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Broadcast Steganography or How to Broadcast a Secret *Covertly*

SESSION ID: CRYP-T08

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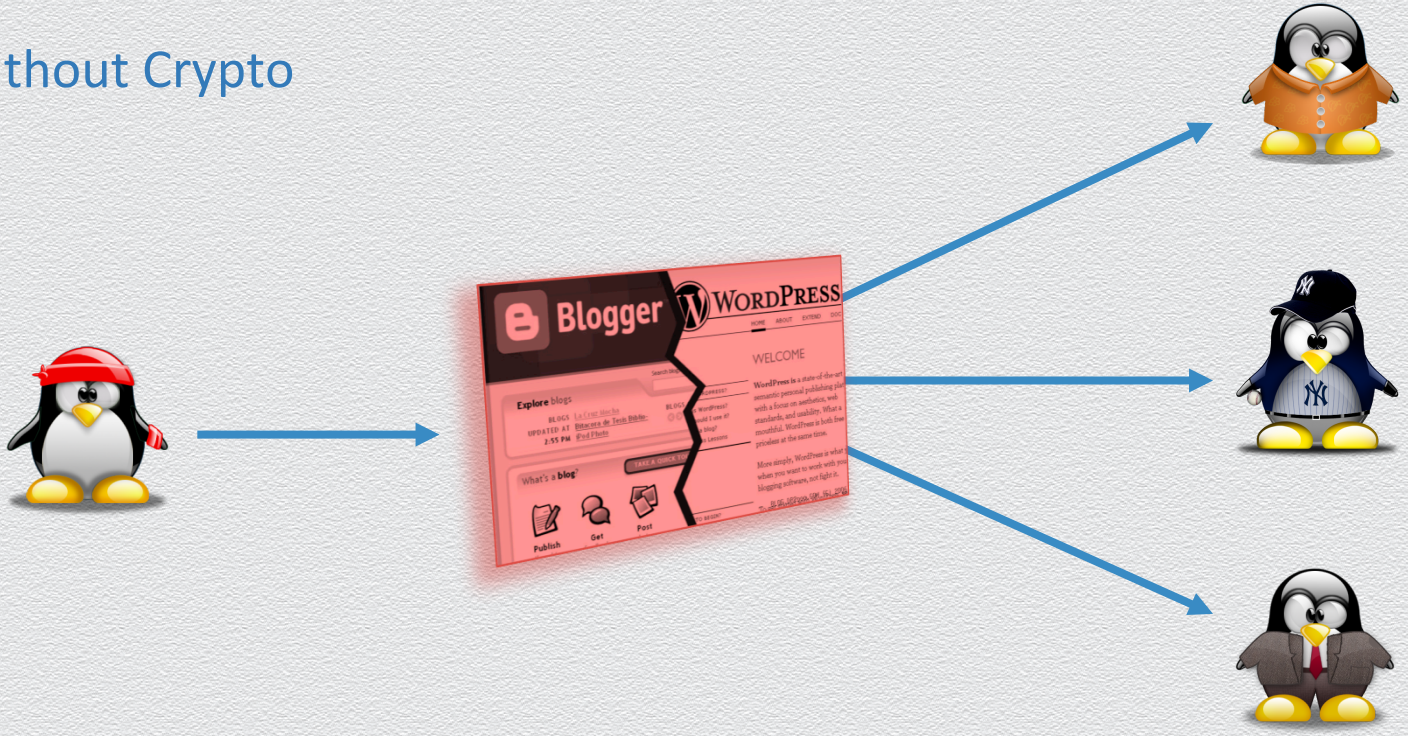
Without Crypto

Without Crypto



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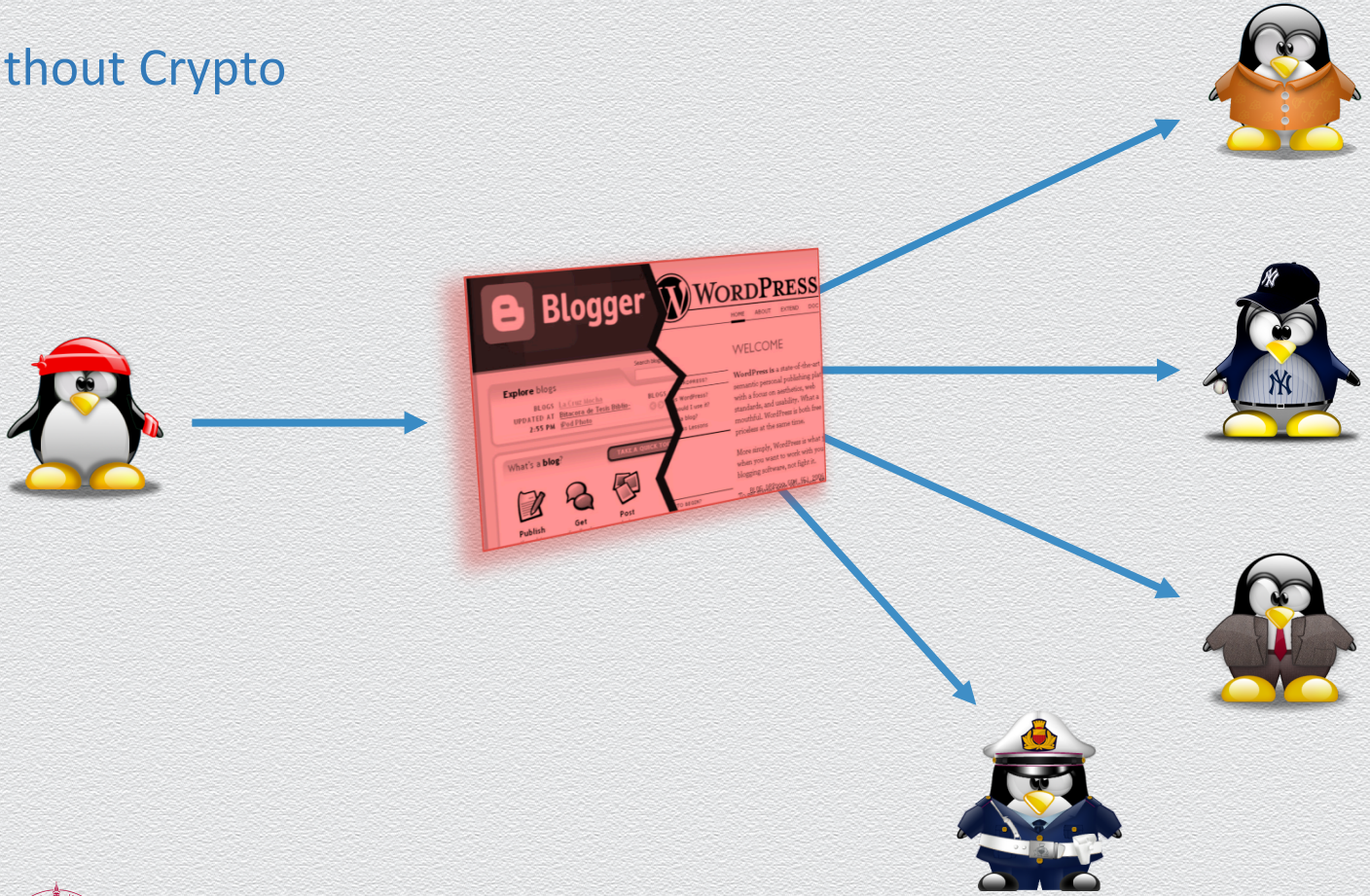

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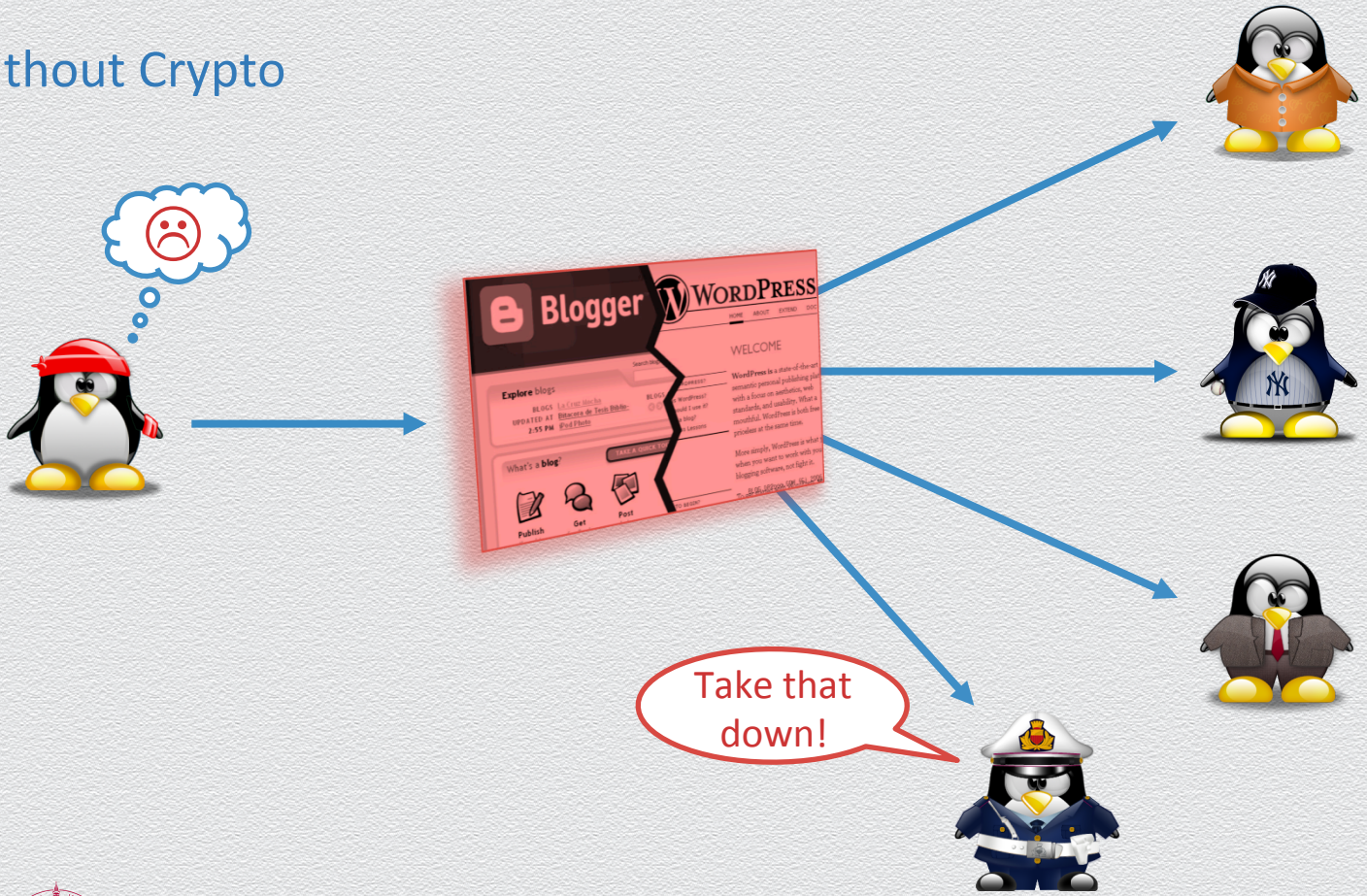

