 6 | 9 | 2 | 4 |

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# High Risk Attack Vectors – Countermeasures and mitigations

| Description of Threat | STRIDE Framework Category | Total Risk Score | Countermeasures | MITRE ATT&CK Mitigation |
|---|---|---|---|---|
| Architecture: CVEs | ALL | 44.00 | Patch Management - System Hardening | Patch |
| Architecture: DoS attacks | Denial of Service | 42.67 | WAF w/DDoS mitigation | Filter network traffic |
| Automation : Data poisoning | Tampering with Data | 34.33 | ICAM - Data Encryption - Secrets Management | Filter network traffic, IPS |
| Authentication : Man-in-the-Middle | Information Disclosure | 32.67 | Secrets Management - DNSsec | Static network config |
| API : Malformed packets | Denial of Service | 32.00 | API security & encryption | Monitoring |
| Architecture: Differing Encryption Offerings and Capabilities | Information Disclosure | 30.33 | ITIL - Change Management - Secrets Management | N/A |
| Authentication : Substitution attack | Denial of Service | 29.33 | Secure Block-cypher - timestamp | Audit, PAM, Cert Mgmt |
| API : Privilege Elevation | Elevation of Privilege | 28.00 | PAM - least privilege | Monitoring, Audit GPO, PAM, User Acct mgmt |
| Automation : Dynamic changes to config causing inconsistency | Denial of Service | 27.33 | SOAR Configuration Management - ITIL | N/A |
| Difference in Management: Auto-Scaling | Denial of Service | 25.67 | ITIL - Event Management | N/A |
| Authentication : Session hijacking | Spoofing Identity | 25.67 | TLS encryption on all sessions & MFA | MFA, delete persistent cookies |
| Architecture: VPN Infiltration | Information Disclosure | 25.33 | ICAM-MFA, Network segmentation | Network segmentation, MFA |

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# Phase 3 - **Develop & Evaluate Defensive Strategies to Secure Multi-cloud Environments**

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Build of test environment

Define scoped attack methodologies

- Authentication

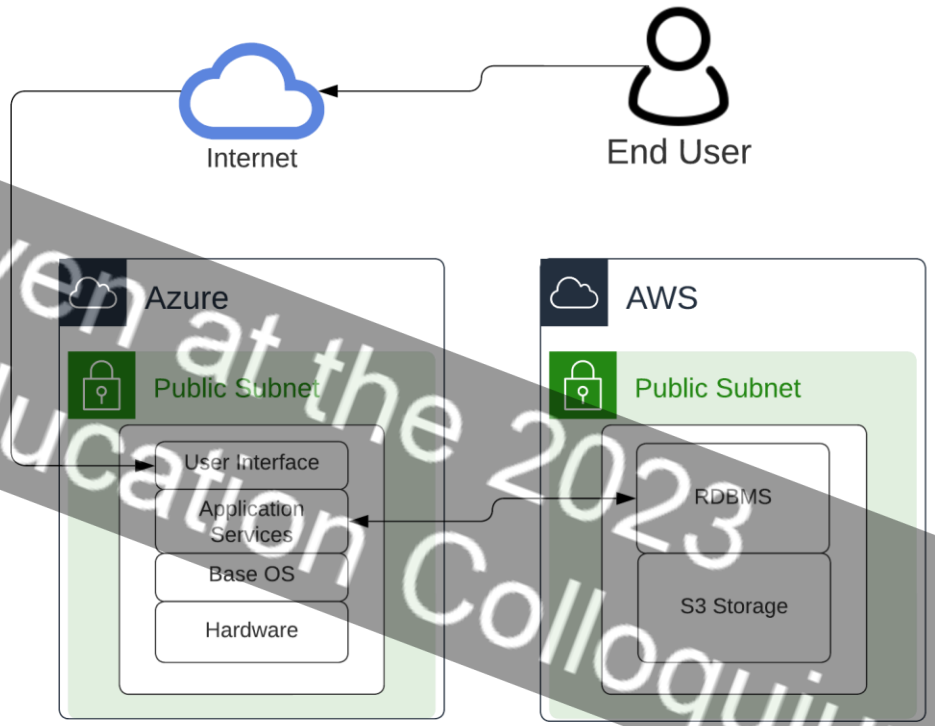
Execute attack

Implement mitigation

Retest attack identifying attack hinderances

# Test Env Architecture

- Utilizing Azure & AWS
- Collapse Front-end and application server
- Exposed UI and DB API
- Separate identity control systems

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# Attack Execution on Authentication

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- Privilege Escalation
  - Gain illegal/illicit access to a system through the elevation of user privilege about the assign authorization level. This can be obtained through the exploitation of a system bug, misconfiguration, or inadequate access controls.

- Session Highjacking
  - Attackers use session cookies that have been stolen from a user's computer to impersonate the session/user gaining access to protected data and systems.

# Final Conclusions

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- Multi-cloud deployments of applications continues to grow and a source of vulnerability
- Vulnerabilities in multi-cloud is similar to single cloud with a few exceptions
  - Multi-cloud adds **COMPLEXITY** to the security
  - Security **PRIORITIES** can change in multi-cloud because of unique exposed vulnerabilities

# Future Opportunities

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- Multi-cloud security direction and research opportunities
  - Recurring mitigation across the attack vectors
    - Change management
      - Enabling coordination of configuration and changes
      - Centralized management
    - Further research
      - Unified management of multi-cloud configuration
      - Automated mitigation implementation across cloud providers

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# Q&A