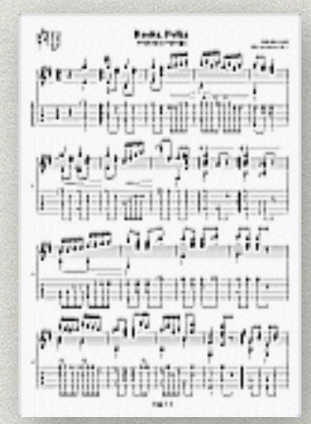
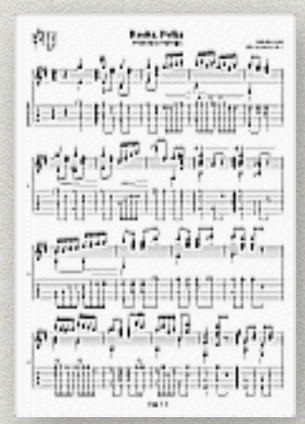
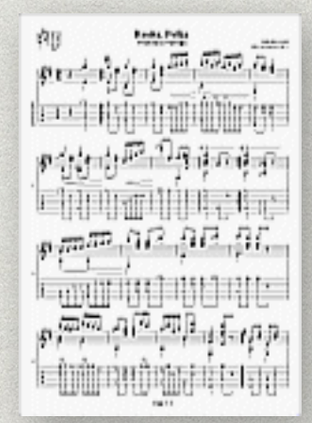
FORWARD PRIVATE SEARCHABLE ENCRYPTION