With Encryption

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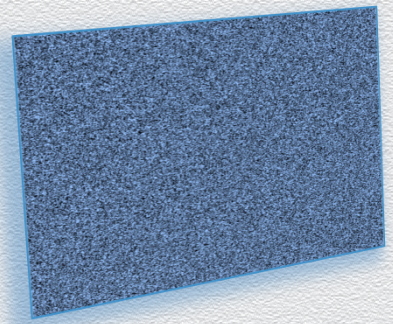

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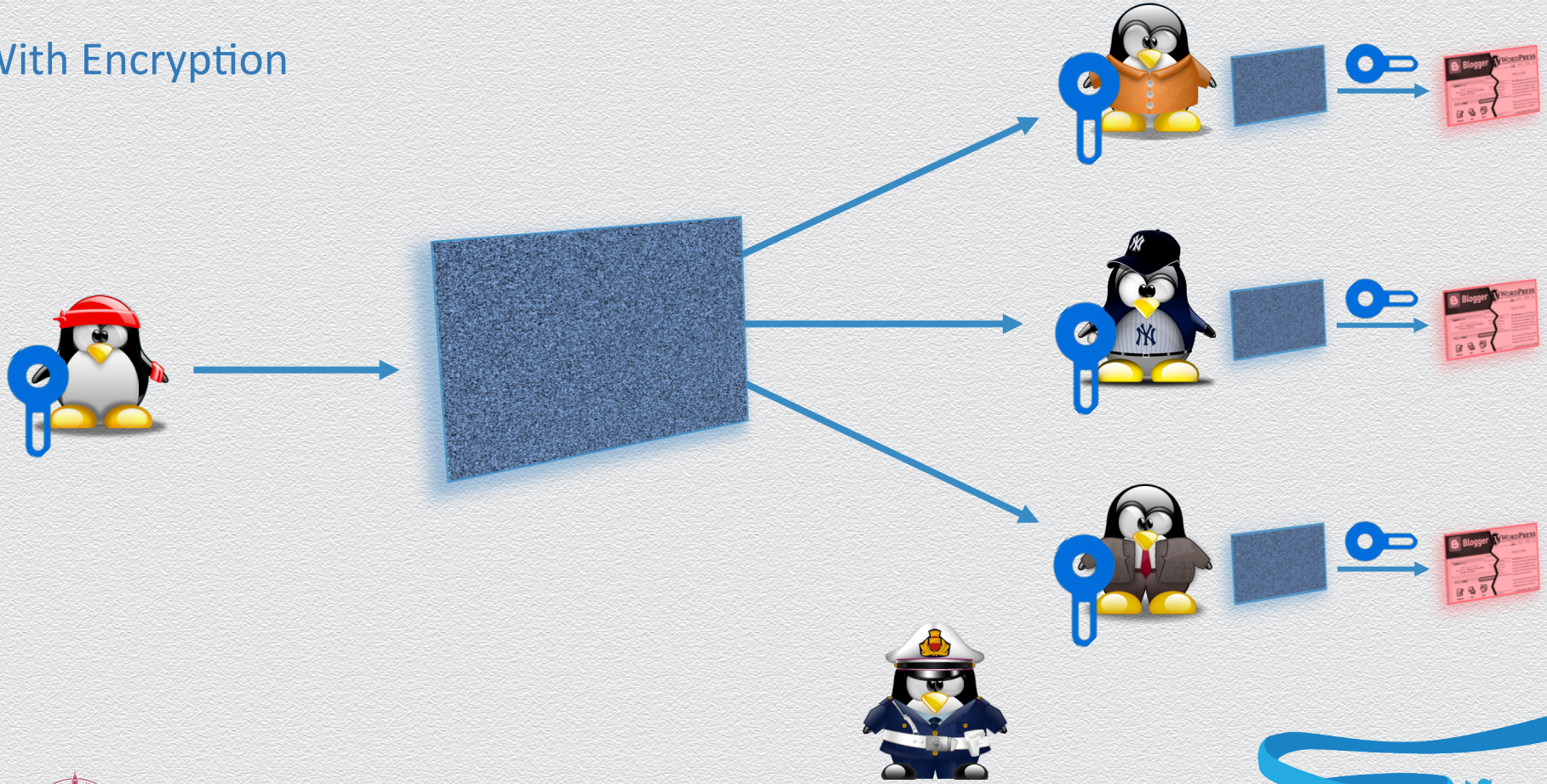

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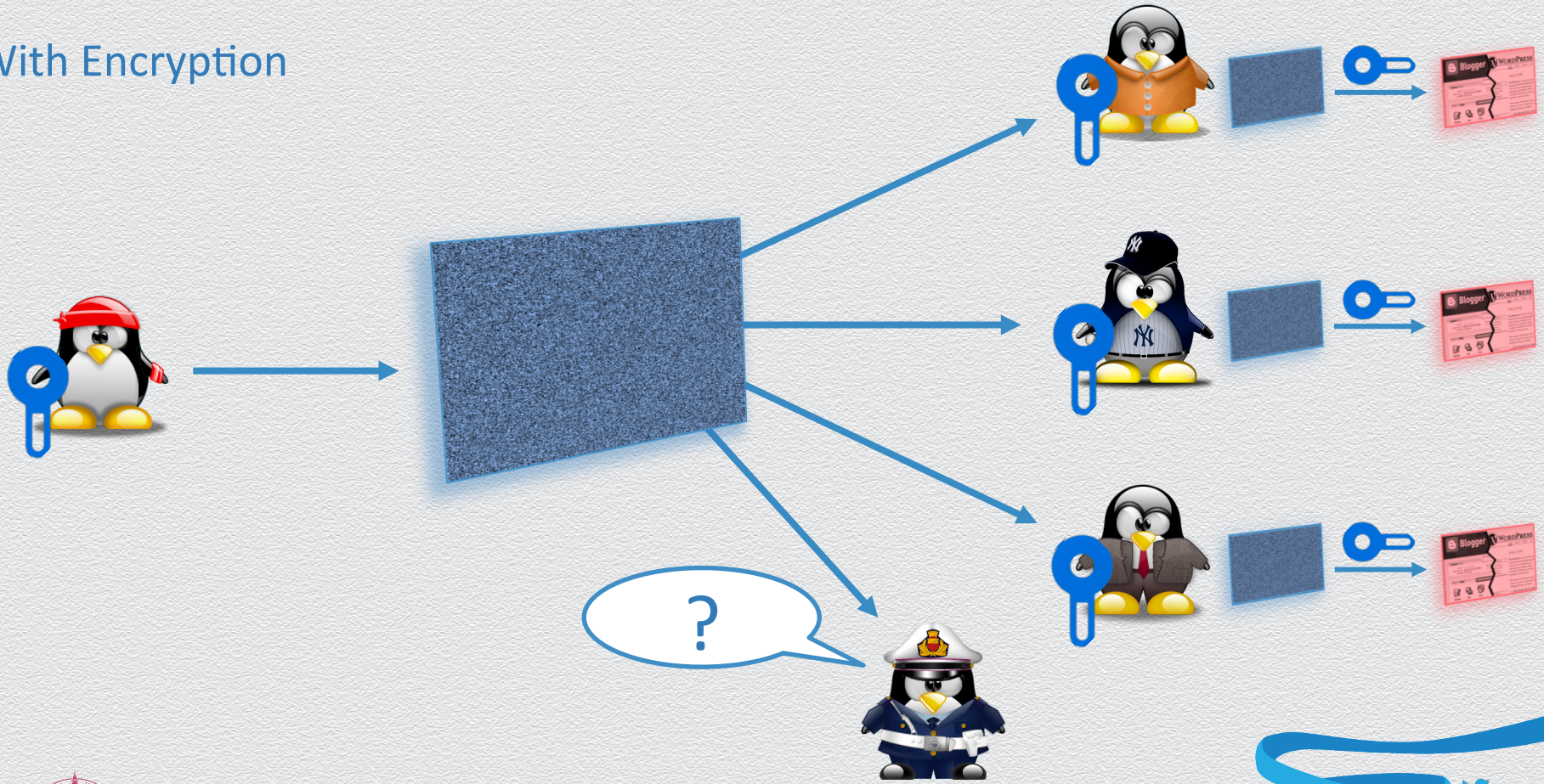

