Information Protection in Content-centric Networks

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Outline

1. Summary
2. Results Summary
3. Test Network Topologies
4. Results Detail

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Original Goals

Contribution of Work

The contribution of this work is a quantitative analysis of policy-centric overlay network options, associated taxonomies of use, and prototypical technology proofs-of-concept.

- *Network Control Options* — This includes various types networks and associated strengths and weaknesses addressing centralized and decentralized models.
- *Taxonomies of Use* — Depending on the specific usage management requirements and context, different overlays have different applicability; this work will provide guidance on suitability; it will eventually lead to how to manage data flow within SDN-capable infrastructure.
- *Prototypical Technologies* — Examples and proofs-of-concept will be required to appropriately analyze various architectural alternatives.

Meeting the Goals

Network Control Options

I have developed and analysed multiple types of overlay systems, both centralized (hierarchical) and non-centralized (non-hierarchical), with differing topologies and integrated content-centric control.

Taxonomies of Use

I have established an verified a taxonomy of usage management and applied that within the network providing mechanisms extendable to SDN use.

Prototypical Technologies

Prototype information-centric networks are running between the Rackspace and Amazon clouds.

Impact and Originality

- Information-centric architectures common in future internet designs
- Significant work with respect to name/object binding, overall topologies, approaches
- No significant work yet on exploiting information-centricity for enhanced security
- They have significant new capabilities inherent in approach that allow for better information security

Additional Contributions

This work, as well as providing alternatives analysis with respect to information-centric security with respect to architectures and approaches, also demonstrates the first implementation of granular context-sensitive security functionality embedded in an information-centric network.

Publications (current)

Conference Papers:

C.C. Lamb and G.L. Heileman. Overlay architectures enabling cloud computing for multi-level security environments. In Services (SERVICES), 2012 IEEE Eighth World Congress on, pages 116-124, june 2012.

Christopher Charles Lamb, Pramod A. Jamkhedkar, Mathew P. Bohnsack, Viswanath Nandina, and Gregory L. Heileman. *A domain specific language for usage management*. In Proceedings of the 11th annual ACM workshop on Digital rights management, DRM '11, pages 51-62, New York, NY, USA, 2011. ACM.

Christopher C. Lamb, Pramod A. Jamkhedkar, Gregory L. Heileman, and Chaouki T. Abdallah. *Managed control of composite cloud systems*. In System of Systems Engineering (SoSE), 2011 6th International Conference on, pages 167-172, june 2011.

P.A. Jamkhedkar, C.C. Lamb, and G.L. Heileman. *Usage management in cloud computing*. In Cloud Computing (CLOUD), 2011 IEEE International Conference on, pages 525-532, july 2011.

Pramod A. Jamkhedkar, Gregory L. Heileman, and Chris C. Lamb. *An interoperable usage management framework*. In Proceedings of the tenth annual ACM workshop on Digital rights management, DRM '10, pages 73-88, New York, NY, USA, 2010. ACM.

Publications (submitted)

Journal Submissions:

C.C. Lamb and G.L. Heileman. Overlay architectures enabling cloud computing for multi-level security environments. In Services (SERVICES), 2012 IEEE Eighth World Congress on, pages 116-124, june 2012.

Christopher Charles Lamb, Pramod A. Jamkhedkar, Mathew P. Bohnsack, Viswanath Nandina, and Gregory L. Heileman. A domain specific language for usage management. In Proceedings of the 11th annual ACM workshop on Digital rights management, DRM '11, pages 51-62, New York, NY, USA, 2011. ACM.

Book Chapters:

Results Overview

Overall evaluation of impact against strategy:

- Encryption most likely to be used...
- ...Rerouting likely the best compromise (but expensive)
- Hierarchical and non-hierarchical networks had similar performance
- No clear leading strategy under all conditions

Property	Redaction	Rerouting	Encryption
Confidentiality	3	2	1
Integrity	0	1	3
Availability	0	1	2

Strategy Impact by Attribute

What does this mean? How did we get it?

Methodology

Confidentiality, Integrity characteristics based on approach.