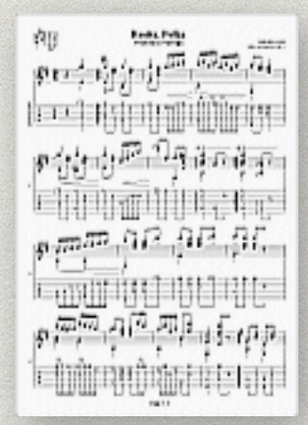
DATE 27/10/2016

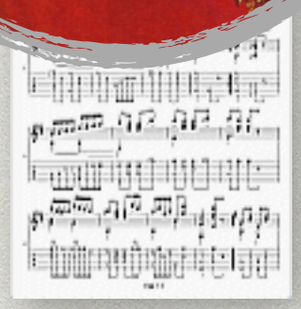
ACM CCS - RAPHAEL BOST

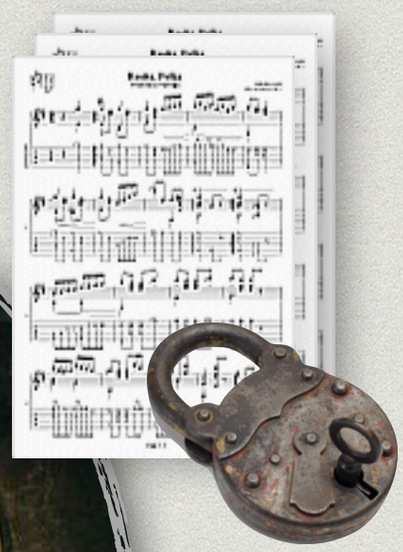


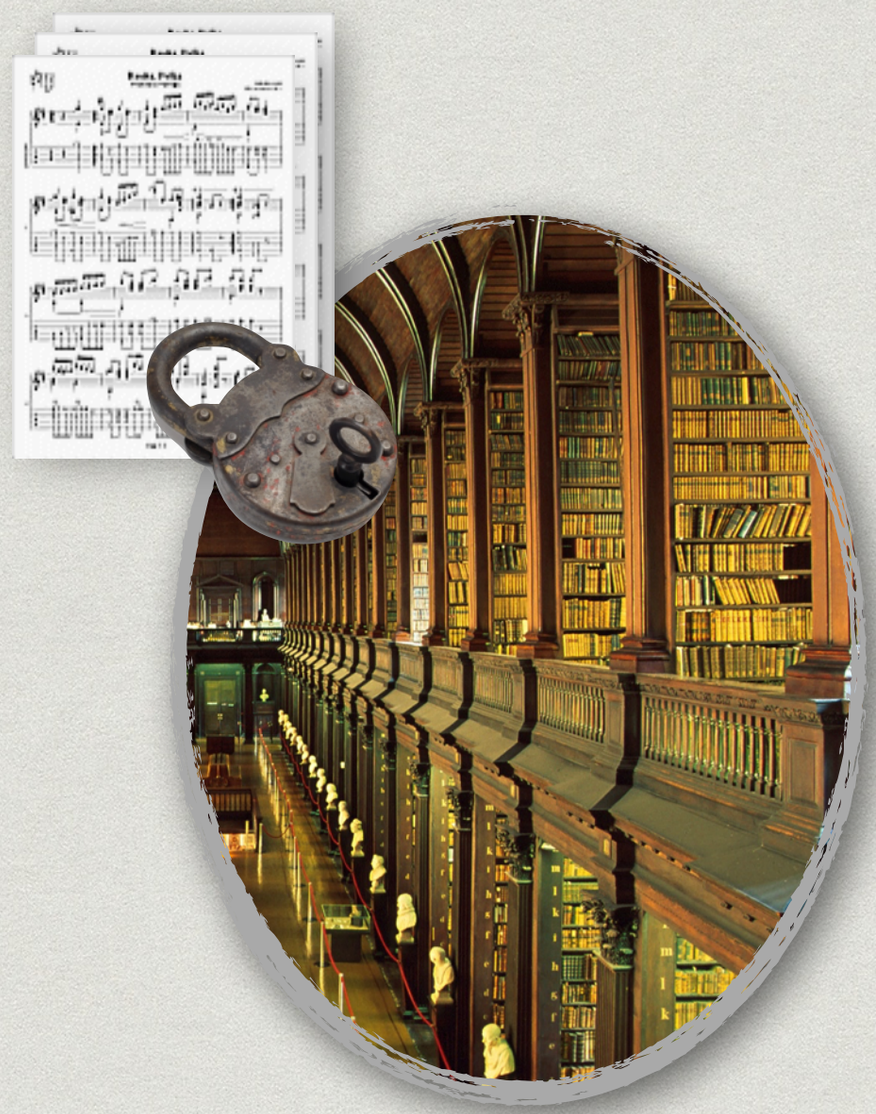


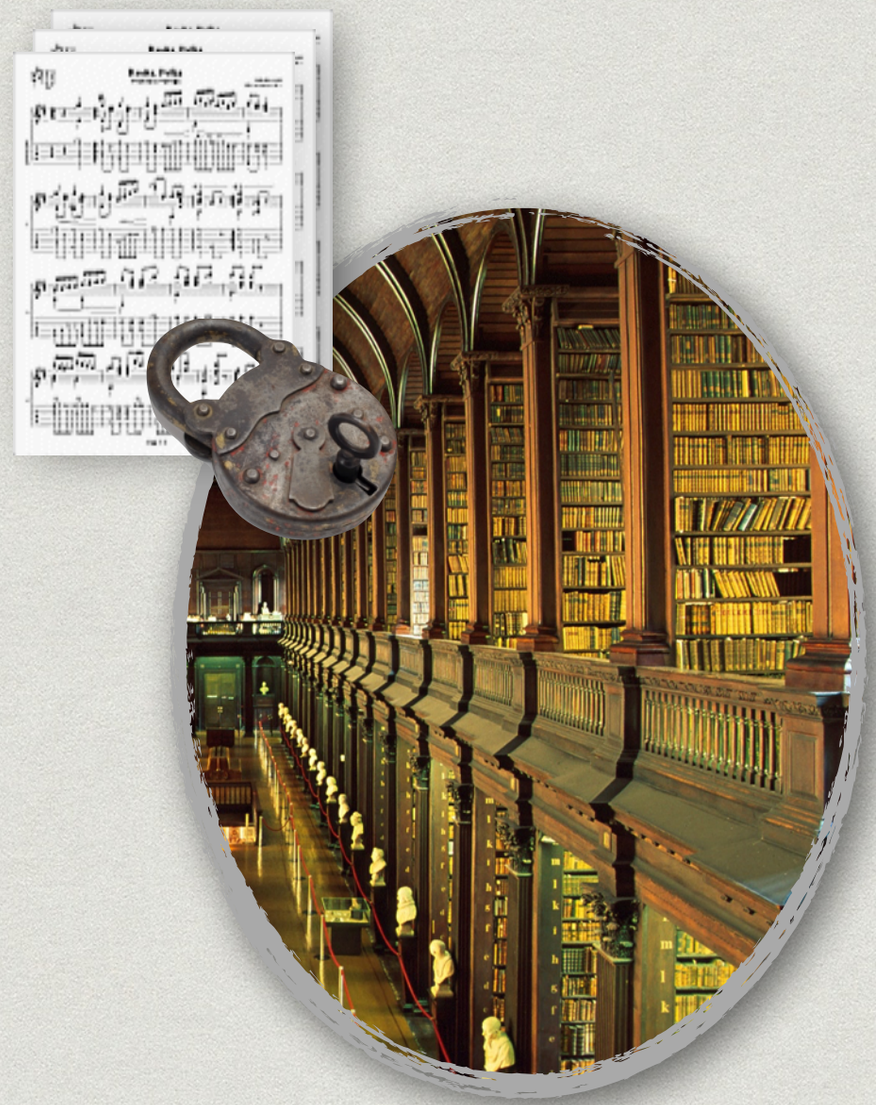


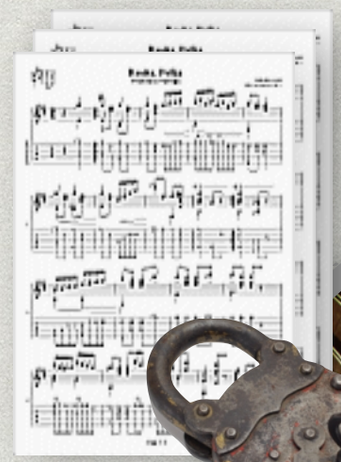


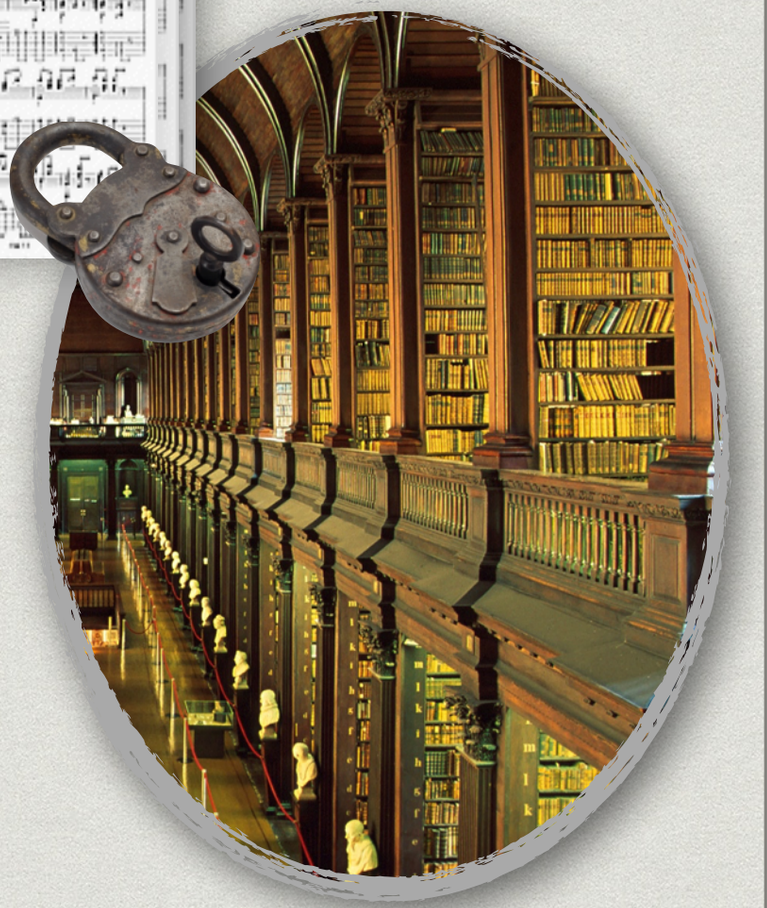


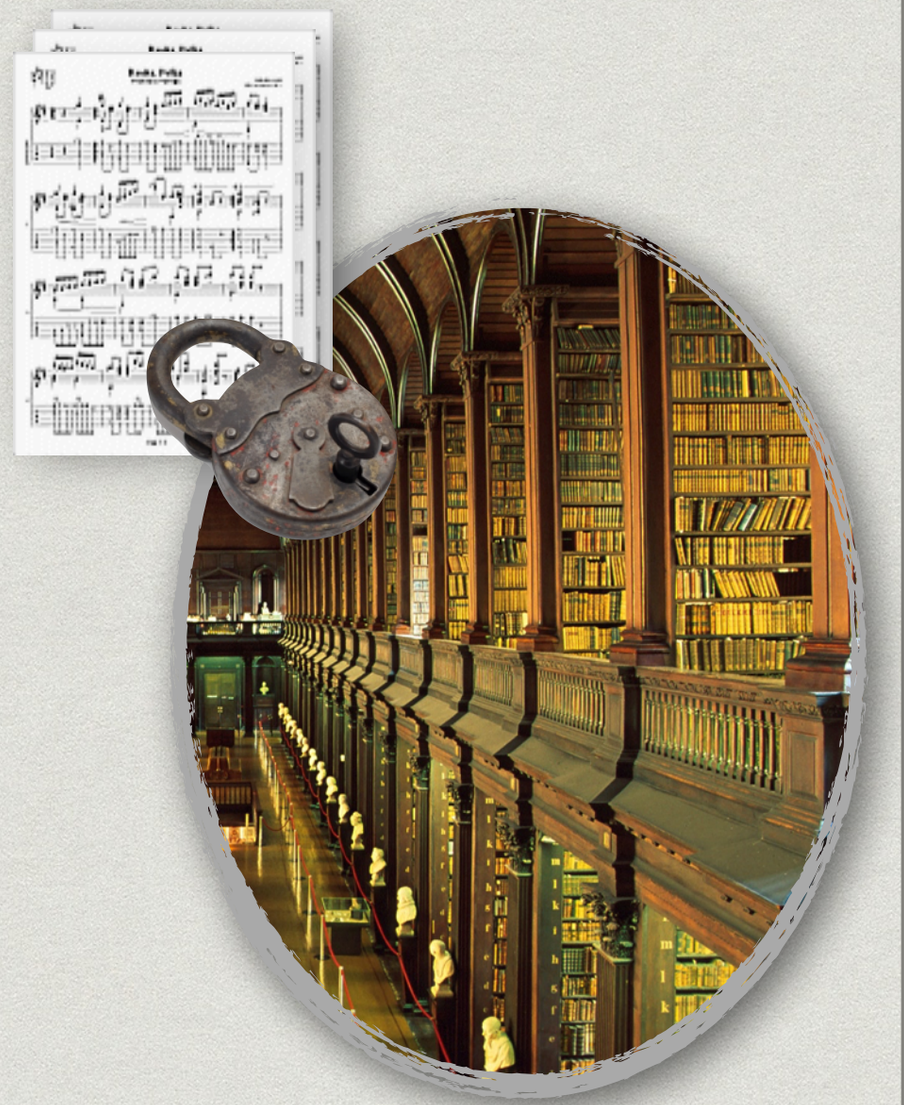


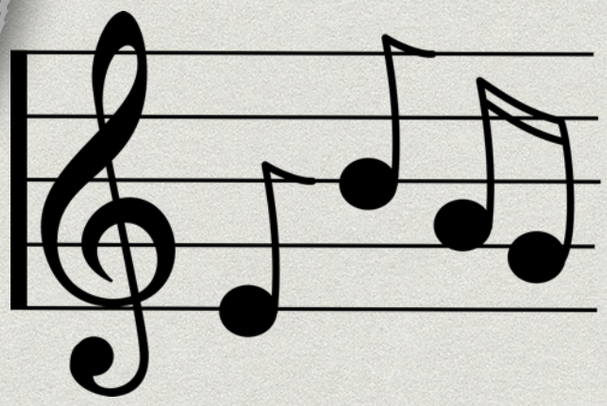


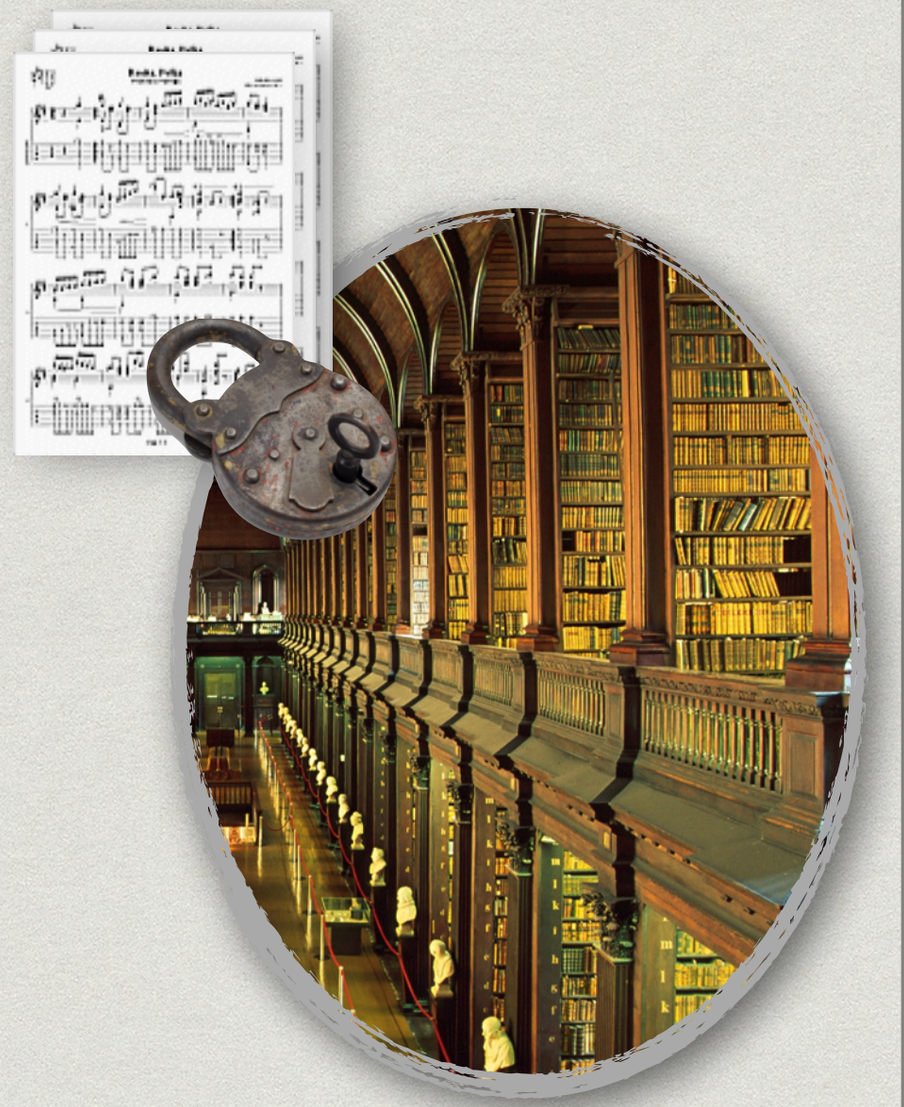












Searchable Encryption

Outsource data

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- securely

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- keep search functionalities

Searchable Encryption

Outsource data

- securely
- keep search functionalities
- aimed at efficiency

Generic Solutions

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Fully Homomorphic Encryption, MPC, ORAM

- ✓ Perfect security
- ✗ Large overhead (computation, communication)

Ad-hoc Constructions

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Can we get more efficient solutions?

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Security/performance tradeoff

Property Preserving Encryption

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Deterministic Encryption, OPE, ORE

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- ✓ Legacy compatible

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Deterministic Encryption, OPE, ORE

- ✓ Legacy compatible
- ✓ Very Efficient
- ✗ Not secure in practice (*cf*. next talk)

Index-Based SE [CGKO'06]

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Encryption of the reversed index

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- Search leakage :
  - repetition of queries

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Encryption of the reversed index

- Search leakage :
  - repetition of queries
- Update leakage:
  - updated documents
  - repetition of updated keywords

File Injection Attacks [ZKP'16]

Non-adaptive file injection attacks

- Insert purposely crafted documents in the DB. Use binary search to recover the query