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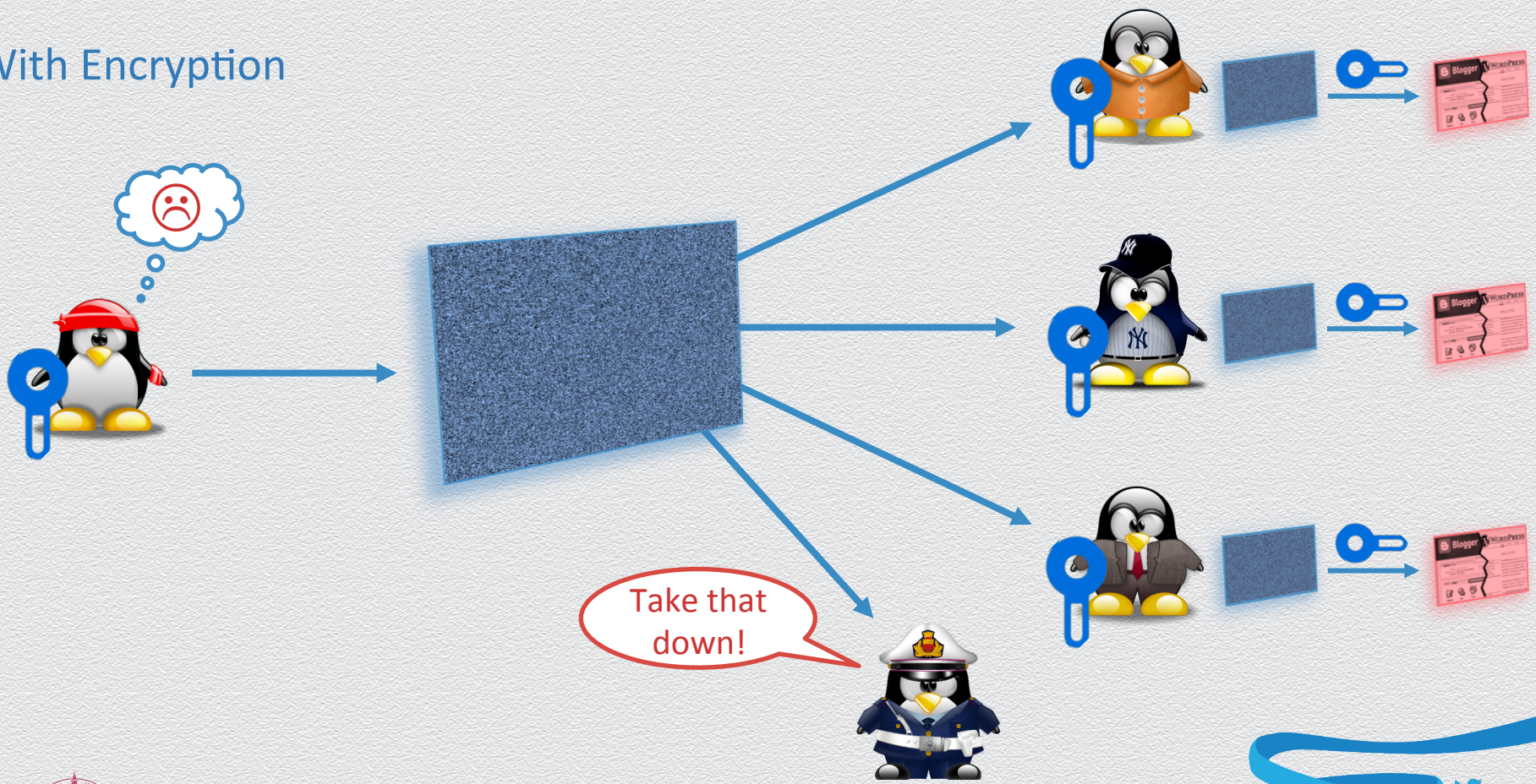

With Steganography

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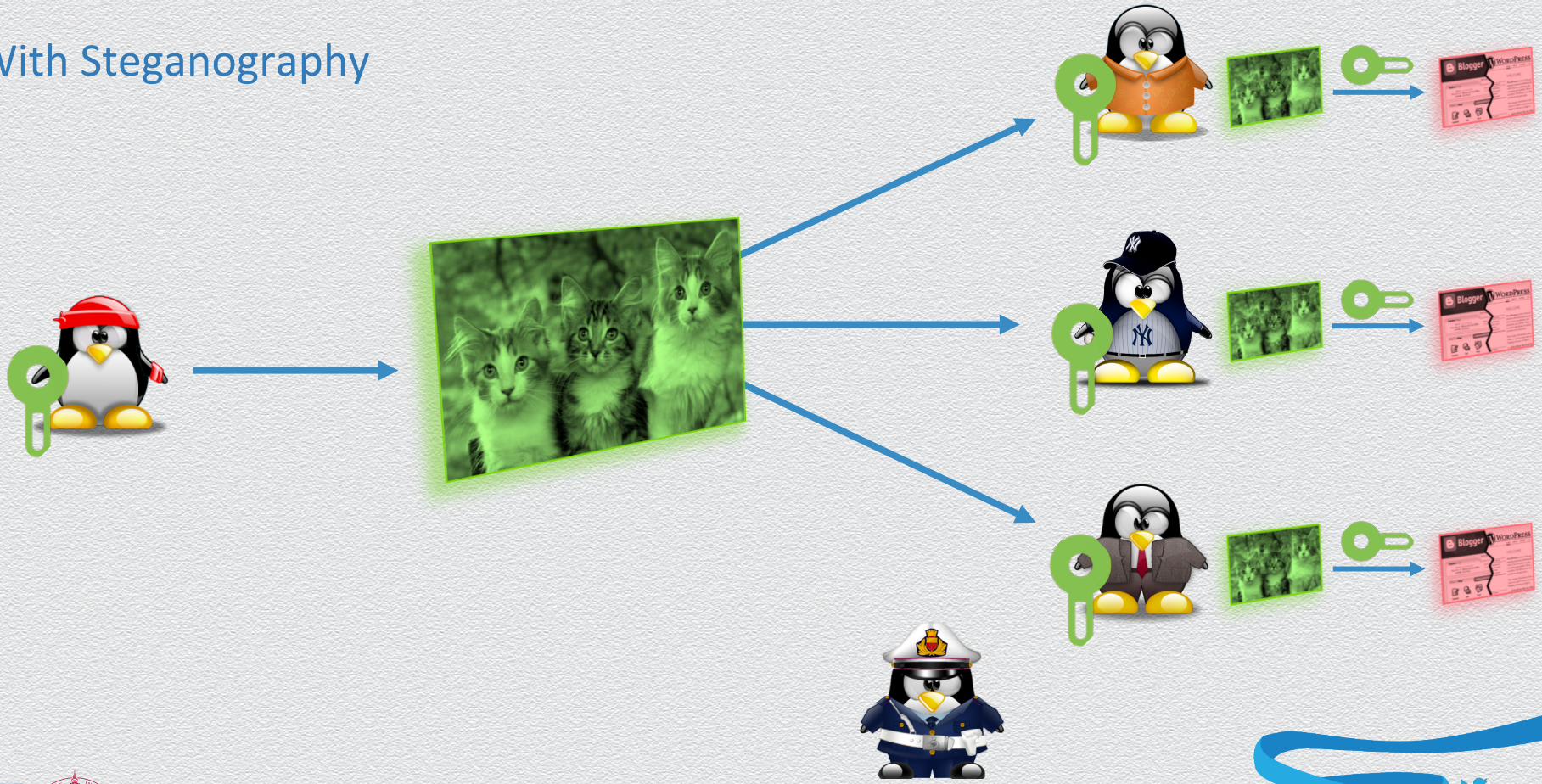

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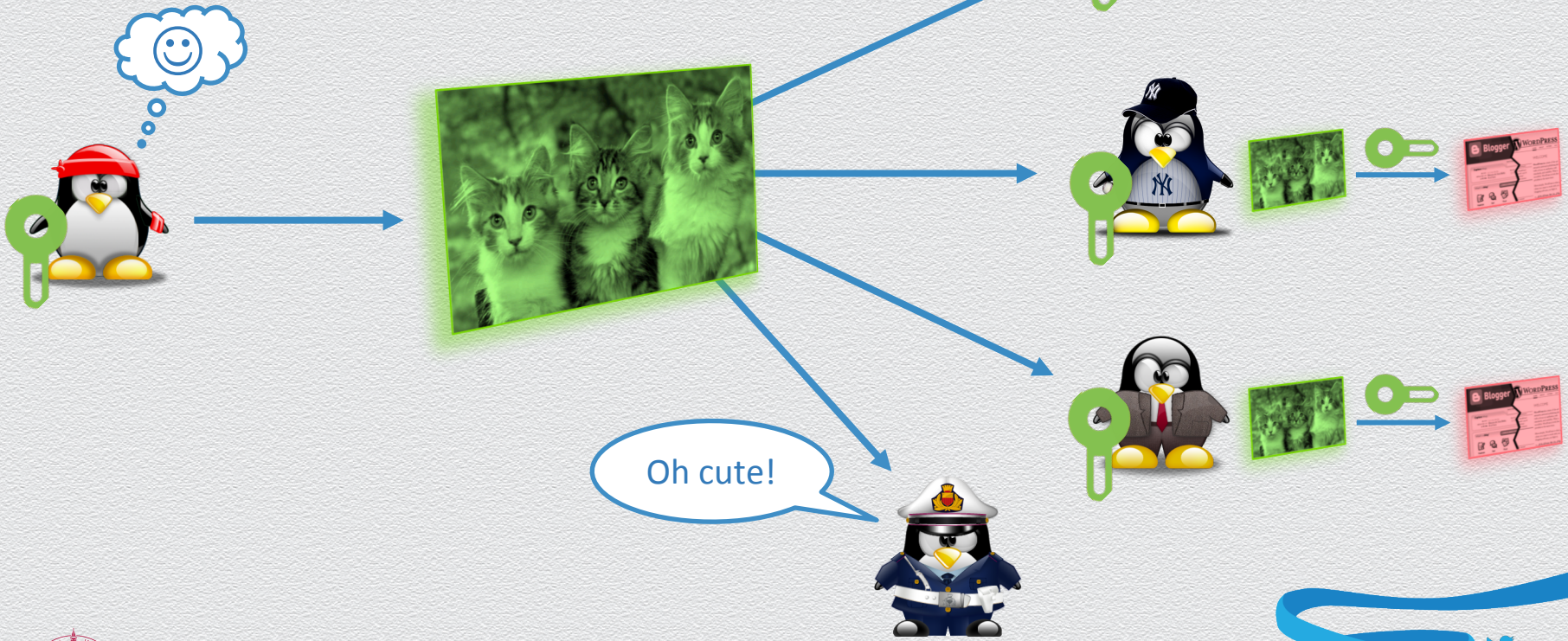

