A Firewall for CCN

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OUTLINE

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- Introduction
- Content Centric Networking background
- Design
- Implementation
- Evaluation
- Conclusion

A Firewall for CCN

INTRODUCTION

Introduction

- Trend towards content retrieval
- Content Centric Networking is built and designed to follow this
  - Some security measures already built-in
    - Authentication of content
  - But real security tools missing
- Our contribution:
  - Identify the security needs for a CCN architecture
  - Design of a semantic CCN firewall
  - Performance evaluation

Related work

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- Jacobson, V., Smetters, D.K., Thornton, J.D., Plass, M.F., Briggs, N.H., Braynard, R.L.**: Networking named content.** In: Proceedings of the 5th international conference on Emerging networking experiments and technologies. pp. 1–12. CoNEXT '09, ACM, New York, NY, USA (2009)
- D. Smetters, V. Jacobson: **Securing Network Content** (October 2009)

- Lauinger, T.: **Security & scalability of content-centric networking** (September 2010)
- Goergen, David; Cholez, Thibault; François, Jérôme; Engel, Thomas: **Security monitoring for Content Centric Networking**, Data Privacy Management and Autonomous Spontaneous Security

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CONTENT CENTRIC NETWORKING BACKGROUND

Content Centric Networking - CCN

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- New paradigm proposed by Van Jacobson et al.
- Redesign networking focusing on data instead of hosts (who provide the data)
- Shift from a communication oriented paradigm to a distribution oriented
- To provide the same functionalities as TCP/IP with build in security features, more efficient content diffusion, mobility, …

How does it work?

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- Routable data instead of routable host
- Content is named in a hierarchical prefix based way

  Examples:

  - uni.lu/people/goergen/presentation/im2013
  - thisRoom/projector
- Like IP, CCN is semantic free. Meaning is defined by application, global conventions, etc.
- Content is requested by user's Interest
- Anyone who has the solicited content can answer

CCN architecture

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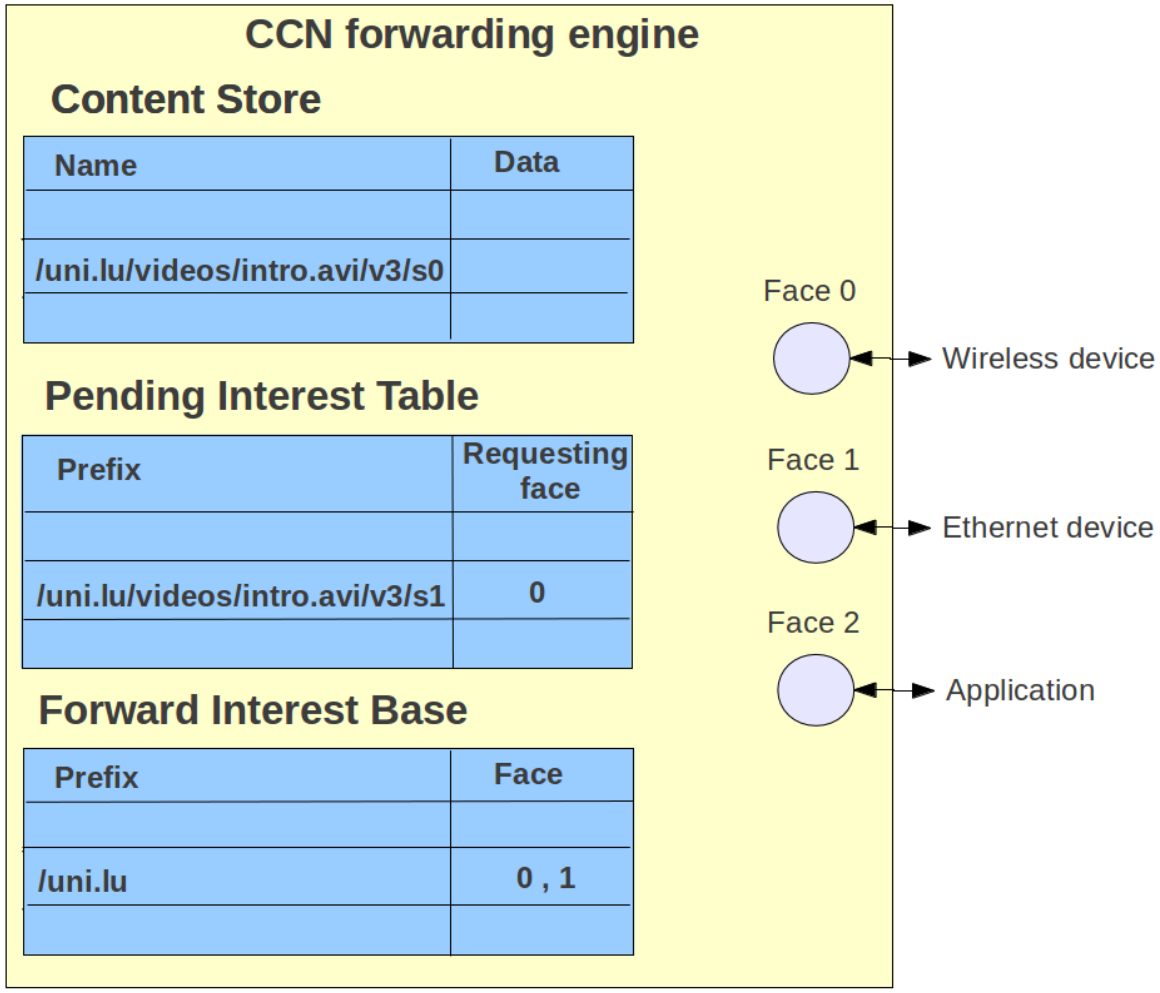
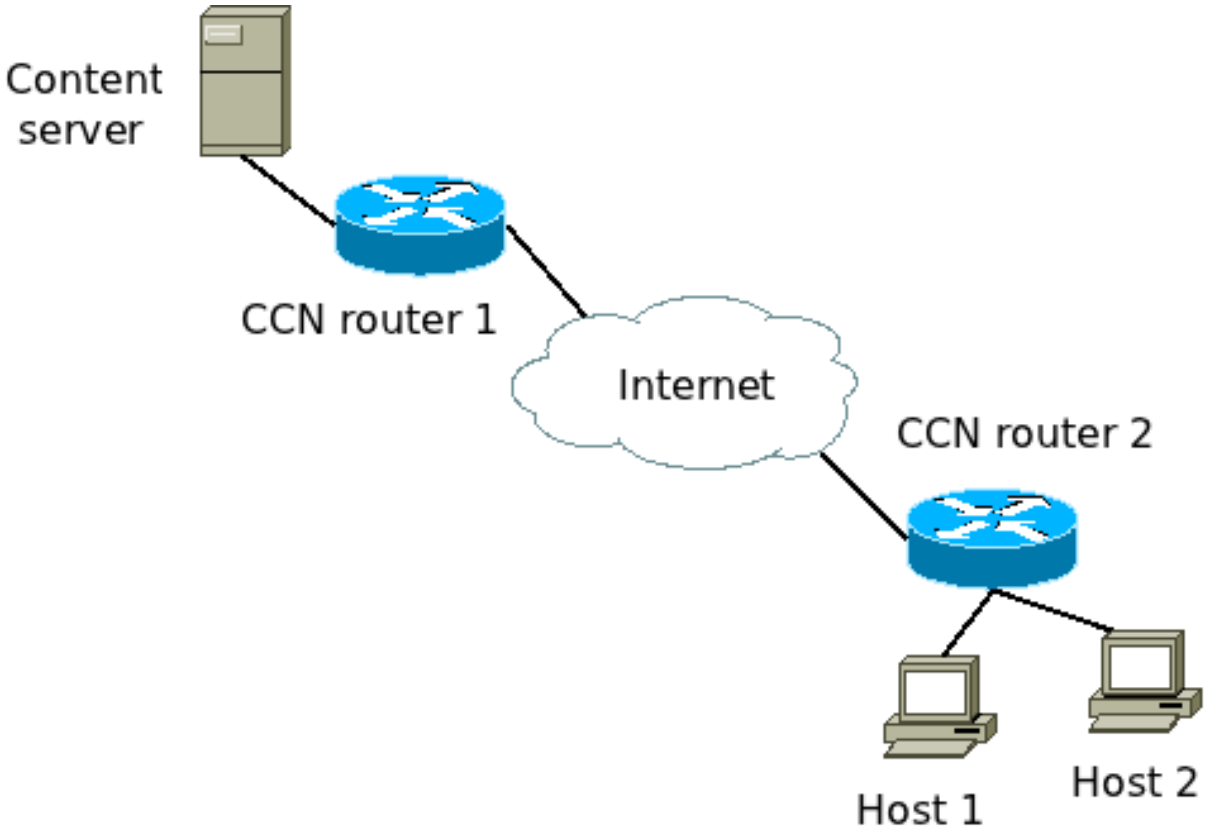
- CCN Packets:
  - **Interest Packets** that express Interest for a certain content
  - **Data Packets**, signed by the contents producer, reply to a certain Interest and consume it
- CCN tables:
  - Content store
    - local repository filled with shared content
  - Pending Interest Table (PIT)
    - Contains pending Interest requests send upstream to a content provider
  - Forward Information Base Table (FIB)
    - Contains the faces which correspond to a certain Interest

