Interest-Based Access Control in CCN

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August 10, 2015

Agenda

1. Introduction and Access Control Overview
   - Encryption-based AC
   - Interest-based AC
2. IBAC Security Model
3. IBAC via Name Obfuscation
   - Encryption-based Obfuscation
   - Hash-based Obfuscation
4. Security Considerations
   - Replay Attacks
   - Authorized Key-Binding Rule
5. Conclusions and Recommendations

The Tenents of CCN

- Content is named and transferred through the network from producers to consumers
- *Any consumer* can ask for content provided its name
- Producers are considered responsible enforcing access control to content object data.

The Access Control Problem

Question: How can we ensure that only *authorized users* are able to access (the body of) a content object?

1. Encrypt the payload of a content object, give decryption keys to authorized users
2. Require that all interests are forwarded to the producer for inspection and authorization checks
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Access Control Groups

Access Control is based in *groups*, where groups are allowed (or not allowed) access to the content under question.

- N - name of a Content Object
- $\mathbb{U}(N)$ - set of consumers authorized to access (read or use) the content with name N
- $\bar{\mathbb{U}}(N)$ - complement of $\mathbb{U}(N)$

Encryption-based Access Control

Main Idea: If $C \notin \mathbb{U}(N)$, then C should not be able to decrypt the body of a content object.

- A preliminary specification was first introduced in [1]
- Many variations based on different public-key cryptographic algorithms have been proposed:
  - Broadcast-based encryption [2]
  - Attribute-based encryption [3]
  - Proxy-based encryption [4]
  - CCN-AC (a general framework for all of the above) [5]

1 Smetters, Diana, Philippe Golle, and Jim Thornton. CCNx Access Control Specifications. Technical report, PARC, 2010.

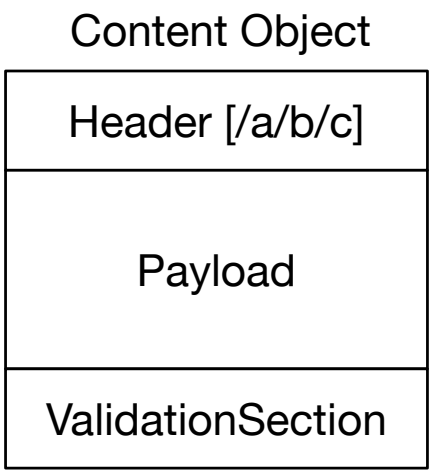
2 Misra, Satyajayant, Reza Tourani, and Nahid Ebrahimi Majd. “Secure Dontent Delivery in Information-Centric Networks: Design, Implementation, and Analyses.” Proceedings of the 3rd ACM SIGCOMM workshop on Information-centric networking. ACM, 2013.

3 Ion, Mihaela, Jianqing Zhang, and Eve M. Schooler. “Toward Content-Centric Privacy in ICN: Attribute-Based Encryption and Routing.” ACM SIGCOMM Computer Communication Review. Vol. 43. No. 4. ACM, 2013.

4 Wood, Christopher, and Ersin Uzun. “Flexible End-to-End Content Security in CCN.” Consumer Communications and Networking Conference (CCNC), 2014 IEEE 11th. IEEE, 2014.

5 Kurihara, Jun, C. Wood, and Ersin Uzun. “An Encryption-Based Access Control Framework for Content-Centric Networking.” IFIP, 2015.

Encryption-based AC in Pictures



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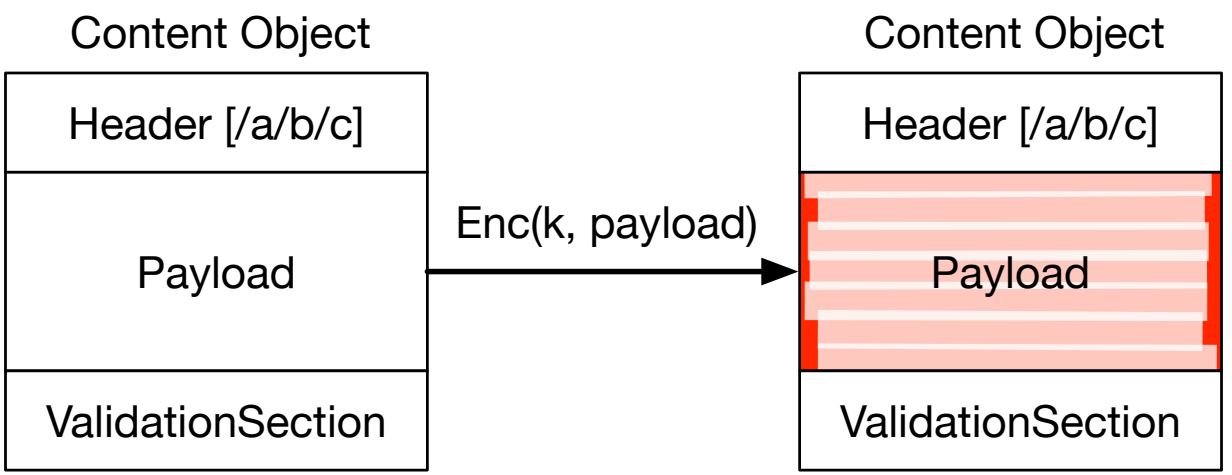

