Section: PUBP-6727

Mutual Monitoring in the Cloud
Progress Report 1

Alexander Stein

Problem Statement

Cloud computing infrastructure is essentially ubiquitous, but adoption is not without challenges. Cloud service providers must cater to customers in regulated sectors, complying with cybersecurity frameworks that create high barriers to entry. One barrier is ongoing evaluation of the provider's cybersecurity posture, often resulting in centralized bureaucracies. FedRAMP oversees and documents a prominent example of such a program, the Continuous Monitoring Program.

Are these bureaucracies an optimal solution, or a last resort that fails to keep pace with cloud technology as it proliferates and evolves? If they are a last resort, is there a better way?

Solution Statement

I will use this research to design and evaluate an alternative to centralized continuous monitoring, mutual monitoring. The foundation of mutual monitoring will be federated data services, known in other security use cases as transparency services. The positives and negatives of FedRAMP's continuous monitoring model will inform its design. Operating such services should change the economics, and thereby the behavior, of cloud service providers and their customers. A new architecture should incentivize auditors to sell value-add analytics via these federated data services, potentially obsoleting centralized authorities for continuous monitoring like FedRAMP.

Completed Tasks (Last 2 Weeks)

1. I read twenty-two references (journal articles; website articles; book chapters) to identify my project in its larger context and understand supporting arguments. I concentrated on the topics below.

- primary source material from FedRAMP, especially process and procedure documentation (for deliverable #1)
- industry analysis and criticism of FedRAMP processes and their impact on FedRAMP stakeholders (for deliverable #1)
- technical methods for monitoring multi-account and multi-tenant cloud service deployments (for deliverables #2 and #4)
- conceptual models, methods, and literature for quantitative cloud security analysis (for deliverables #2 and #4)
- transparency service specifications (e.g. SCITT; C2SP Static Certificate Transparency API) and industry analysis of their efficacy (for deliverable #3)
- taxonomies and models for auditing and monitoring (for deliverable #2)

2. I presented a proposal and reviewed scope of research with four advisors that are highly familiar with FedRAMP strategy, policies, and operations. Three advisors have accepted, while one's acceptance is still pending.

3. I began an outline for critical analysis for FedRAMP's centralized continuous monitoring model (e.g. proposal deliverable #1).

4. I initialized a code repository to save the architecture documents and prototype code in version control (e.g. proposal deliverables #2 and #3, respectively).

5. I incorporated feedback from Professor Kuerbis to add and adjust research topics and evaluation methods in my outline for the project and specific deliverables.

Tasks for the Next Project Report

In the next two weeks, I will focus on the following goals. I have sorted them in order of priority.

1. Complete first draft of federated data service architecture, request feedback from advisors.

2. Implement primary component of data service, submission API for cloud service providers and external third-party auditors.
3. Complete outline of FedRAMP critical analysis.
4. Start draft of FedRAMP critical analysis, request feedback from advisors.

Questions or issues I'm having

Alignment with Practicum Requirements

1. My project focuses on a policy challenge in cloud security, but does not have a conventional policy recommendation like other policy track proposals. Is a policy document an explicit requirement?

Project Scope

1. One of my deliverables (a critical analysis of FedRAMP's current approach) is not a prerequisite I must complete to start other deliverables, but will establish important qualitative detailed background for readers, but likely it will be too detailed for the final report. Should I include this deliverable in the final report appendix or use it as an input for a summary analysis in the final report only?
2. One of my deliverables will be a prototype of federated data service, which will have server and client components that does statistical analysis of data. There will not be a user-friendly web interface to keep scope focused and meet the projected timeline. Is this reasonable?
3. If I cannot complete all the code for the prototype and I must scope down the prototype, do I inventory outstanding work in the future work section of the final report? Will this negatively impact my final grade for this project. Is this normal and expected?