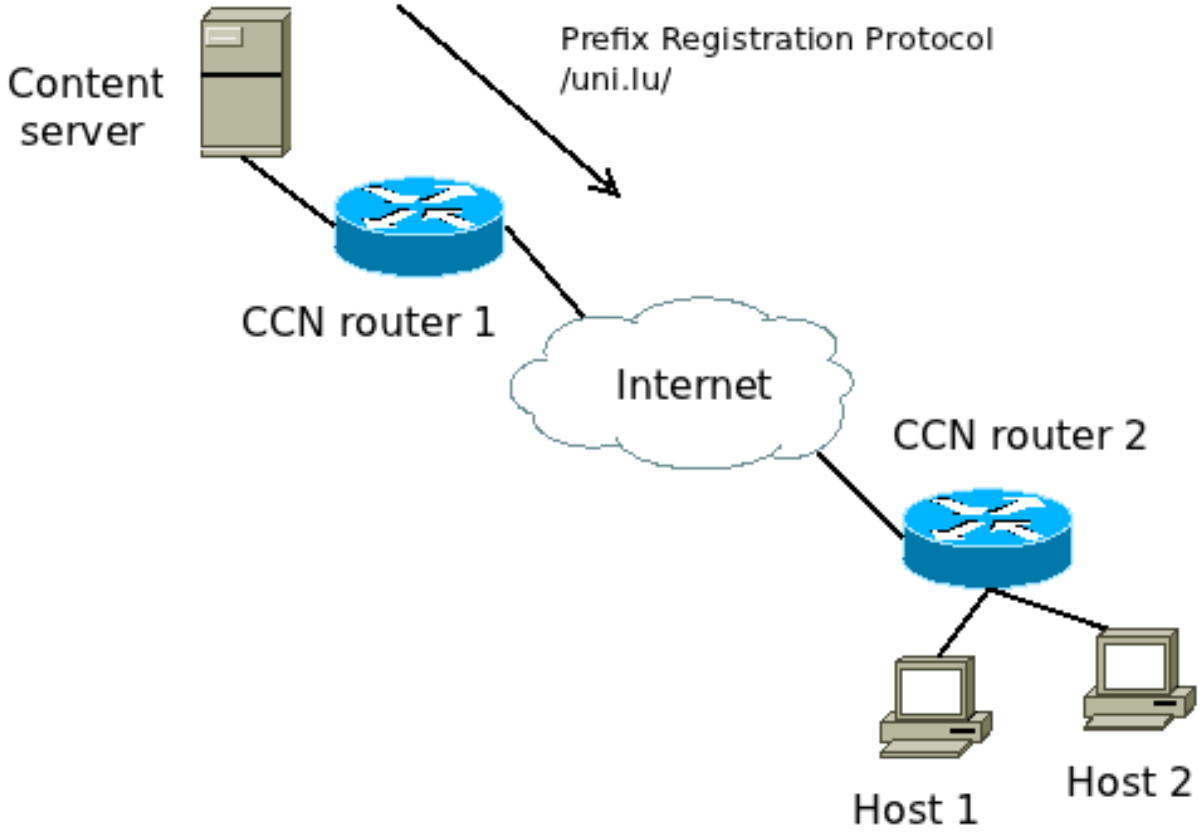
CCN node model



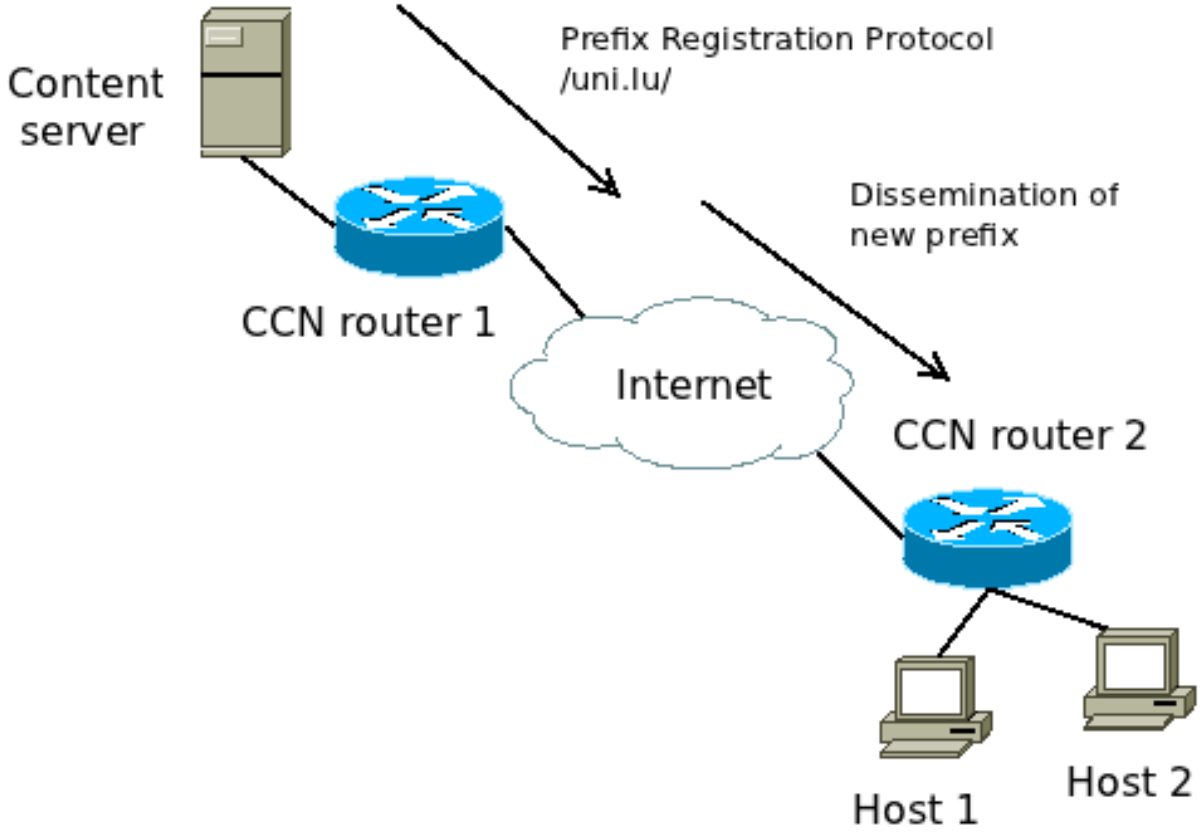
Routing example



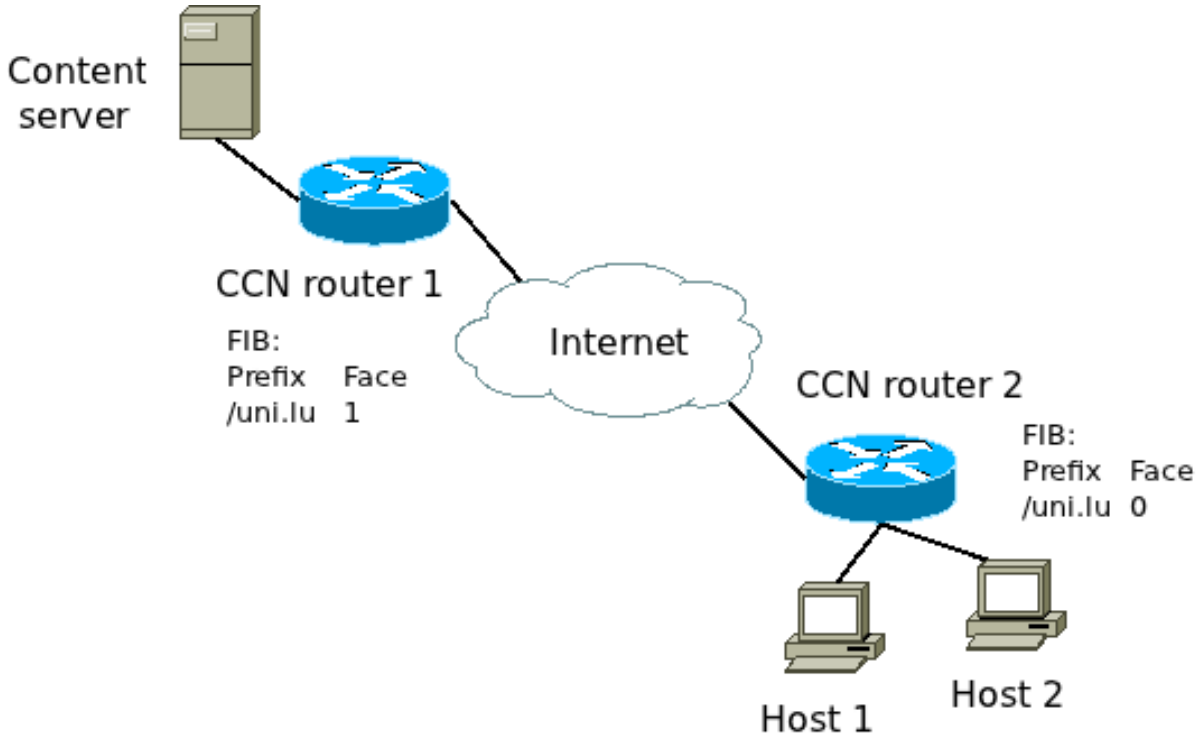
Routing example cont'd



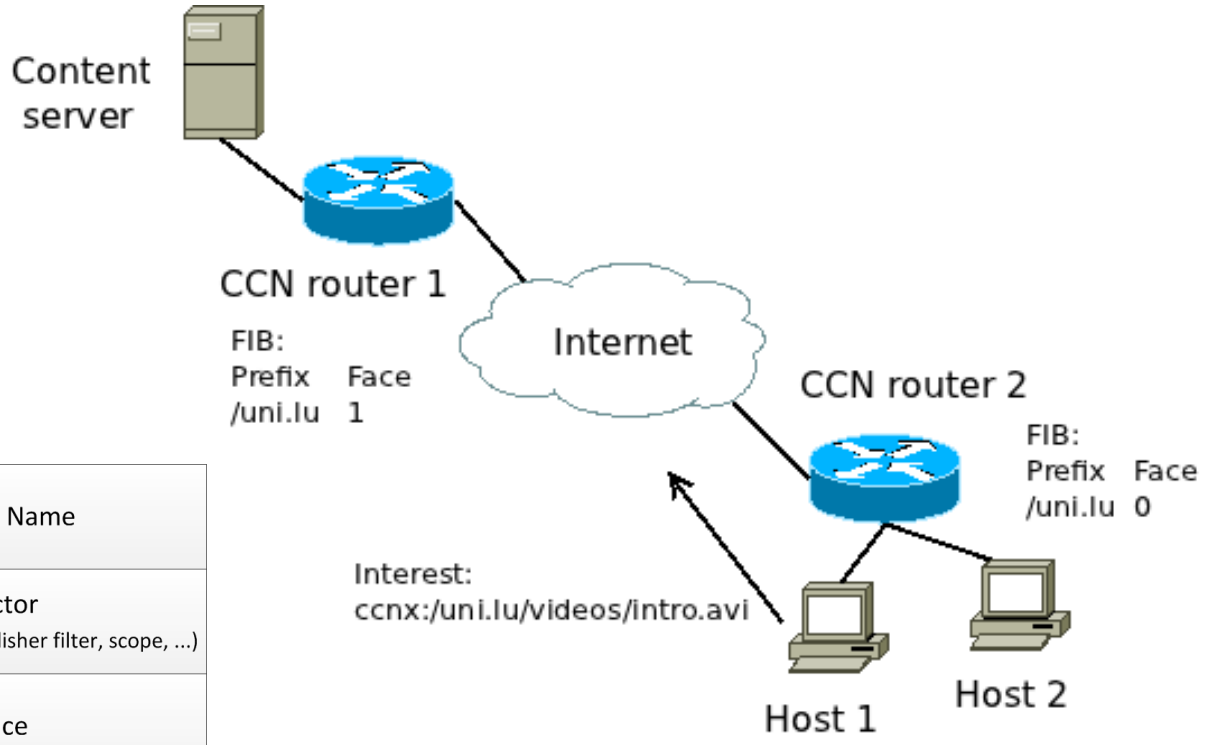
Routing example cont'd



Routing example cont'd