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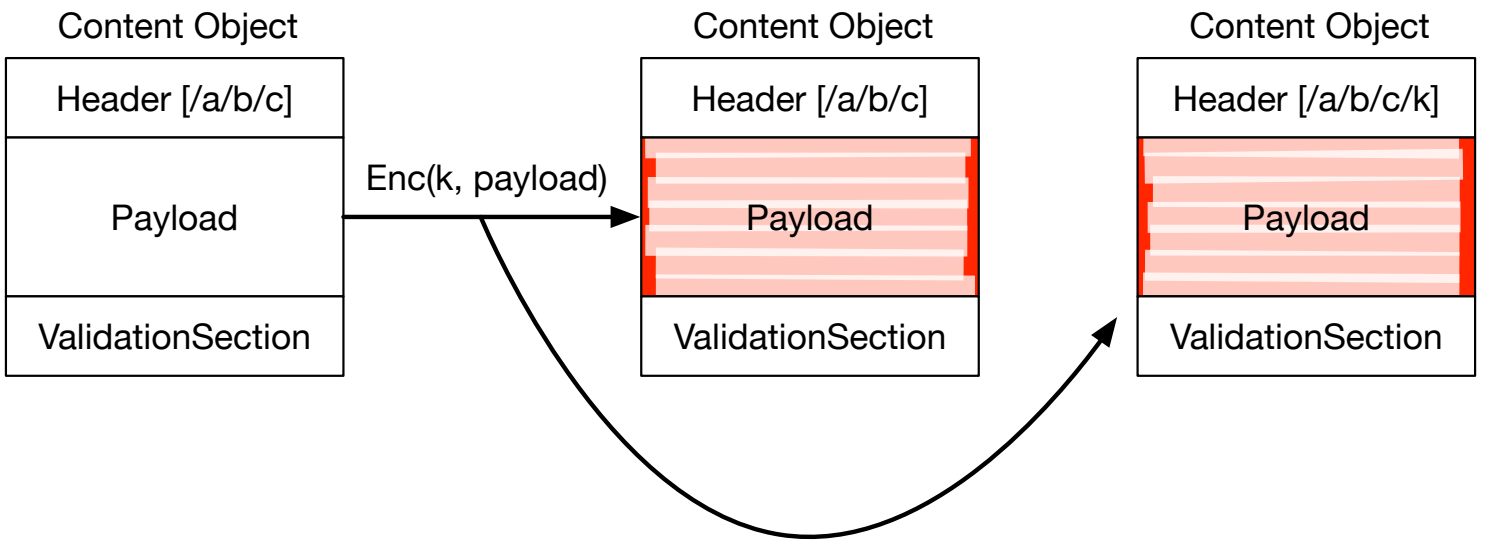

Interest-based Access Control

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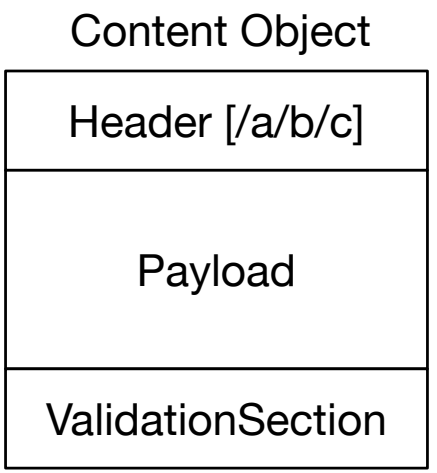