Evaluation and Measurement

1. I am proposing a novel solution that is considerably different from the current state without an "apples to apples" comparison. It is more like an "apples to oranges" comparison. The difference is a significant factor to improve on the

current state. However, direct comparison is difficult. Is there any significant risk to my project if I design my own quantitative and qualitative metrics?

Methodology Paragraph Summary

For this project, I will use multiple methods to implement an alternative architecture for monitoring cloud services and modeling its potential impact. To start, I will use a quantitative and qualitative analysis of the current shortcomings and gaps for the current FedRAMP Continuous Monitoring Program. This will be the primary example of centralized continuous to which I will compare you mutual monitoring model. For qualitative analysis, I can perform textual analysis and sentiment analysis. I will leverage academic analysis, industry analysis, and a new primary source: FedRAMP's web-based forums for the 20x reform initiative and its community working groups. In these forums, stakeholders discuss their praise and criticism of current centralized processes and plans for future ones. In addition, I will use publicly available information from FedRAMP and industry analysis to quantify the burden of the current FedRAMP Continuous Monitoring and its manual workflow. As I build a prototype based on my architecture, I will design several use cases to estimate the cost and resource efficiency in comparison to the current processes with their manual workflows. In addition to these methods, I will use advisors familiar with FedRAMP from different stakeholder perspectives to validate information or analysis where these methods prove lacking and leave gaps.

Timeline

Week #	Description of Task	Status
W1 (May 12-18)	Identify references for key research topics.	Complete
W1	Identify advisors to review FedRAMP analysis and architecture.	Complete
W2 (May 19-25)	Initialize code repository for prototype service.	Complete
W2	Present proposal to advisors and integrate feedback; obtain commitment from advisors.	In Progress

W2	Read FedRAMP documentation for continuous monitoring processes.	In Progress
W2	Begin outline of FedRAMP ConMon critical analysis.	In Progress
W3 (May 26 - Jun 1)	Implement data service internals and submission API.	Pending
W3 (May 26 - Jun 1)	First draft of data service architecture specification.	Pending
W4 (June 2-8)	Implement data service internals and submission API.	Pending
W4	Finalize architecture specification with advisors' reviews.	Pending
W5 (June 9-15)	Implement data service client to submit to submission API instances.	Pending
W5	Complete data service internals and submission API.	Pending
W5	Complete FedRAMP critical analysis document.	Pending
W6 (June 16-22)	Complete data service client to submit to submission API instances.	Pending
W6 (June 16-22)	Implement continuous monitoring quantitative processing module for API.	Pending
W6	Design MVP continuous monitoring use cases and quantitative measurements.	Pending
W7 (June 23-29)	Complete continuous monitoring quantitative processing module for API.	Pending
W7	Implement MVP continuous monitoring use cases in API quantitative processing module.	Pending
W8 (June 30 - July 6)	Start prototype deployment to cloud service tenants for testing.	Pending
W9 (July 7-13)	Complete prototype deployment to cloud service tenants for testing.	Pending

Evaluation

[Include any evaluation plans and/or results by Progress Report 4. This may expand as you finalize the report.]

Report Outline

[Include an outline of your final report by Progress Report 4. This may expand as you finalize the report.]

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Appendix

Practicum Proposal: Mutual Monitoring in the Cloud

Alexander Stein
astein38@gatech.edu

1 Problem Statement

Cloud computing infrastructure is essentially ubiquitous, but adoption is not without challenges. Cloud service providers must cater to customers in regulated sectors, complying with cybersecurity frameworks that create high barriers to entry. One barrier is ongoing evaluation of the provider's cybersecurity posture, often resulting in centralized bureaucracies. FedRAMP oversees and documents a prominent example of such a program, the Continuous Monitoring Program (2025, p. 14).

Are these bureaucracies an optimal solution, or a last resort that fails to keep pace with cloud technology as it proliferates and evolves? If they are a last resort, is there a better way?