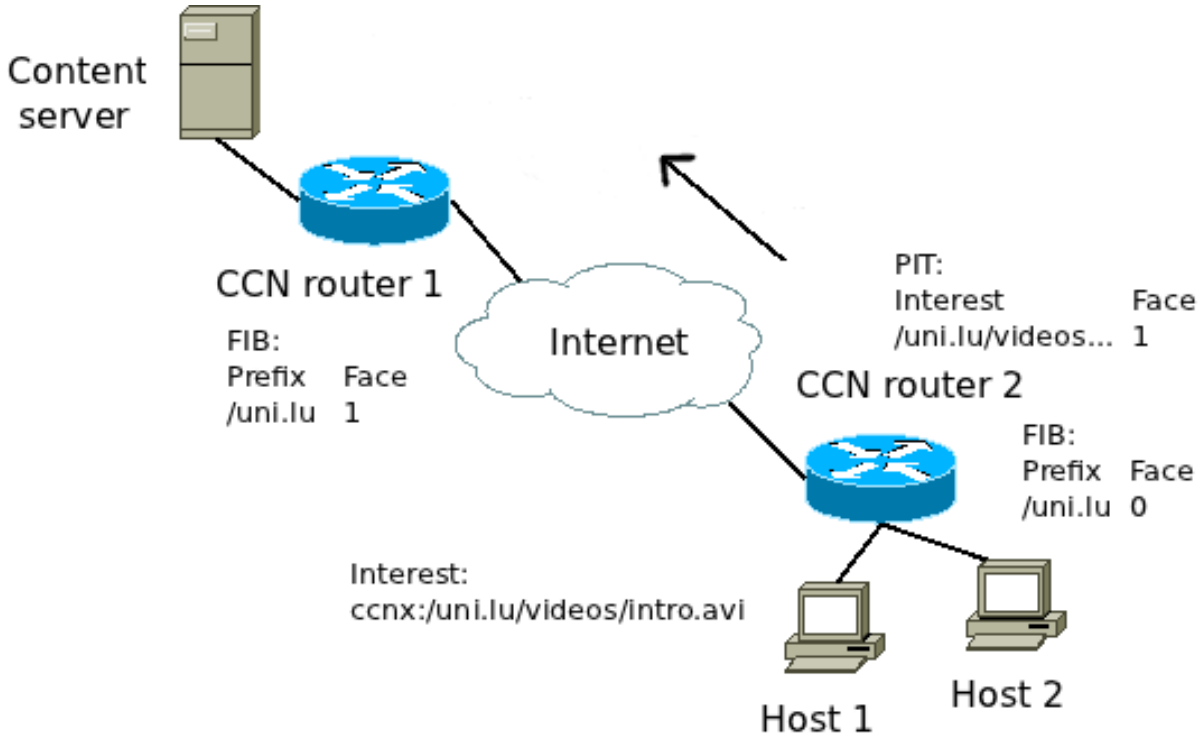


Routing example cont'd

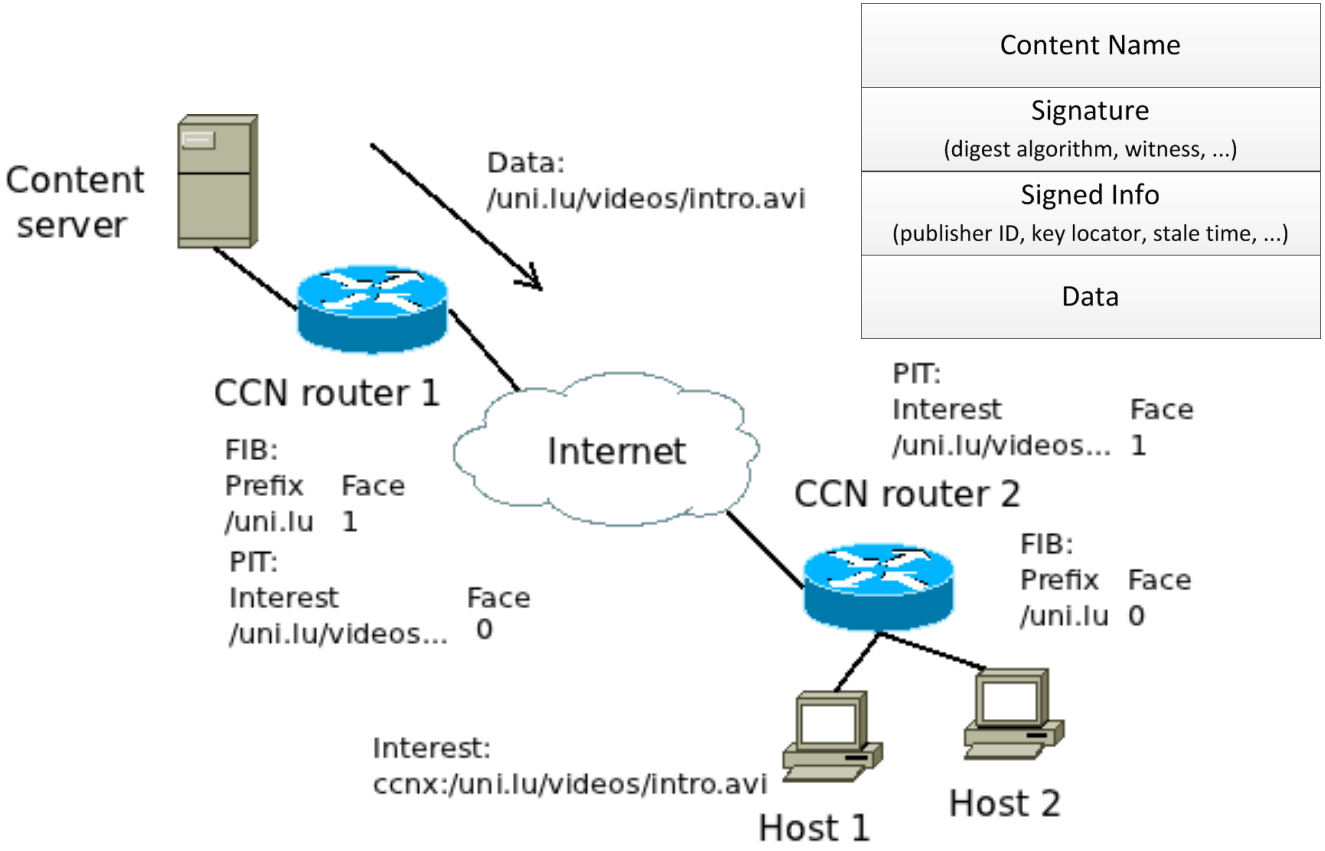


Content Name
Selector (order preference, publisher filter, scope, ...)
Nonce

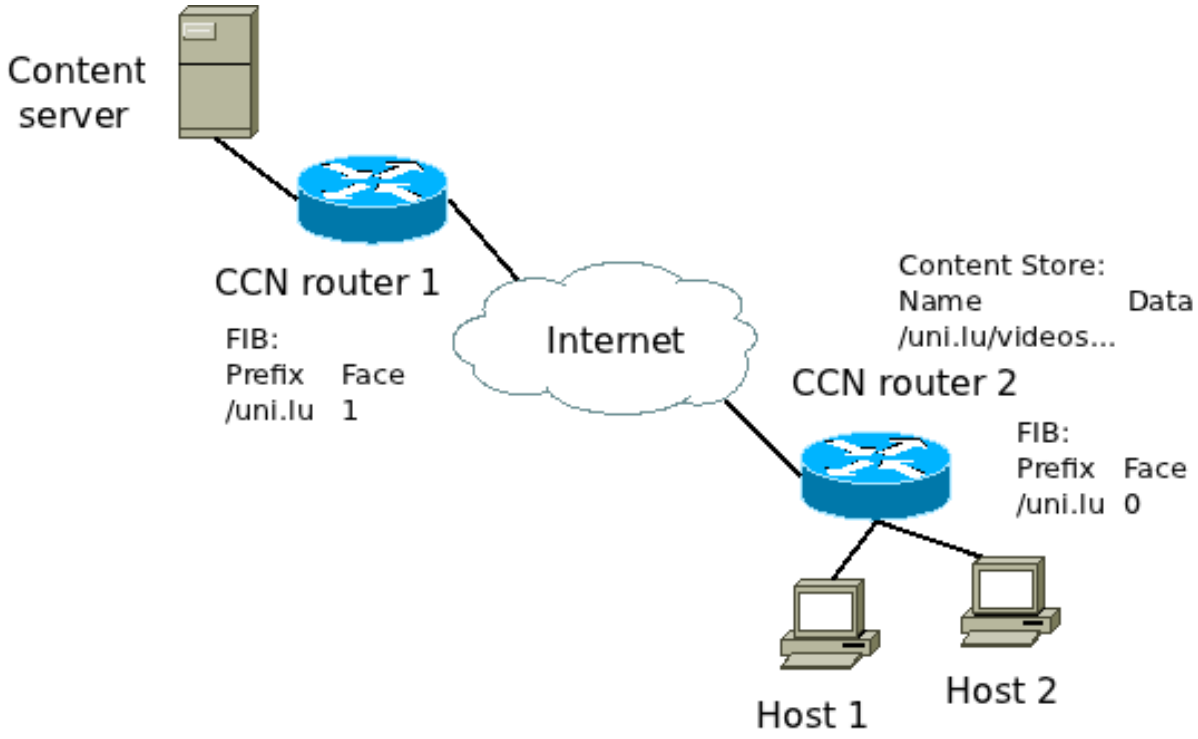
Routing example cont'd