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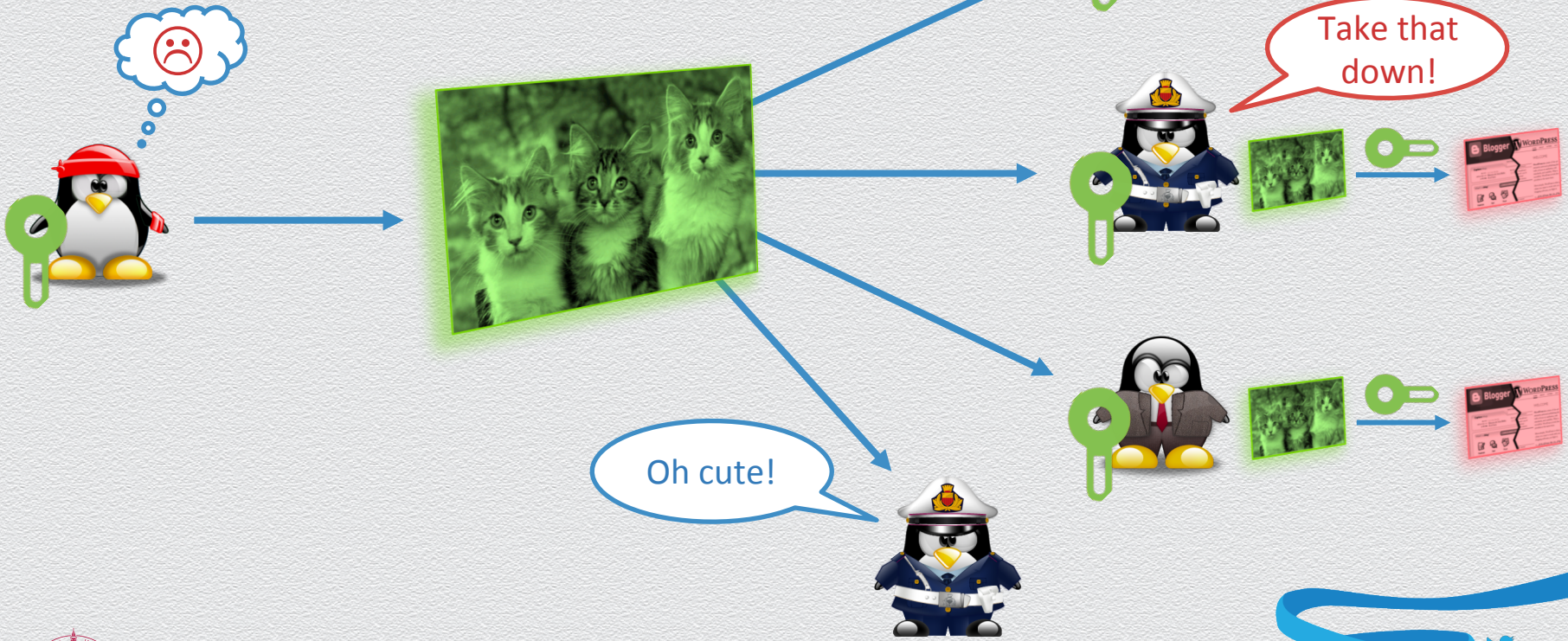

With Broadcast Steganography [This Work]

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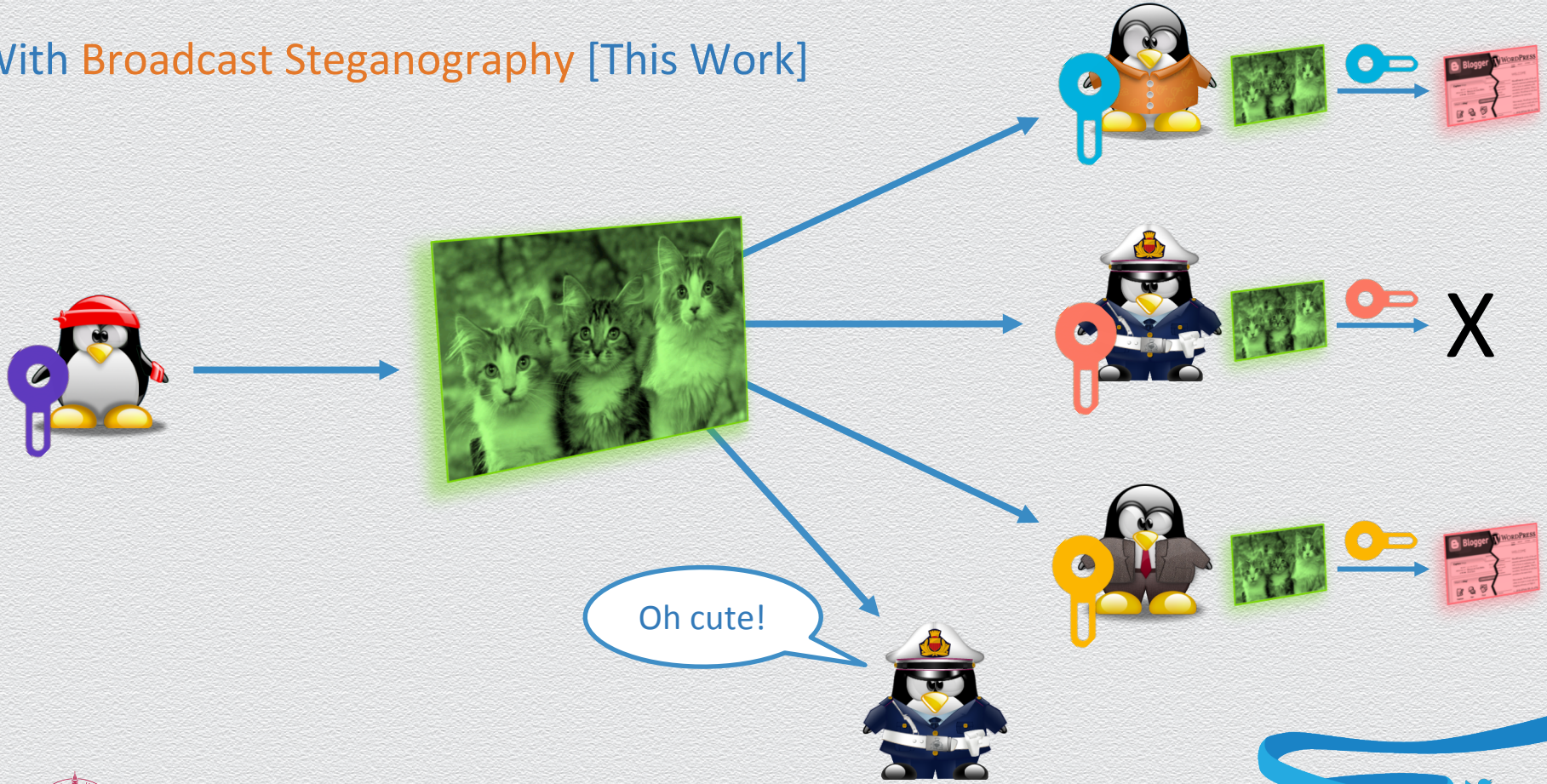