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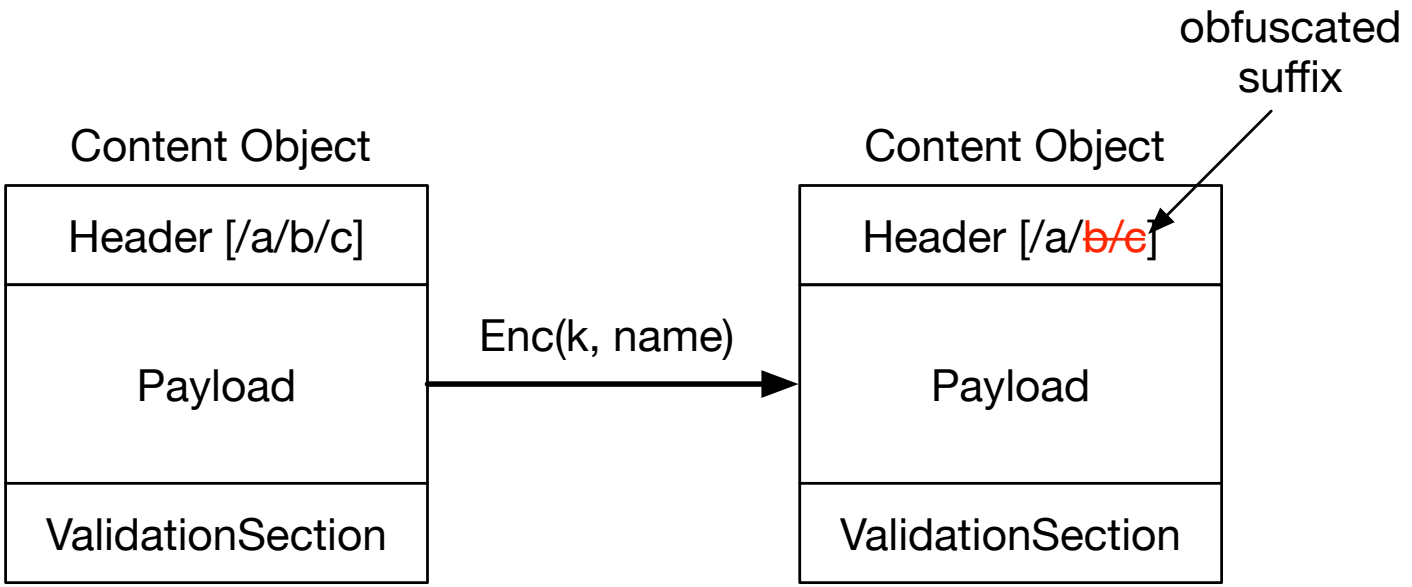
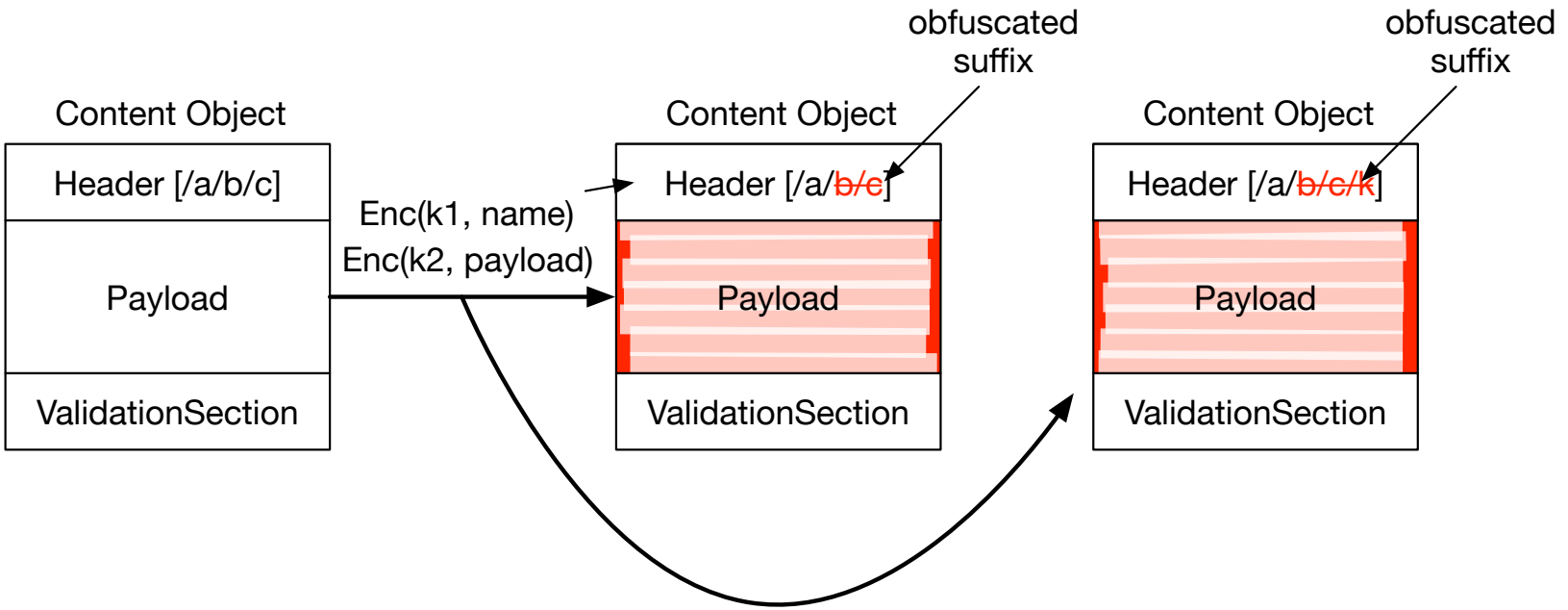