- **Redaction**, by removing information, by definition destroys integrity while guaranteeing confidentiality; unavailable information that is cannot be leaked
- **Rerouting** removes information from a context damaging integrity that can possibly be repaired later, potentially increasing confidentiality by rendering that information unavailable
- **Encryption** minimizes integrity impacts be keeping ciphered data with original context at the expense of possible interception and cryptanalysis exposure

Availability is based on performance.

- **Performance** is measured via end-to-end time of transmittal

Redaction

Redaction: Removing content that is not approved for transmission over a given link or consumption by a given agent from a larger context of suitable content.

- Strongest confidentiality
- Destroys integrity
- Mixed impact on availability

Fast and easy to implement

Property	Redaction	Rerouting	Encryption
Confidentiality	3	2	1
Integrity	0	1	3
Availability	0	1	2

Rerouting

Rerouting: Removing content that is not approved for transmission over a given link and rerouting that content to its destination through secondary means (e.g. SMTP).

- Confidentiality dependent on secondary links
- Integrity compromised temporarily and perhaps permanently
- Availability dependent on secondary links

Undependable, expensive, good information control

Property	Redaction	Rerouting	Encryption
Confidentiality	3	2	1
Integrity	0	1	3
Availability	0	1	2

Encryption

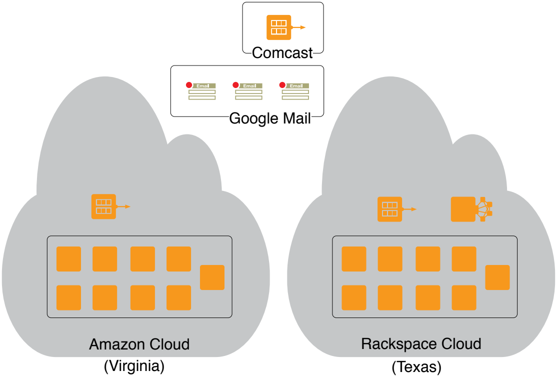
Encryption: Enciphering content within larger documents, deciphering enciphered sections when suitable by defined policy and when content needs to be re-evaluated.

- Confidentiality questionable over time
- Integrity compromised temporarily and perhaps permanently
- Availability dependent on secondary links

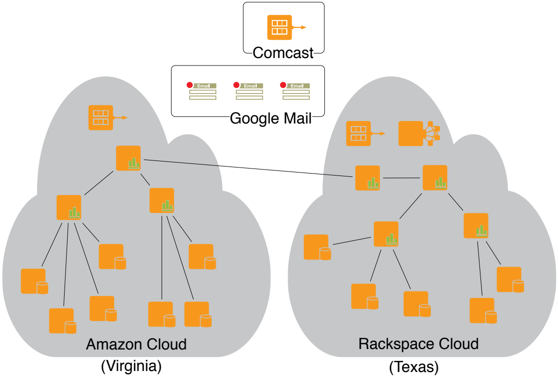
Reasonably secure, simple and performant

Property	Redaction	Rerouting	Encryption
Confidentiality	3	2	1
Integrity	0	1	3
Availability	0	1	2