2 Choice of Problem

The cybersecurity of cloud services poses many challenges, but the inefficiency of continuous monitoring has systemic impact on the economics and timely, accurate risk modeling for heavily interconnected, interdependent systems built on cloud services. FedRAMP is a highly visible and representative example that other regulatory frameworks emulate, so any improvement or optimization will yield significant improvement to cloud service adoption across regulated industries.

2.1 Economic Impacts

Although FedRAMP is a highly visible cloud security program, there is limited public data with details about costs and economic impact for providers, auditors, and customer agencies. However, industry estimates significant costs for all these stakeholders, even when considering global expenditure on cloud services.

Gartner estimates that global spending on cloud infrastructure in 2024 was $595.7 billion dollars (2024). The think tank CSIS estimates that the United States government spent $17 billion of its total $130 billion dollar IT budget in 2024 on cloud

services alone (2025, p. 1). Although federal agencies are not fully compliant with FedRAMP's requirements mandated in the FedRAMP Authorization Act, the long-term goal is maximal oversight over the cloud building blocks of this seventeen billion dollar investment. And continuous monitoring is a sizable component of this investment.

FedRAMP processes require specialized tools operated by dedicated staff, from providers, auditors, and often the customer agencies. Analysts at stackArmor estimate that an initial authorization costs a provider $250,000 to $750,000 dollars, of which $100,000 to $400,000 alone is for continuous monitoring activities (2024). Given a conservative estimate, any improvement or optimization can benefit all stakeholders in reducing $42,600,000 in spend by 426 services currently authorized, but potentially a much larger sum.

2.2 Cybersecurity Impacts

Even with all this investment, the staff from cloud service providers, auditors, and agency customers experience strategic and operational bottlenecks for heavily interconnected cloud services, increasing ambiguity in a holistic view of cybersecurity posture in real-world composite systems for all parties involved, not only auditors.

Firstly, a centralized review process finalized by a small number of FedRAMP staff constitutes a single point of failure. As FedRAMP documents, cloud providers, auditors, and agency customers must use a single, centralized wiki site, USDA's connect.gov, and coordinate out of band with FedRAMP staff for final review (2025, pp. 3,14). Paradoxically, providers and auditors get no guarantees for the cybersecurity posture of this system where they store data for FedRAMP's reviewers. There is no mutual monitoring or assurance. Access to this data on connect.gov is manually coordinated on an ad hoc basis, hindering sharing between different agency staff who need FedRAMP data, and even those outside these agencies focused on other regulatory frameworks. They rely on reciprocity guarantees to justify the use of FedRAMP authorization and continuous monitoring, which is not particularly feasible in practical terms given restricted access to this data.

The impacts of manually curated data from FedRAMP's continuous monitoring extend beyond its stakeholders. Interrelated regulatory frameworks depend upon it. Given FedRAMP's rigorous review process, especially continuous monitoring, many

providers and their auditors use artifacts from FedRAMP for equivalency, or reciprocity,as evidence for controls in other regulatory frameworks preferred by the defense, commercial, and finance sectors of the United States. Therefore, any optimization in FedRAMP's processes has second order effects on the quality, quantity, and speed of cloud security review methodologies across industry.

3 Expected Deliverables

I will use this research to design and evaluate an alternative to centralized continuous monitoring, mutual monitoring. The foundation of mutual monitoring will be federated data services, known in other security use cases as transparency services. The positives and negatives of FedRAMP's continuous monitoring model will inform its design. Operating such services should change the economics, and thereby the behavior, of cloud service providers and their customers. A new architecture should incentivize auditors to sell value-add analytics via these federated data services, potentially obsoleting centralized authorities for continuous monitoring like FedRAMP. To validate this hypothesis, I propose the list of deliverables below, in addition to the final report summarizing their outcome.

1. a critical analysis of FedRAMP's continuous monitoring model
2. an architecture specification for mutual continuous monitoring
3. prototype code for transparency services for mutual continuous monitoring
4. a quantitative cloud security measurement framework to use in the prototype

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