Both Dimensions of AC



Security Model

Recall that IBAC is about encrypting the name (though the payload may also be encrypted)...

Let $\text{Path}(Cr, P)$ be the set of all routers on the path between the consumer $Cr \in \mathbb{U}(N)$ and P.

We assume an adversary Adv who can deploy and compromise any unauthorized consumer or any router $R \notin \text{Path}(Cr, P)$.

- On-path adversaries can see the names!
- ... but, we will consider on-path adversaries and replay attacks later

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IBAC via Name Obfuscation

The goal of IBAC is to make the name N of a content object *unguessable* by unauthorized users, i.e., publish N under the name $N' = f(N)$ for some obfuscation function f.

There are at least two ways to do this:

- Encryption-based obfuscation
- Hash-based obfuscation

Note: the obfuscation function only encrypts the *suffix* of a name – not the routable prefix!

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Encryption-based Obfuscation

$$N' = \mathrm{Enc}(k, N),$$

where k is the private key associated with an authorized user.

Supporting Multiple Groups

Question #1: What if we want group-based access control, i.e., where consumers in the same group deterministically generate the same obfuscated name?

(One) Answer: Consumers in the same group share the same encryption key.

Question #2: How does a producer identify the correct decryption key $k_{\mathbb{G}_i}$ for content?

(One) Answer: Include the group identifier $mathsf ID_{\mathbb{G}_i}$ in the payload of each interest.

$$\mathrm{ID}_{\mathbb{G}_i} = \mathrm{H}(k_{\mathbb{G}_i})$$

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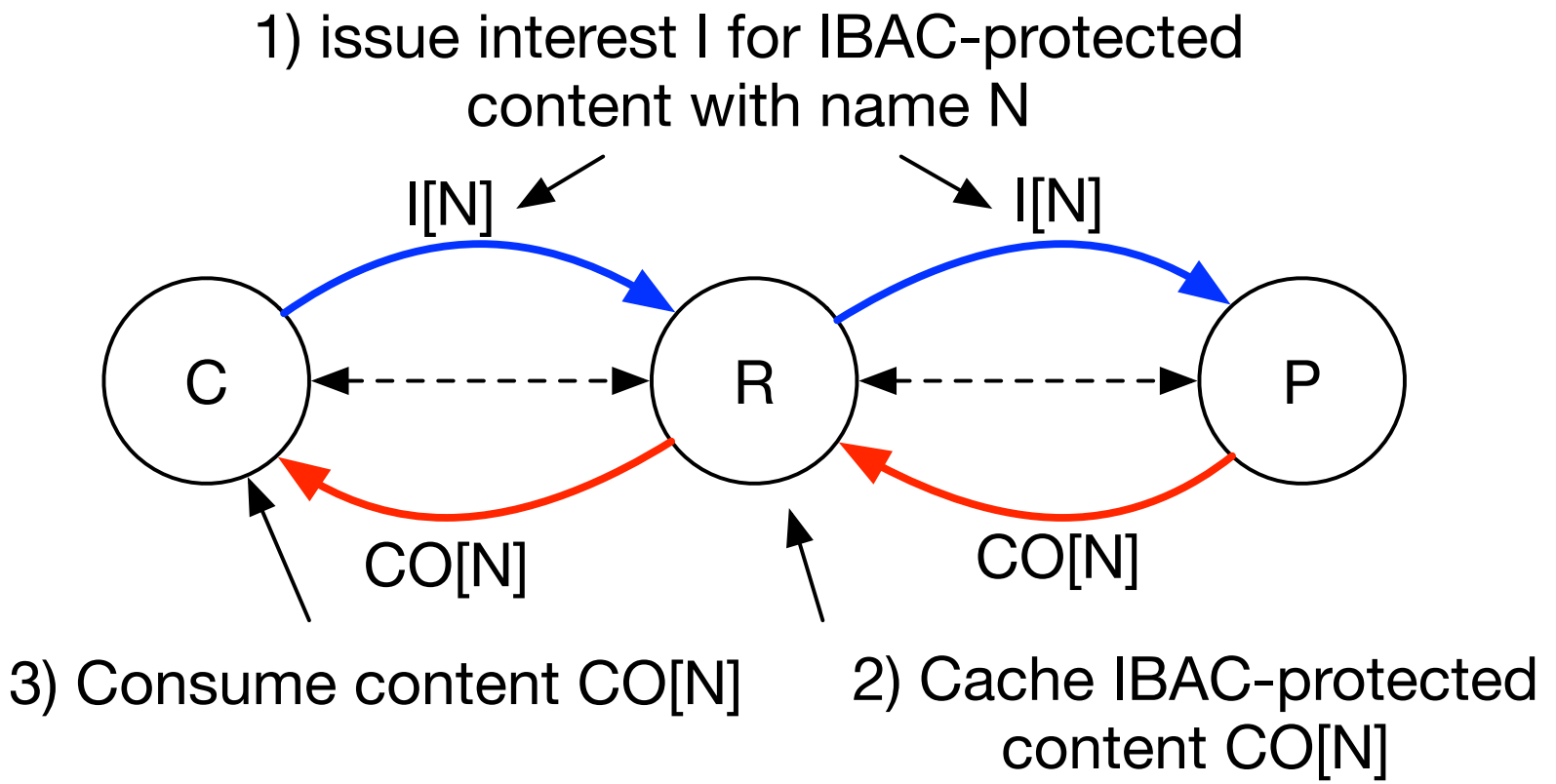
Replay Attacks