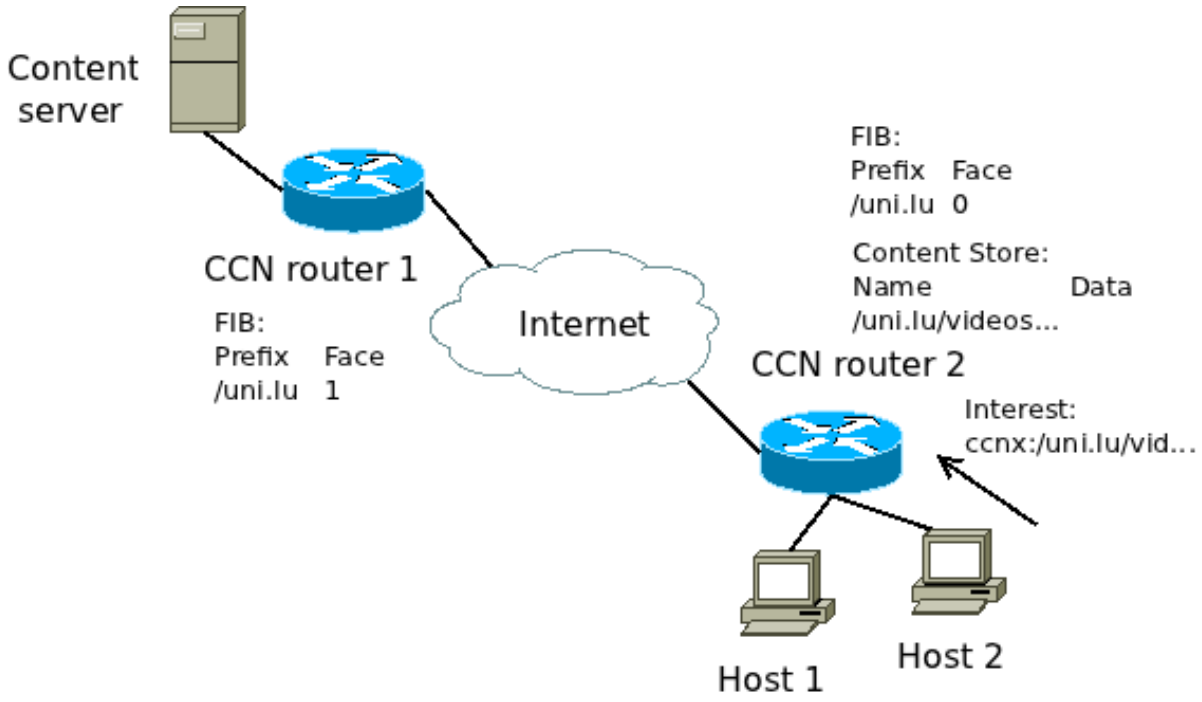
Routing example cont'd



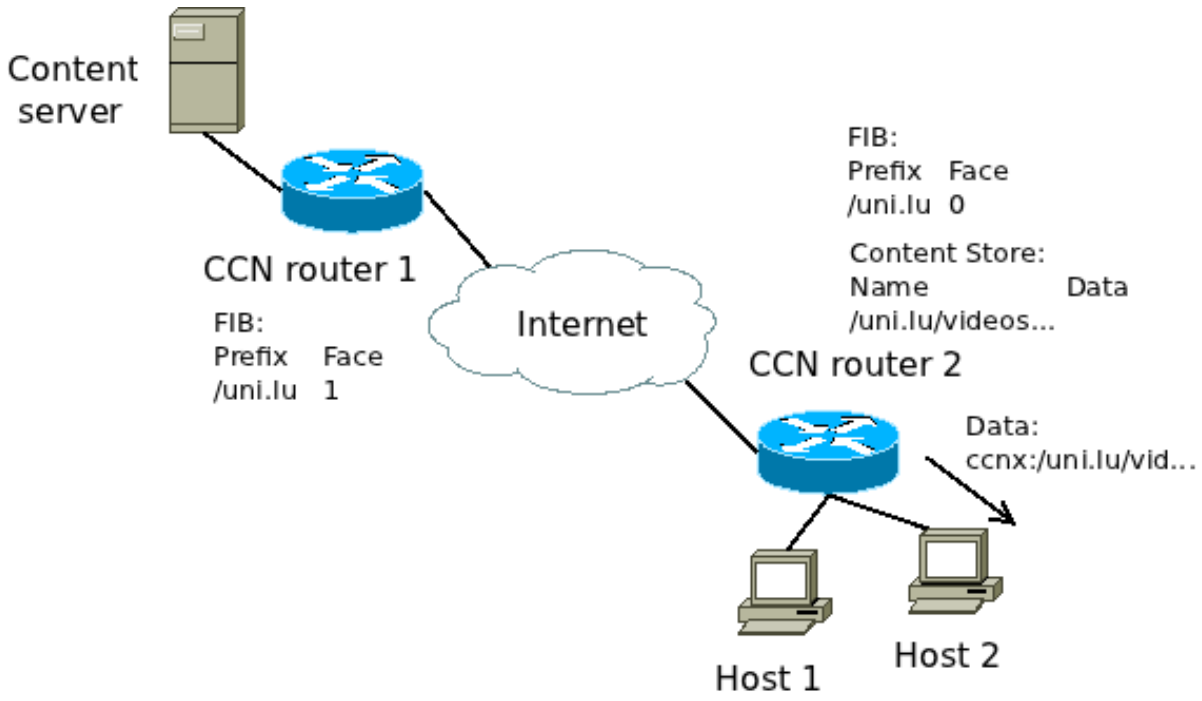
Routing example cont'd



Routing example cont'd



Routing example cont'd



Security layer

- No Content transmission before Interest reception
  - Renders classic Denial-of-Service, like flooding, inefficient
- Strongly relies on cryptography
  - Authentication of Content and its producer
  - Exclusion of untrustworthy sources
- But new kind of attacks
  - Stateful routers → More vulnerable ?
  - Missing tool for enforcing security policies