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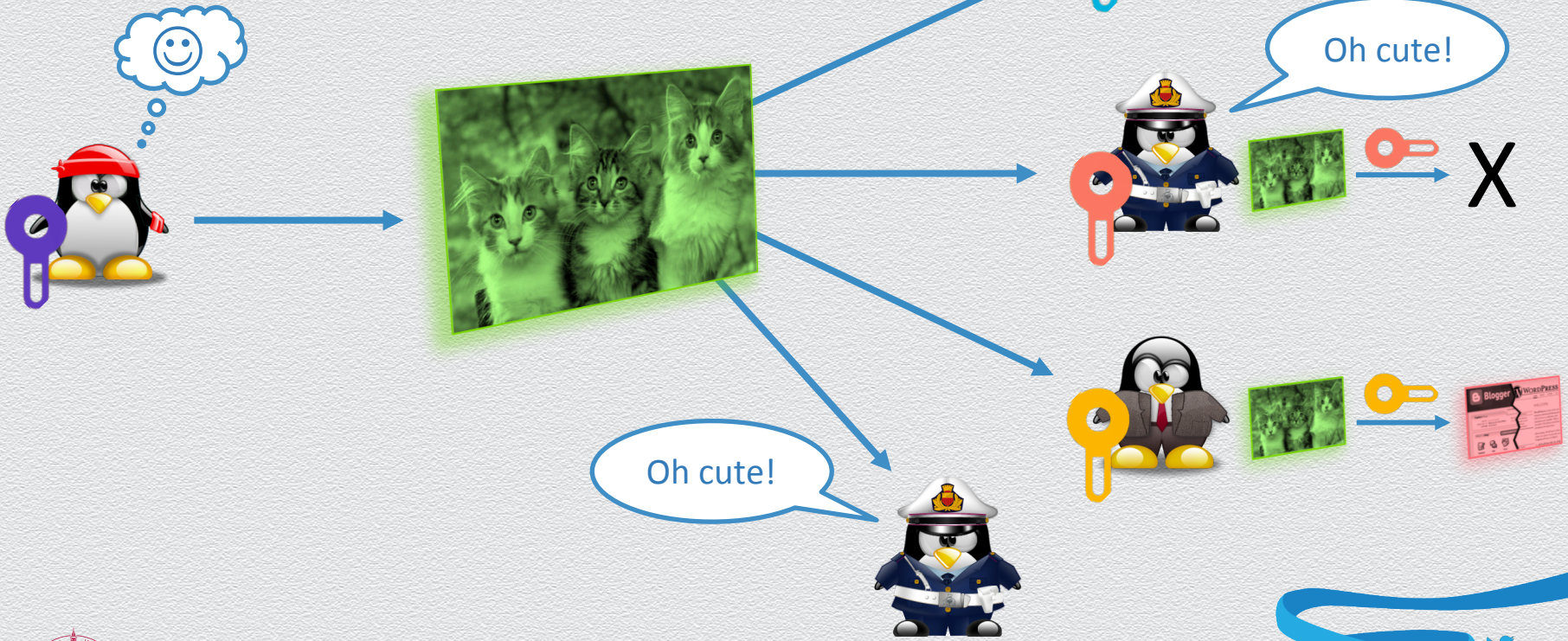
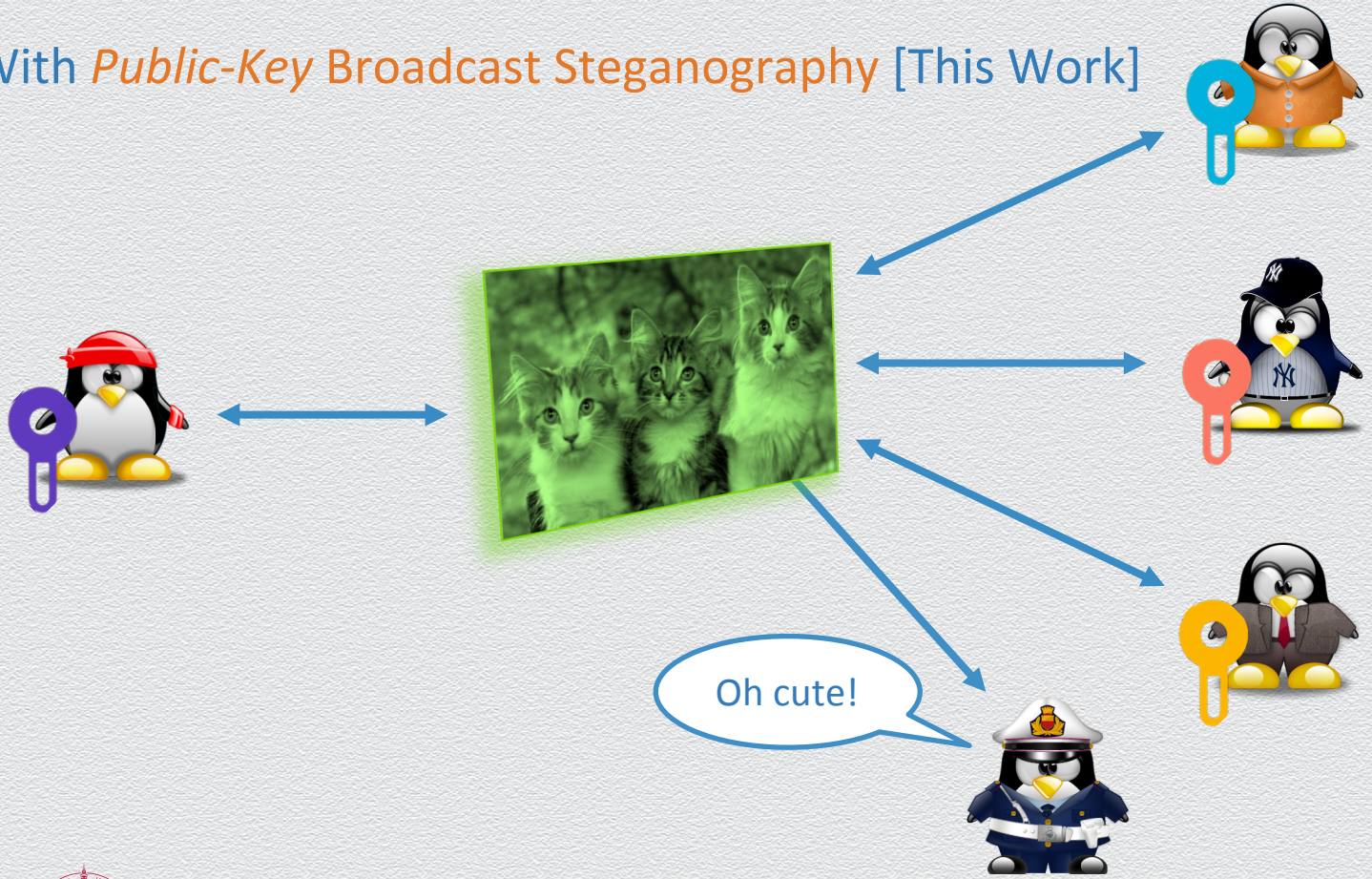
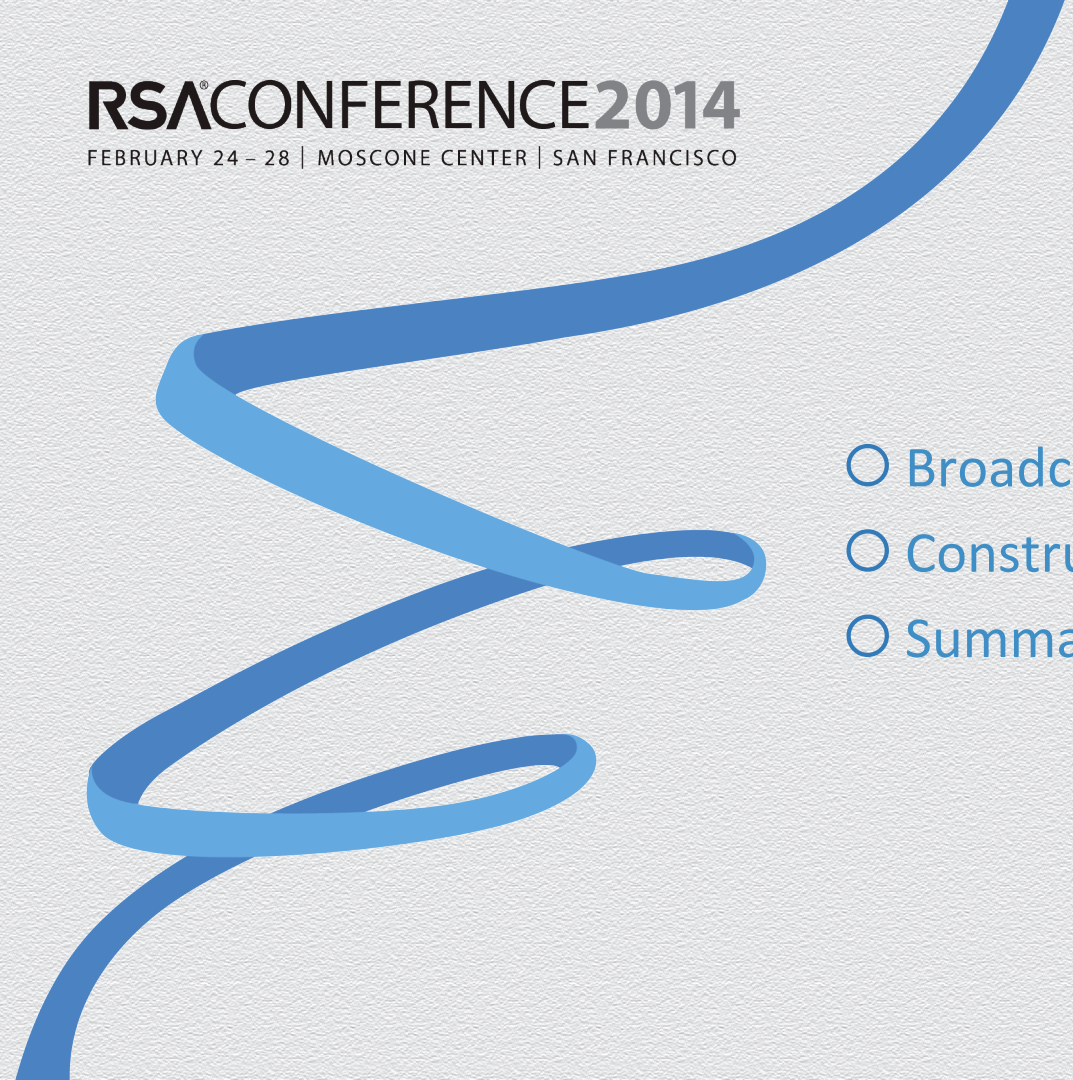
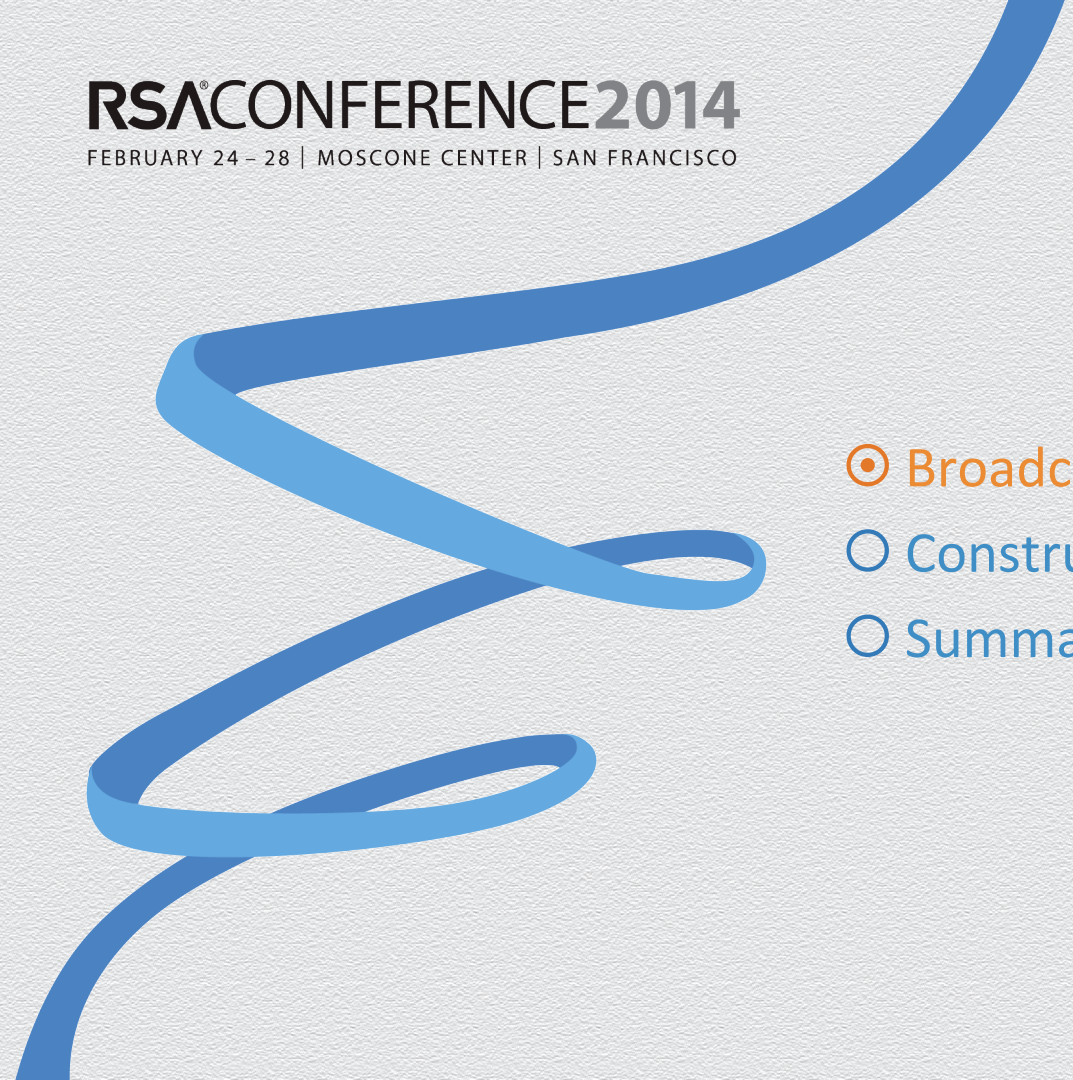


With *Public-Key* Broadcast Steganography [This Work]