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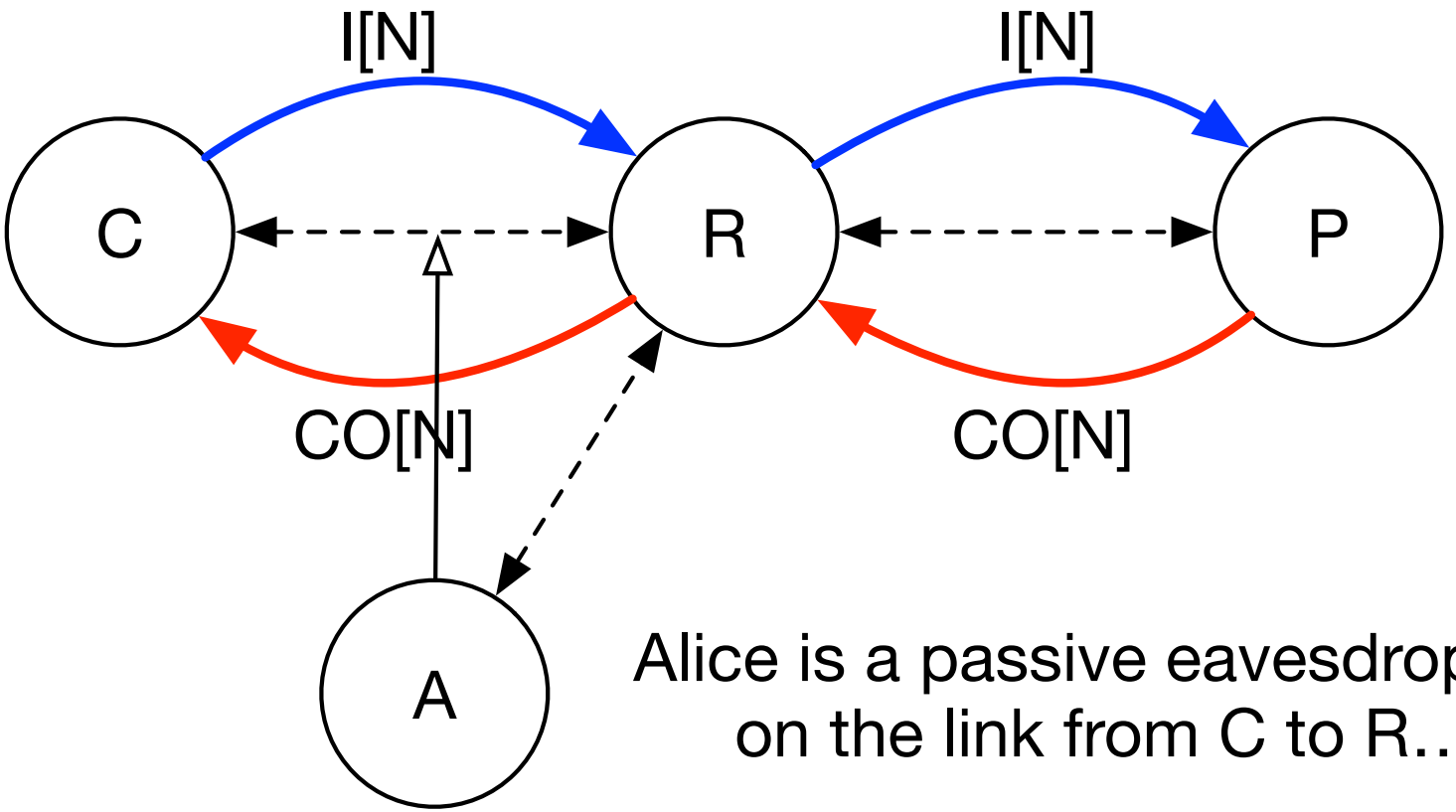