A Firewall for CCN

DESIGN

IP firewall general use cases

- IP_UC1
  - Based on the protocol
    - Example: http, mail, p2p, voip, …
- IP_UC2
  - According to the status of the connection
- IP_UC3
  - Using known blacklisted IP addresses
- IP_UC4
  - Unusual inbound traffic
    - From a denial of service attack

CCN-specific use cases

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- CCN_UC1
  - Filtering on content provider
    - Example: known untrustworthy or banned
- CCN_UC2
  - Filtering on bad signature
- CCN_UC3
  - Filtering on content name and semantic
    - Example: excluding files with certain extensions
- CCN_UC4
  - Composition (content provider & content name)

CCN-specific use cases

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- CCN_UC5
  - Filtering on content direction
    - Example: avoid leakage of certain documents
- CCN_UC6
  - Filtering on heavy traffic
    - Perservation of QoS
- CCN_UC7
  - Filtering of stored data
    - Example: Only storing specific content

Comparison

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IP use cases	CCN use cases	Filtering on
IP_UC1	CCN_UC3	Protocol / Content name
IP_UC2	--	Status of the connection
IP_UC3	CCN_UC1	Listed IP / Content provider
IP_UC4	CCN_UC6	Unusual / Heavy traffic
--	CCN_UC2	Bad signature
--	CCN_UC4	Composition of filters
--	CCN_UC5	Content direction
--	CCN_UC7	Stored data

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IMPLEMENTATION

Syntax definition

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- Syntax based on iptables
  - Ease of use and readability
- Distinguish between 3 types of rules
  - **r_interest**
    - `interest SP direction SP match_interest SP “pit” SP action`
  - **r_face**
    - `face SP number`
  - **r_data**
    - `data SP direction SP match_data SP [“cs” | “pit”] SP action`

r_interest & r_face

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```
interest SP direction SP match_interest SP "pit"
SP action
```

- direction
  - `int | ext | *`
- match_interest
  - * or regular expression
- action
  - `forward | drop`

- example :

```
interest * \@game|play|fun\@ 15 pit drop
```

```
face SP number
```

Number of active faces

- example :

```
face 200
```

r_data

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```
data SP direction SP match_data SP ["cs" | "pit"] SP action
```

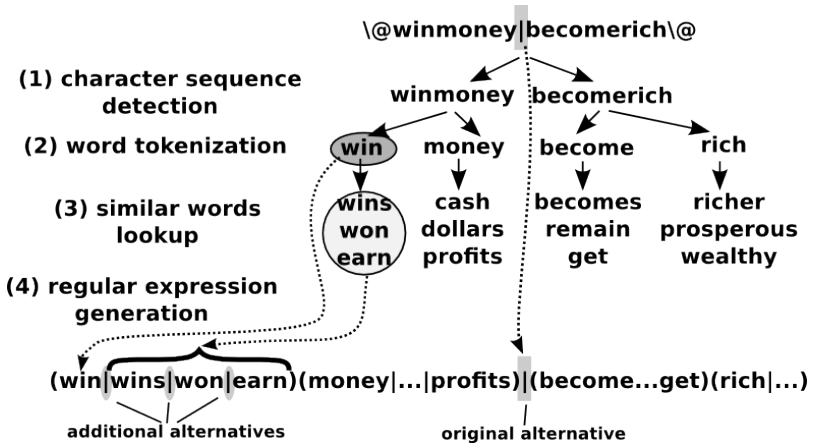
- direction
  - `int | ext | *`
- match_data
  - `content_name SP provider`
- content_name
  - * or regular expression
- provider
  - `sign_check SP provider_sign`
- signcheck
  - `0 | 1`
- provider_sign
  - * or hex representation of one or more signatures
- action
  - `forward | drop`

- example :

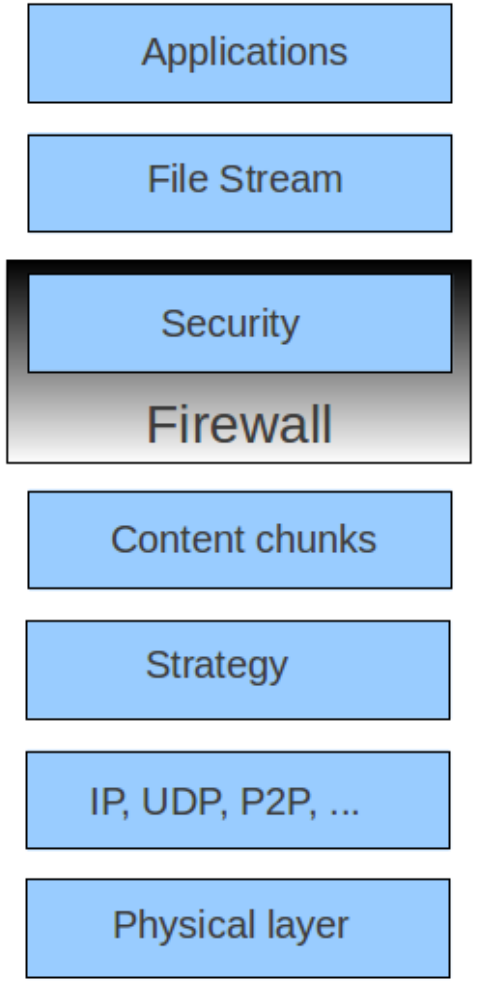
```
data * \@game|fun\@ 0 0 123456789ABCDEF;FFFF0000AAAA pit drop
```

Pre-processing with Disco

- >= 3 character sequences are extracted
- Segmented as real human-readable words
- For each sequence find x similar alternative sequences
- Recombine with original to create new regular expression



Implementation into CCN stack



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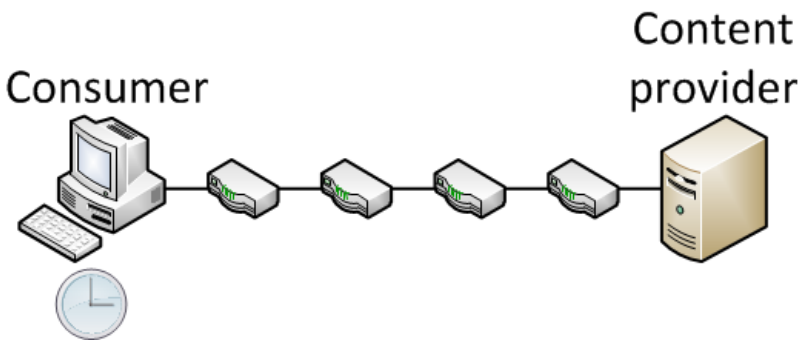
EVALUATION