- Broadcast Steganography (BS)
- Constructions
- Summary



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The Setting

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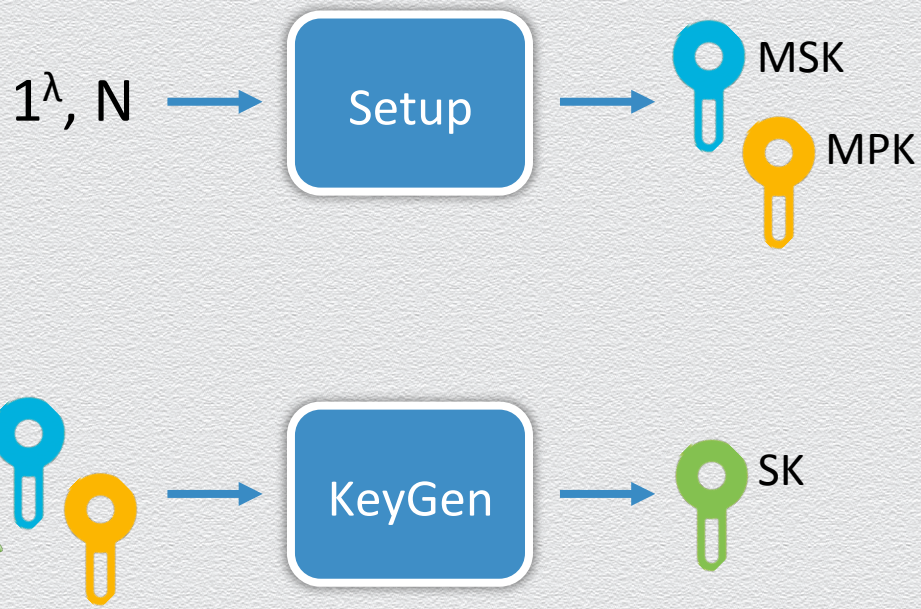
KeyGen

The Setting



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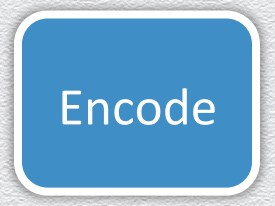

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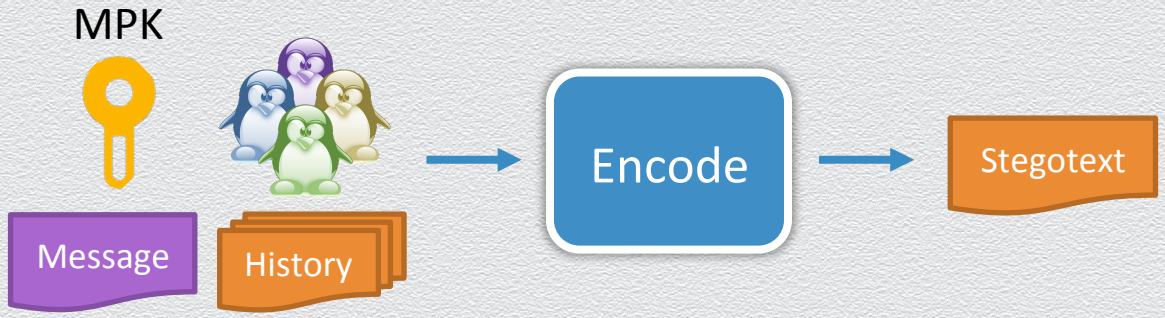

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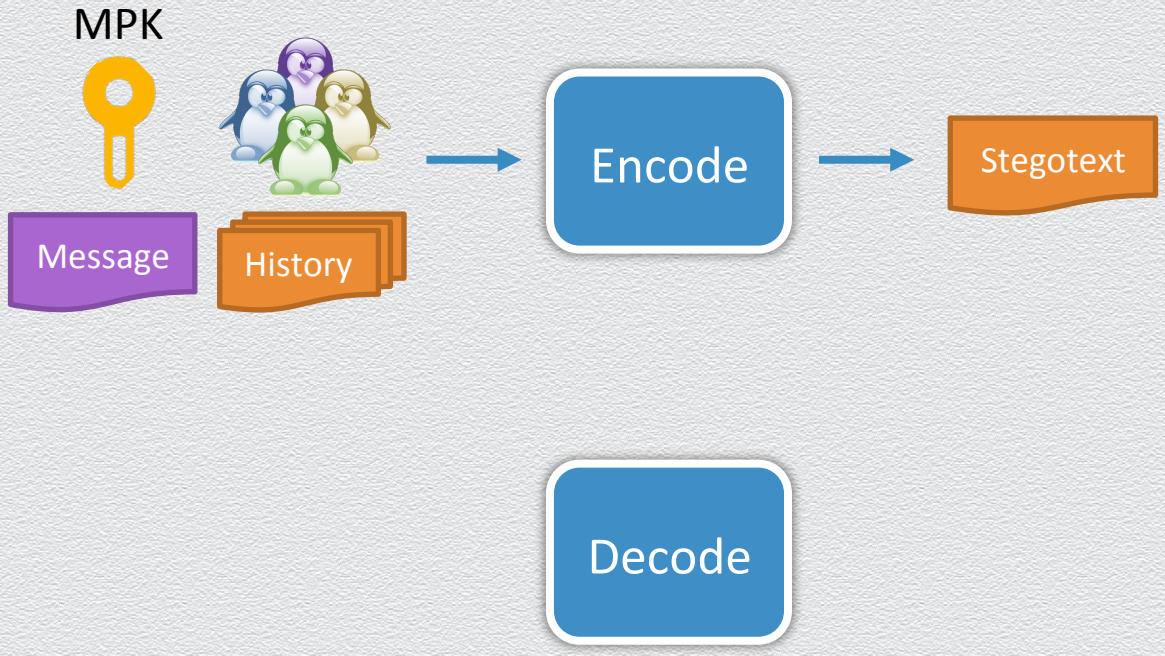

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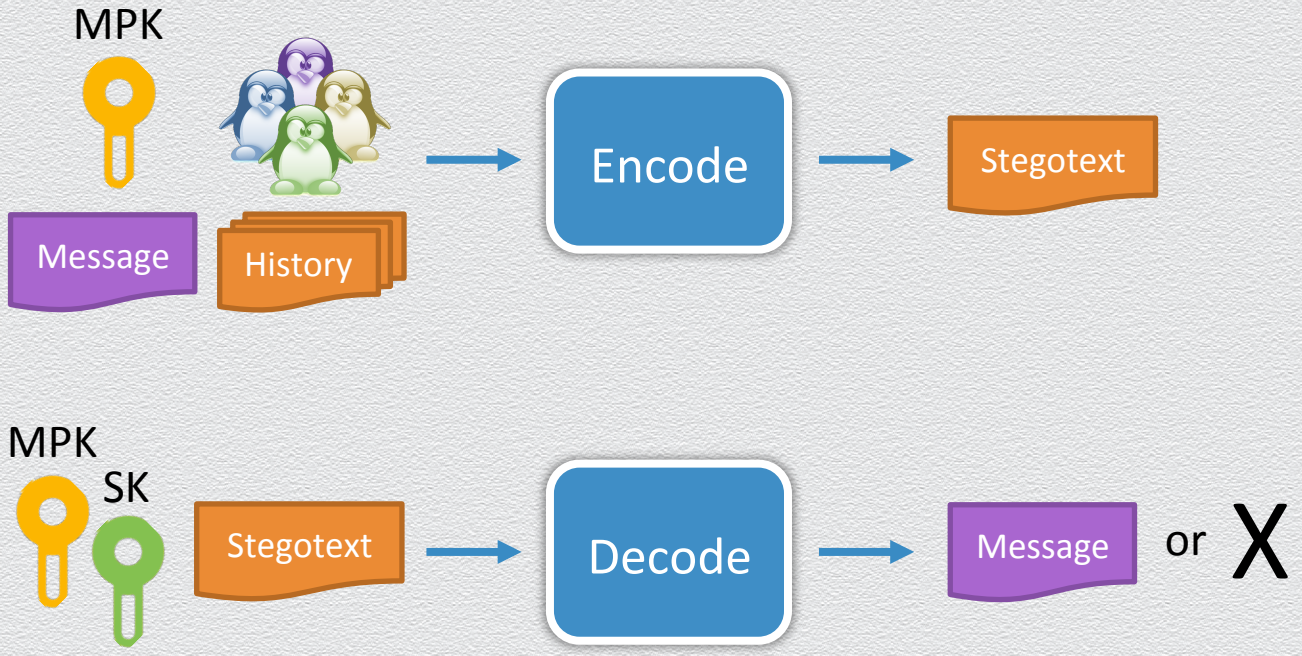
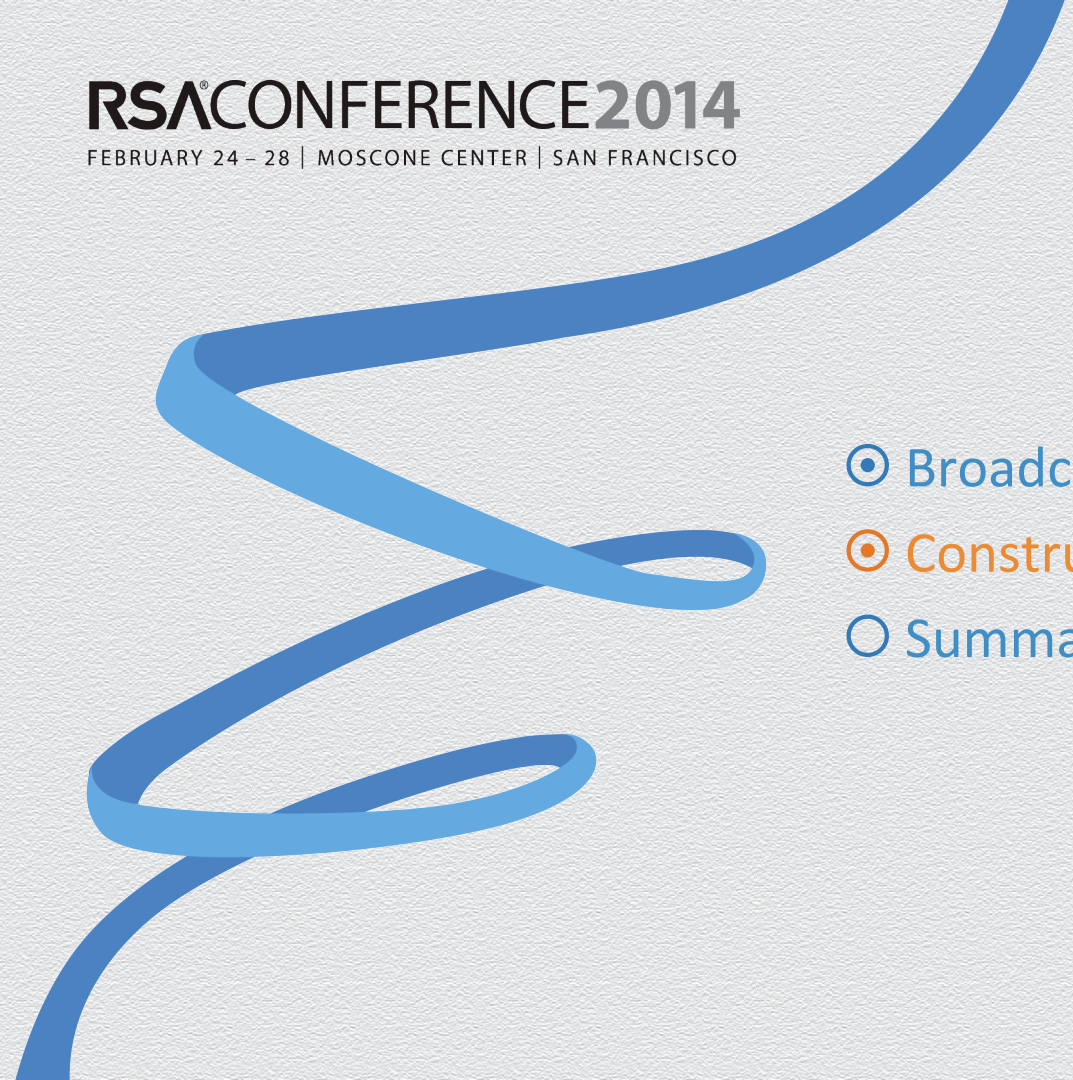