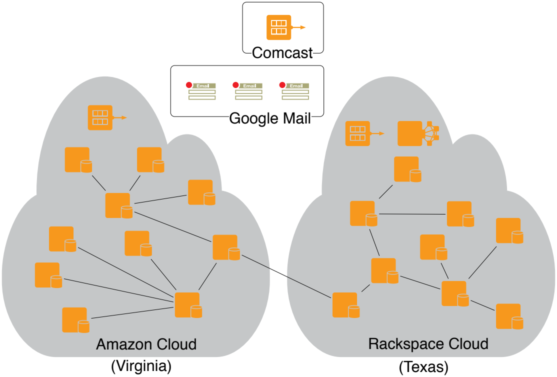
Physical Topology



Hierarchical Topology



Non-Hierarchical Topology



Hierarchical Effects

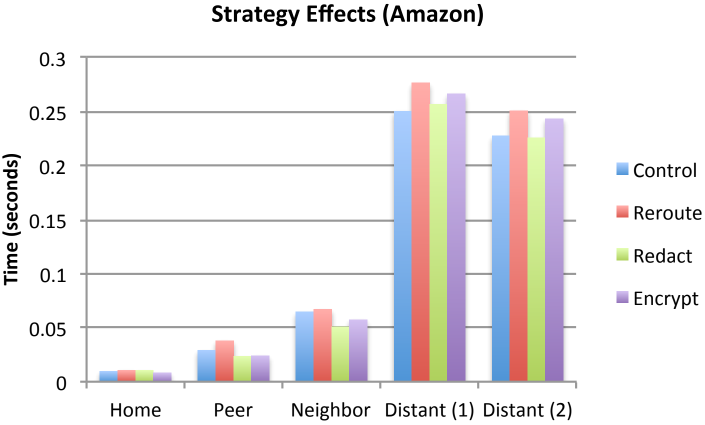


Figure: Hierarchical Results from Amazon

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Hierarchical Effects

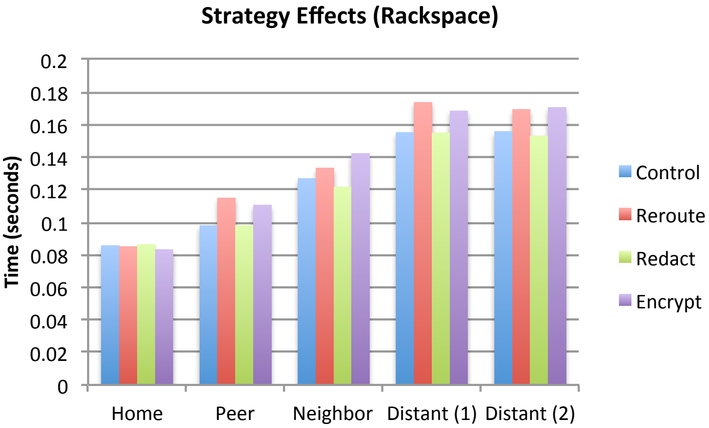

Figure: Hierarchical Results from Rackspace

Hierarchical Effects

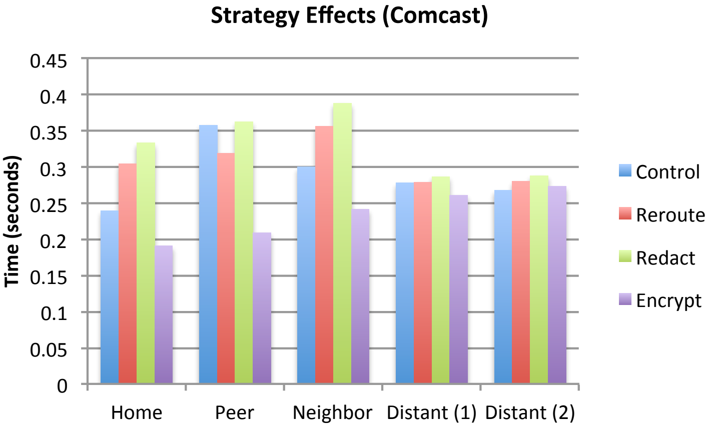

Figure: Hierarchical Results from Comcast

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Hierarchical Analysis