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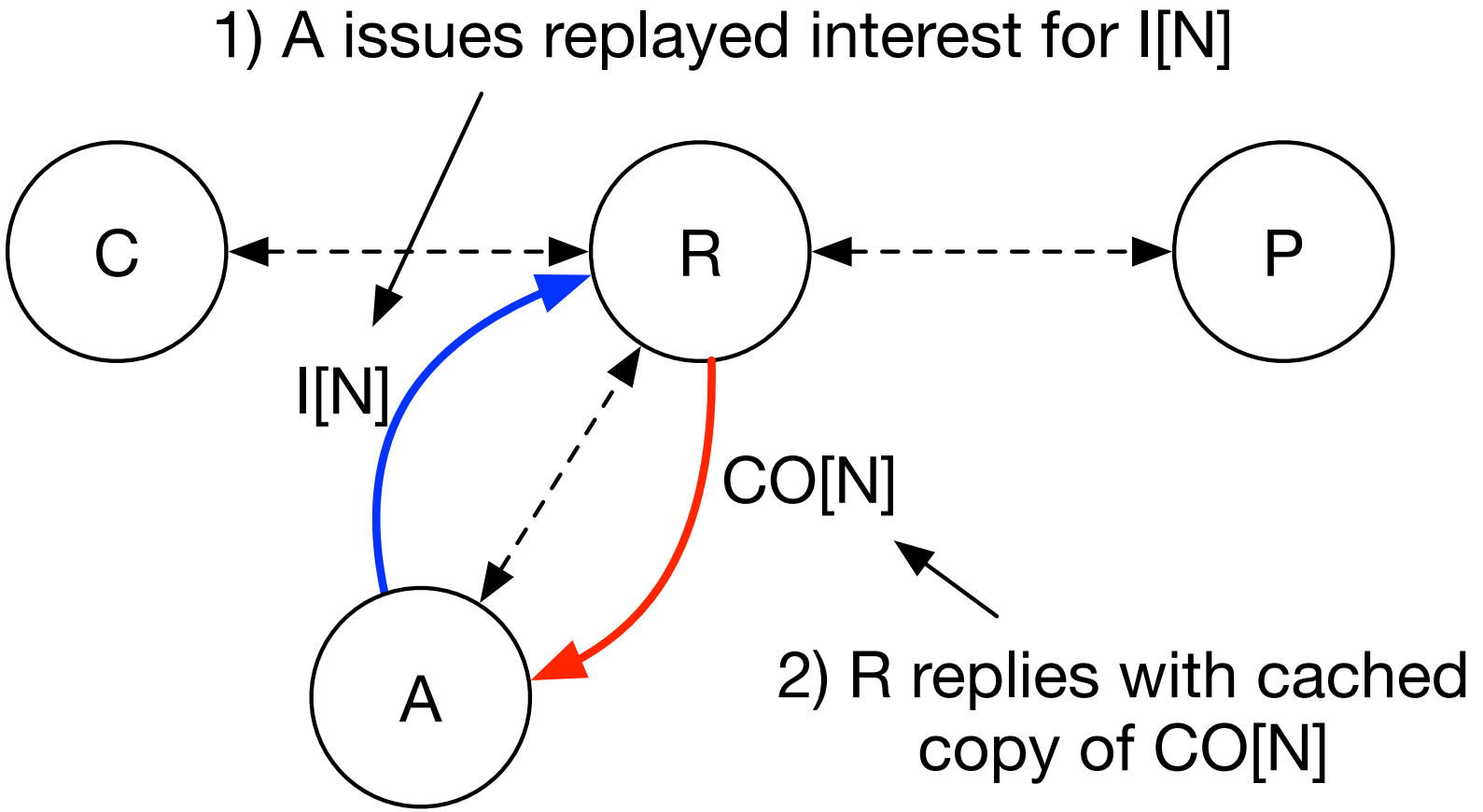

Replay Attacks in Detail

Any adversary can observe an obfuscated interest, replay it, and get the same content

We need **replay prevention**:

- Nonces and timestamps help prevent replay attacks
- ... in addition to consumer authentication information

$$\texttt{Payload} = \left(\mathrm{ID}_{\mathbb{G}_i}, r, t, \sigma = \mathrm{Sign}_{sk^s_{\mathbb{G}_i}}\left(N' || \mathrm{ID}_{\mathbb{G}_i} || r || t\right)\right)$$

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Question: How can a router check if a given (cached) content object can be returned in response to an interest?