MPK
Message
History
Encode
Stegotext
MPK
SK
Stegotext
Decode
Message
or
X

The Security Model

1. Chosen-Covertext Attack (BS-IND-CCA)
   - Analogous to BE-IND-CCA model
   - Adversary is allowed to corrupt users
   - Adversary is also given access to a decoding oracle
2. Publicly-Detectable Replayable Chosen Covertext Attack (BS-IND-PDR-CCA)
   - Similar to BS-IND-CCA, but with stricter restrictions on allowable decoding queries
3. Chosen-Hiddentext Attack (BS-IND-CHA)
   - Analogous to BE-IND-CPA model
   - Adversary is only allowed to corrupt users
   - No decoding queries



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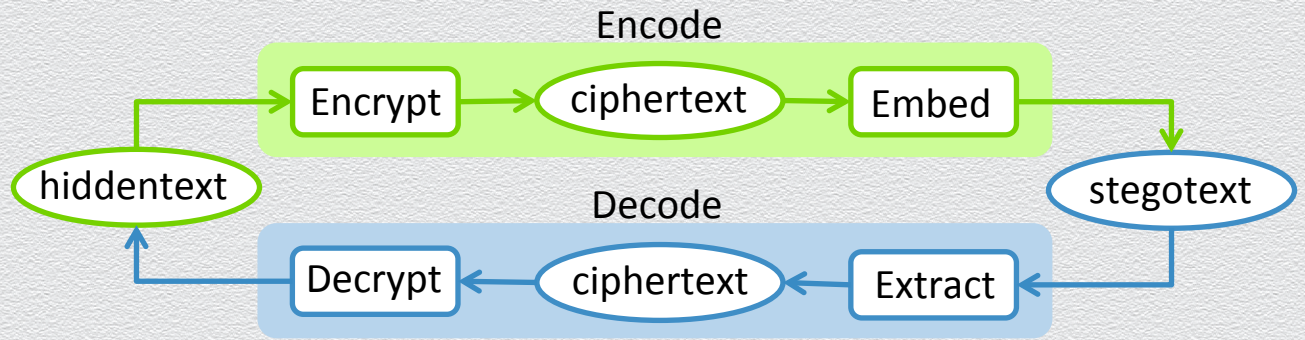
Realizing Broadcast Steganography

- Encrypt-then-Embed Paradigm [HLvA02, BaCa05]



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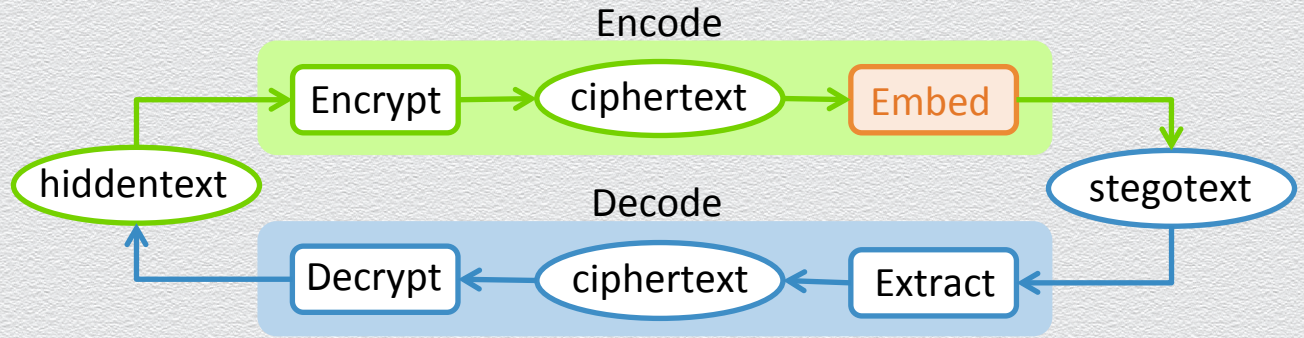

- Embed (rejection-sampling)
  1. Let H be a strongly universal hash function
  2. Break the ciphertext c into bits $c_1, c_2, \ldots, c_l$
  3. To embed c_i, sample s_i from the channel until $H(s_i) = c_i$
  4. Output $s = s_1 || s_2 || \cdots || s_l$

Realizing Broadcast Steganography

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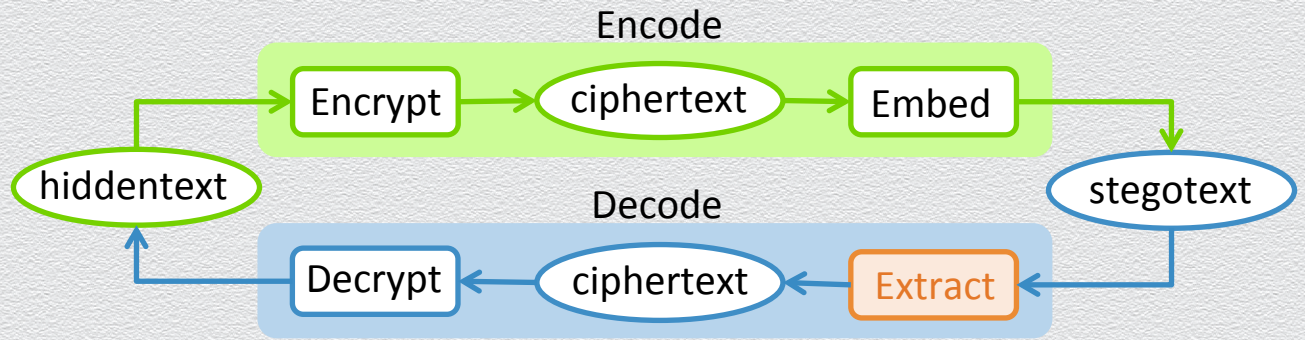

- Extract
  1. Break the stegotext s into documents $s_1, s_2, \ldots, s_l$
  2. Set $c_i = H(s_i)$
  3. Output $c = c_1 || c_2 || \cdots || c_l$

Broadcast Encryption + Encrypt-then-Embed = Broadcast Steganography?

- Encrypt-then-Embed requires pseudorandom ciphertexts …
- … but, Broadcast ciphertexts have structure

broadcast ciphertext format

- Neither header nor body is pseudorandom

Outsider-Anonymous Broadcast Encryption [FaPe12]

- Motivation: Anonymous Broadcast Encryption with short ciphertexts
  - A fully anonymous ciphertext length is subject to a linear lower bound [KiSa12]
  - In some applications, content may give recipient set away
    - ⇒ Suffices to protect anonymity of receivers from outsiders

- Outsider-Anonymity in Broadcast Encryption
  - Trades some degree of anonymity for better efficiency
  - Allows constructions with sub-linear ciphertext length

oABE Encryption in [FaPe12]

- Encrypt(S, m)
  1. Group users in S into S', a set of disjoint subsets
     - $|S'|$ is sub-linear in $|S|$
  2. Generate a ciphertext c_i for each s_i in S' (using anonymous IBE)
  3. Attach a tag t_i to each c_i (for efficient decryption at the receivers)
  4. Bundle all (t_i, c_i) components using one-time signature

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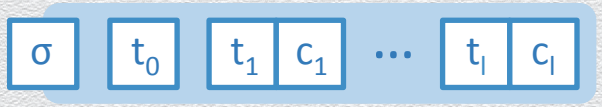

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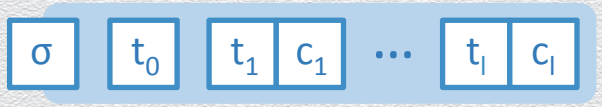
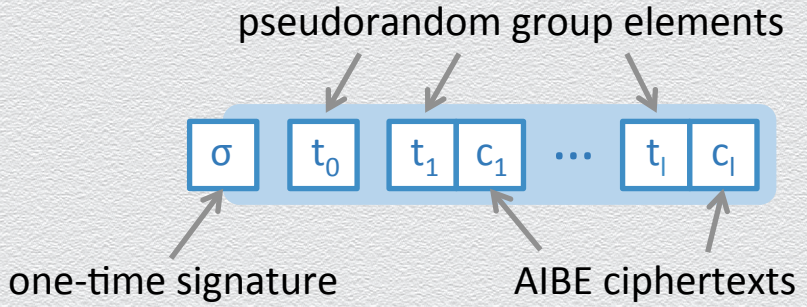


- Notice that ciphertexts have no header …
- … but still exhibit structure due to tags and signature
- Idea: Toward a BS construction, make these components pseudorandom

oABE with Pseudorandom Ciphertexts (oABE$) [This Work]