Setup

- 6 nodes
- Intermediate routers don’t cache
- Consumer request single binary file 500MB or 1GB
- Measured transfer time request → received



1st evaluation: Impact of rules

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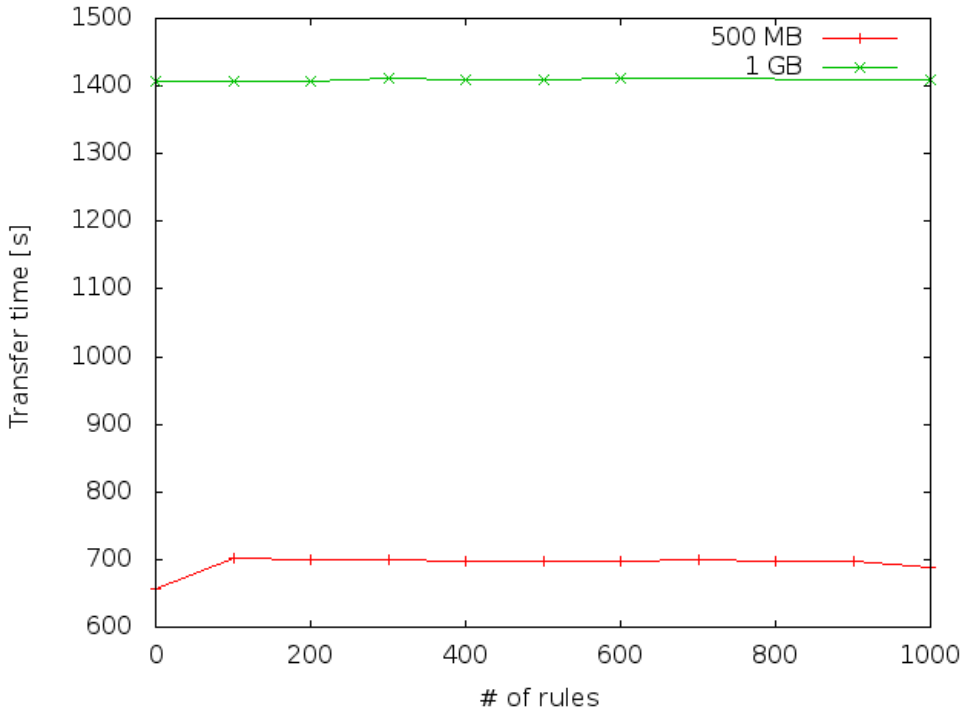
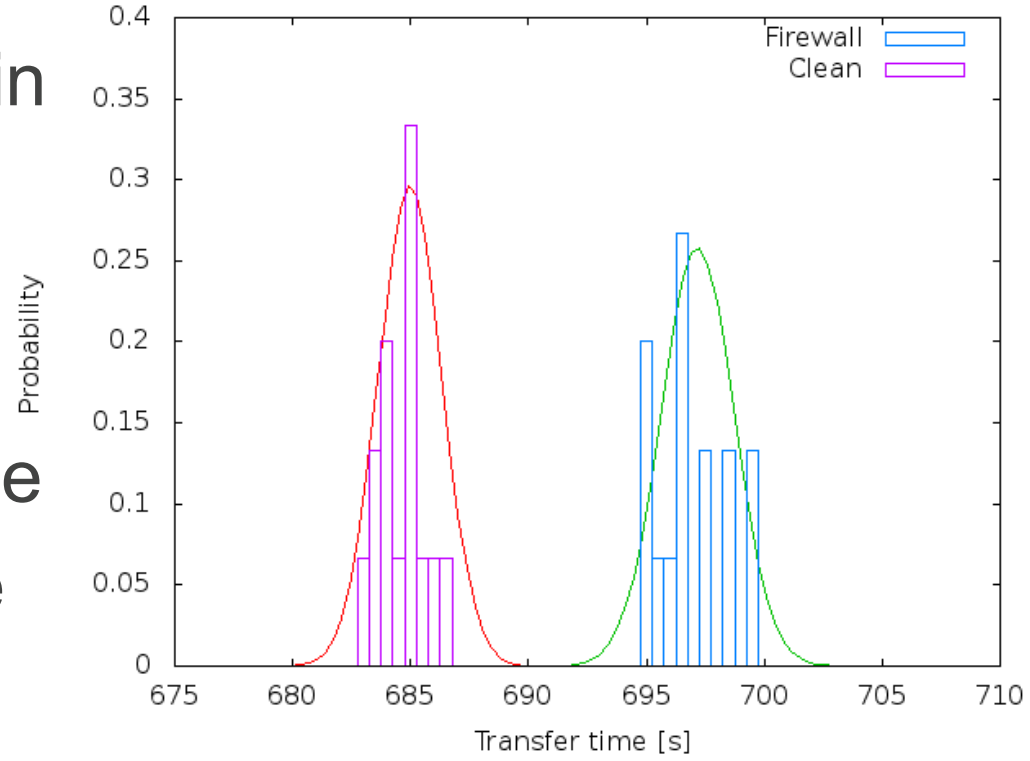
- Impact on the number of processed rules
  - Increasing step 100
  - Request 500 MB and 1 GB file
- Shows small to no impact on transfer time



2nd evaluation: Clean vs. Firewall

- Repeated experiment to obtain significant results
- Firewalled CCN
  - 1000 rules
- Request 500 MB file
- Applied Chi-square and KS-test on obtain result



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CONCLUSION

Conclusion

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- Introduction of a first firewall implementation dedicated to CCN
  - Use case analysis
  - Grammar definition
  - Implementation
- Use of semantic tools
- Overhead of the firewall is neglectable
- Published in IM2013 - MC2: Security Management and Recovery; *A semantic firewall for Content Centric Networking*

- Future Work
  - Rule reordering
  - Using Bloom filters

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THANK YOU FOR YOUR ATTENTION
QUESTIONS?