Answer: Routers will have to verify some authenticator provided in interests (e.g., a digital signature)

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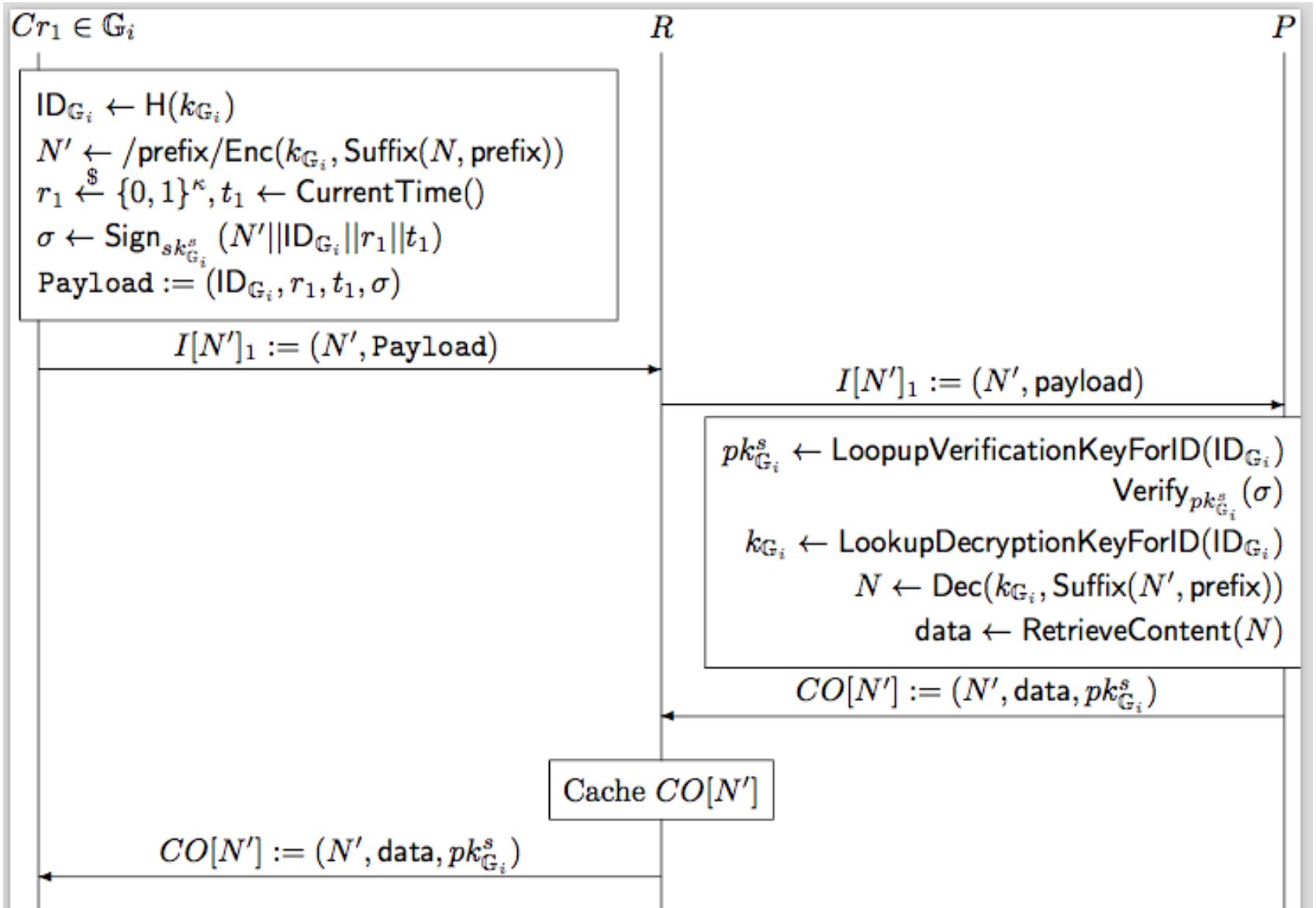
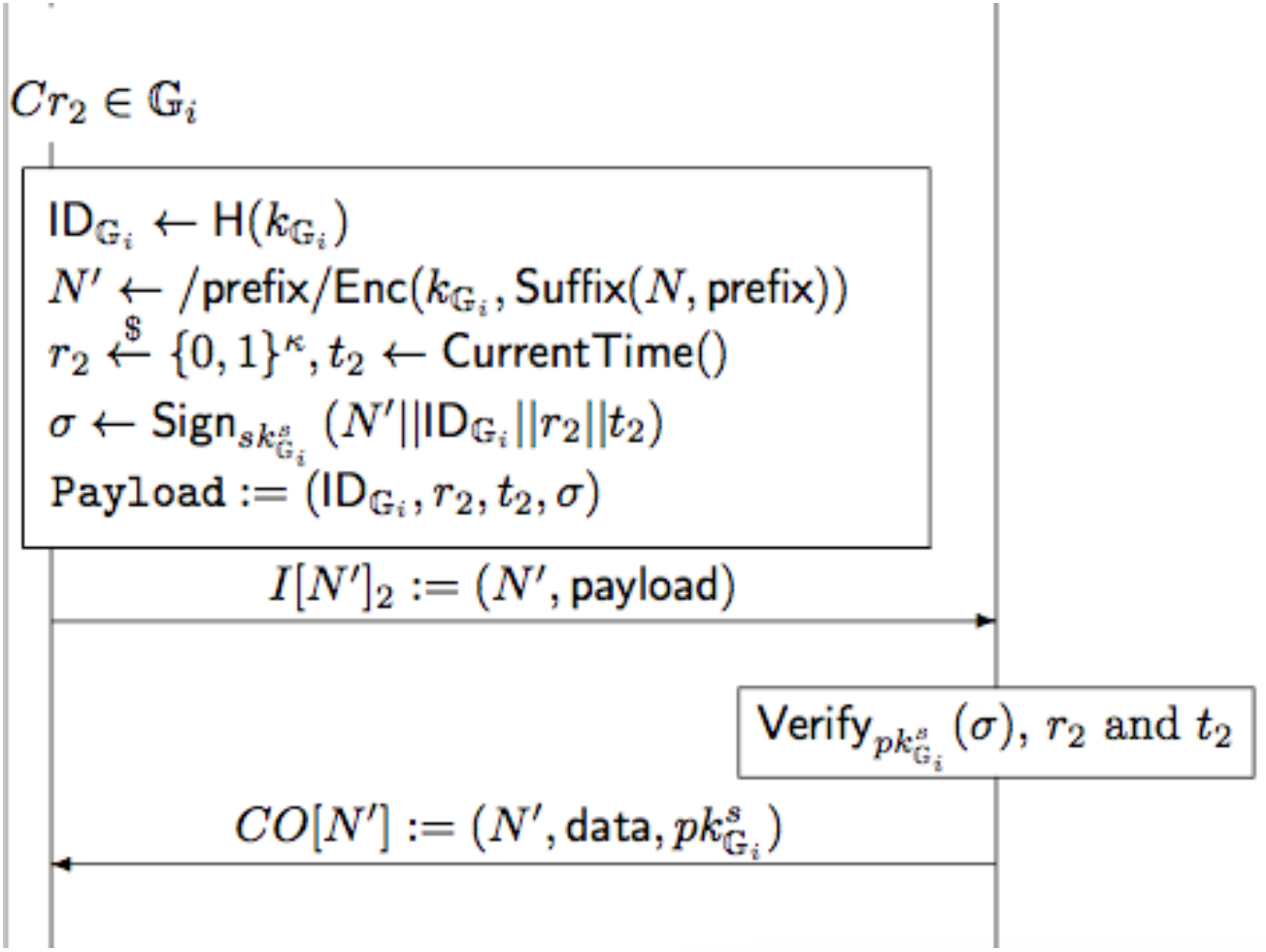


AKB in Action (Part 2)



Recommendations

1. If *replay attacks* are not a concern, then consumers only need to use a name obfuscation function and include their group identity in the `Payload`.
2. If *replay attacks* are plausible and *name privacy* is a concern, then name obfuscation must be used and authorization information must be included in interest `Payload` fields.
3. If *replay attacks* are plausible but *name privacy* is not a concern, then only authorization information is sufficient.

Conclusion

1. Motivated about encryption- and interest-based access control
2. Discussed two ways to enforce interest-based access control
3. Provided an extension for to handle replay attacks in the network
4. Finished with recommendations for using IBAC

Q&A

Questions?...

Fire away!