Non-Hierarchical Effects

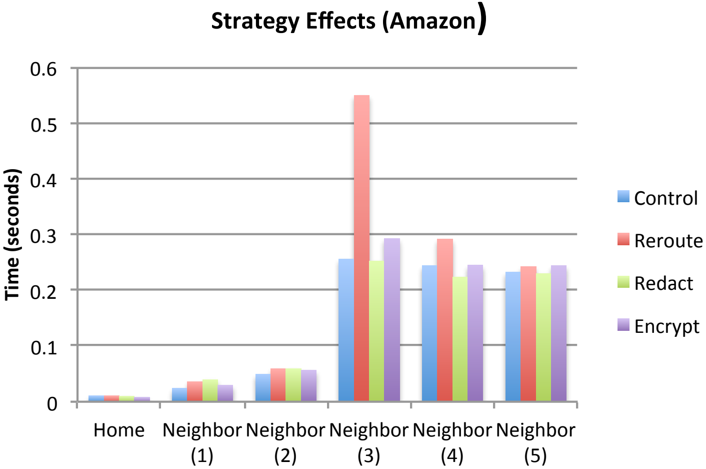

Figure: Non-Hierarchical Results from Amazon

Non-Hierarchical Effects

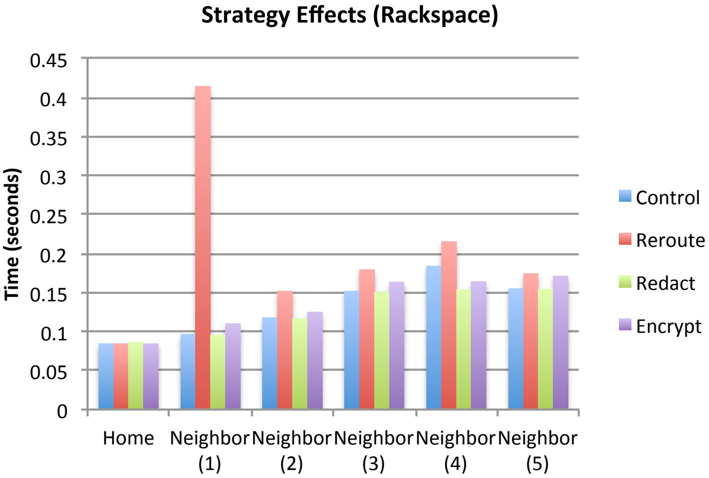

Figure: Non-Hierarchical Results from Rackspace

Non-Hierarchical Effects

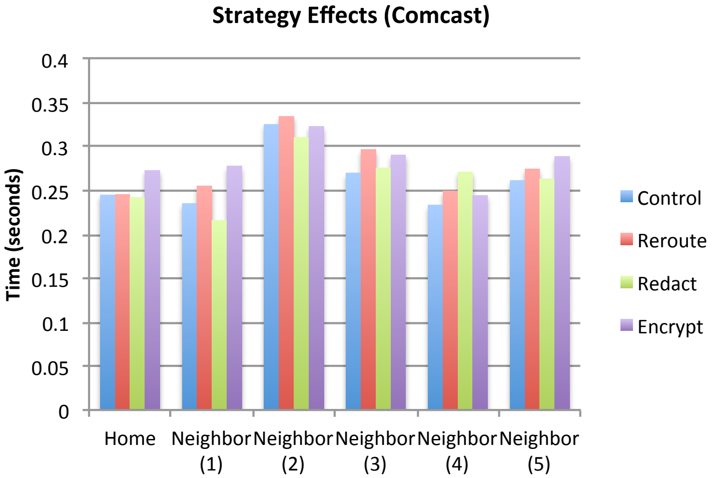

Figure: Non-Hierarchical Results from Comcast

Non-Hierarchical Analysis

Network-Free Evaluation

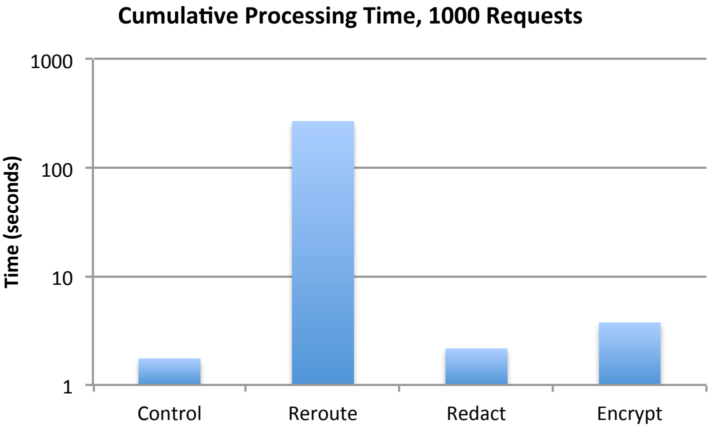

Figure: Results from Requests to a Singe Node

Network-Free Analysis

Questions? Comments?