- How to make oABE ciphertexts pseudorandom?
  1. Replace the underlying AIBE with AIBE$ [AgBo09]
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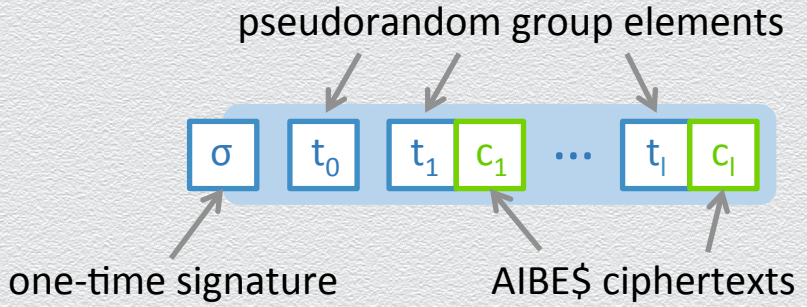

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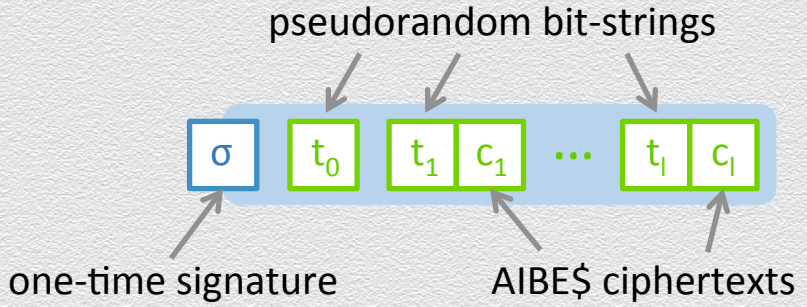

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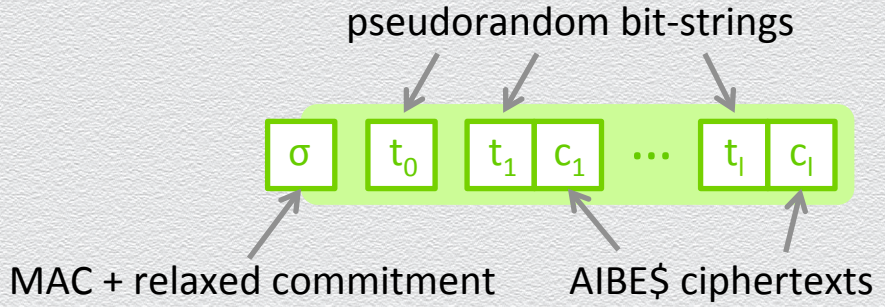

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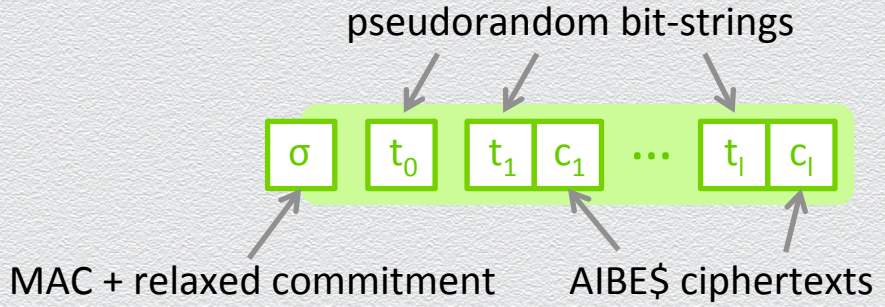

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Question: How to embed the MAC key in c_i's and still obtain CCA security?

Solution: Construct an encapsulation mechanism [DoKa05, BoKa05]
with pseudorandom commitments

Comparison of BE Schemes with Anonymity Properties

Scheme	|PK|	|sk|	|c|	Security Model	Anonymity
BBW06	O(N)	O(1)	O(N-r)	Static, RO	Full
LPQ12	O(N)	O(1)	O(N-r)	Adaptive, Standard	Full
FaPe12a	O(N)	O(log N)	O(r log (N/r))	Adaptive, Standard	Outsider
FaPe12b	O(N log N)	O(N)	O(r)	Adaptive, Standard	Outsider
This Work	O(N)	O(log N)	O(r log (N/r))	Adaptive, Standard	Outsider

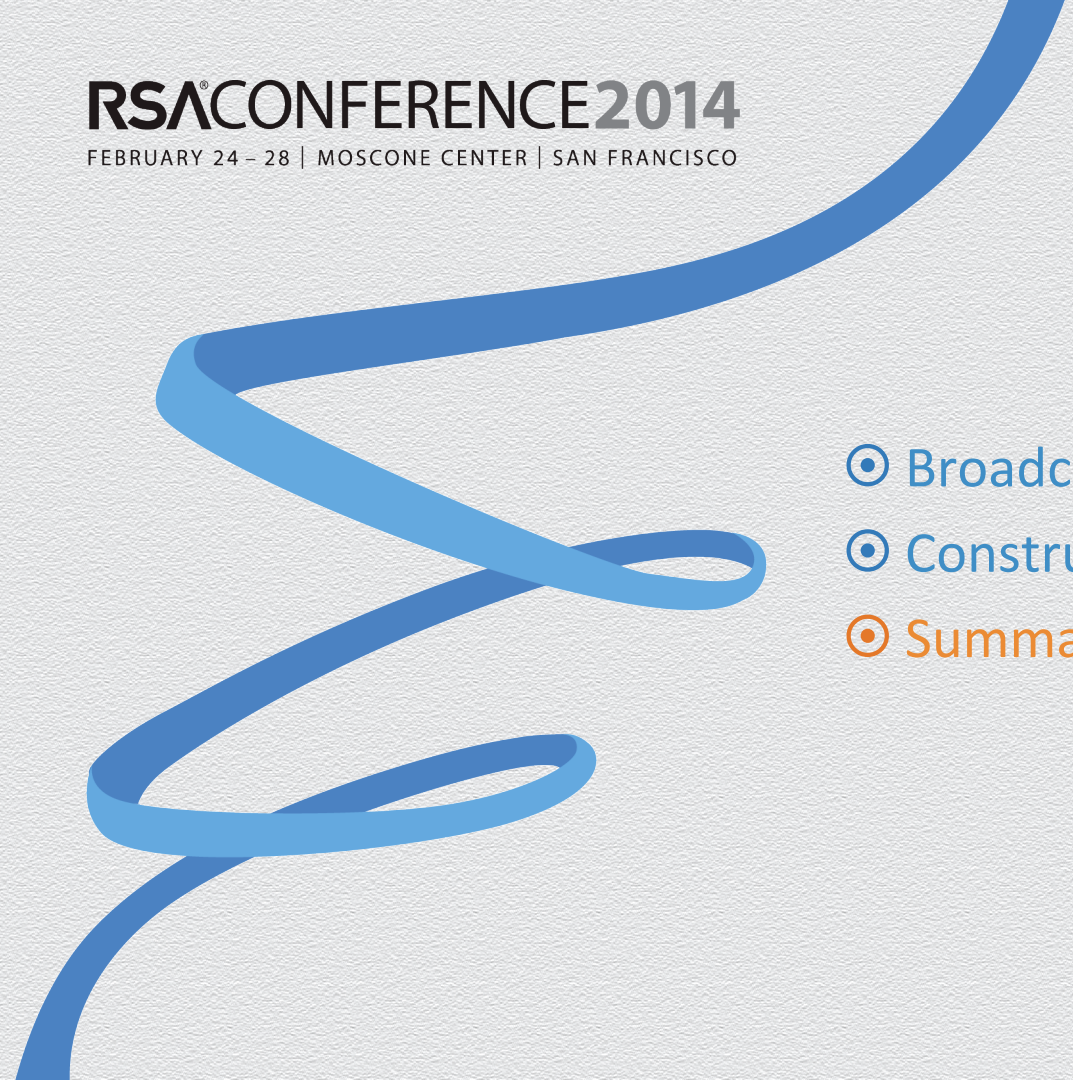
N: total number of users, r: number of revoked users

- Only oABE$ provides pseudorandom ciphertexts

Our Construction of Broadcast Steganography

- Highlights
  - oABE$ + Encrypt-then-Embed = Broadcast Steganography
  - Our constructions have sub-linear stegotext length
  - For CCA security, requires stateless channel

- Constructions:
  1. BS-CHA
  2. BS-PDR-CCA
  3. BS-CCA



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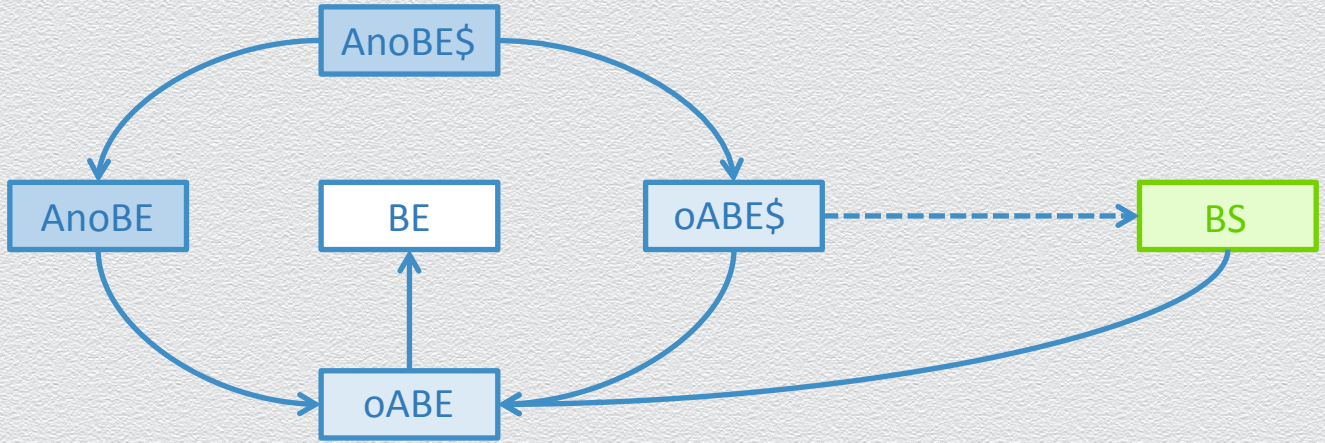
BE and Friends



Summary

- Initiated the study of Broadcast Steganography
  - A multi-recipient communication tool to plant undetectable messages in innocent-looking conversations
- Put forth sublinear constructions of broadcast steganography under a range of security notions
- In the process, devised efficient broadcast encryption schemes with pseudorandom ciphertexts and anonymity properties
  - Implementing CCA checks without imposing structure on broadcast ciphertexts required overcoming multiple technical hurdles