D_1	k_1	k_2	k_3	k_4	k_5	k_6	k_7	k_8
D_2	k_1	k_2	k_3	k_4	k_5	k_6	k_7	k_8
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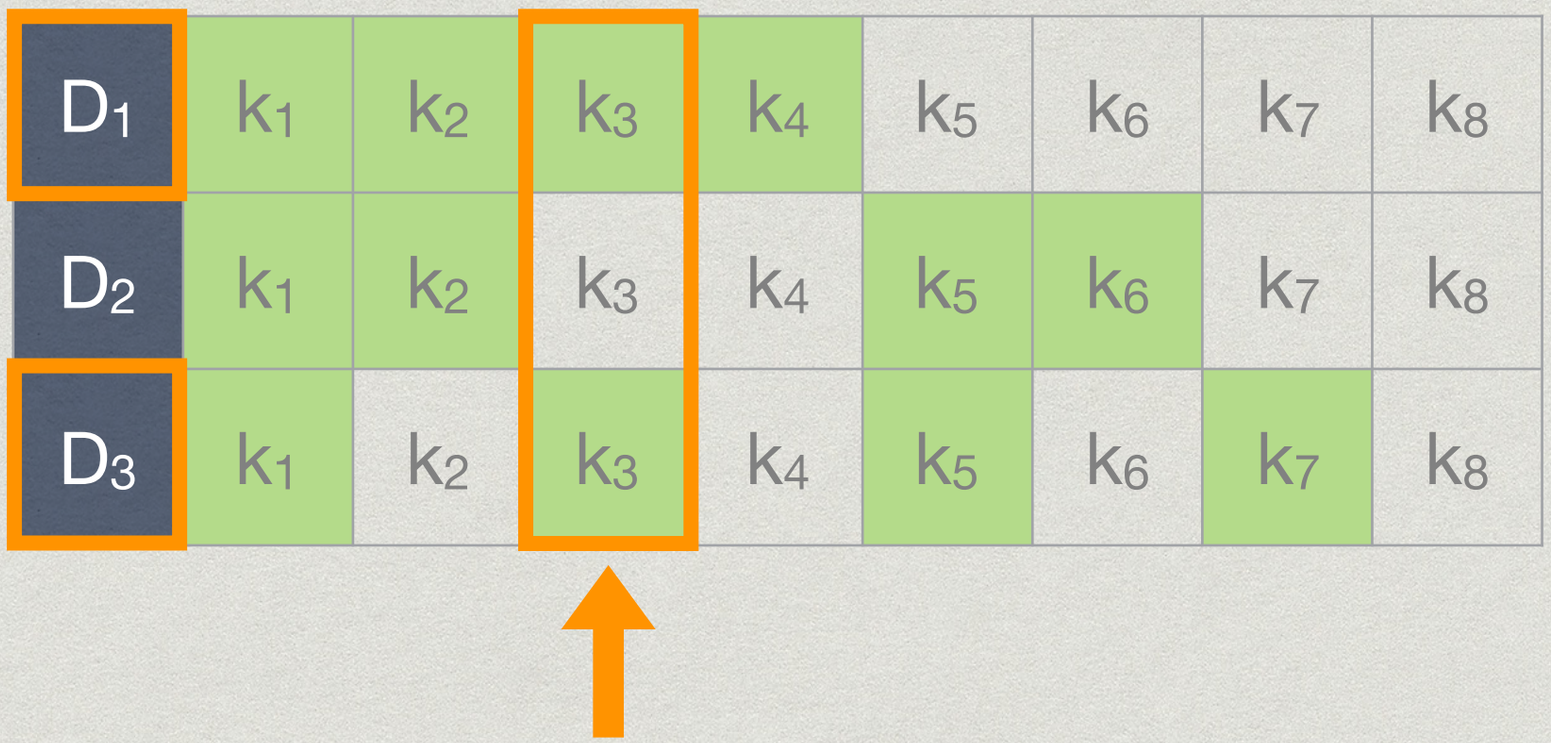

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log K injected documents

File Injection Attacks [ZKP'16]

- Insert purposely crafted documents.
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  ➡ Counter measure:
  no more than T kw./doc.

  (K/T) · log T injected documents

- Adaptive version of the attack

  (K/T) + log T injected documents

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  log T with prior knowledge

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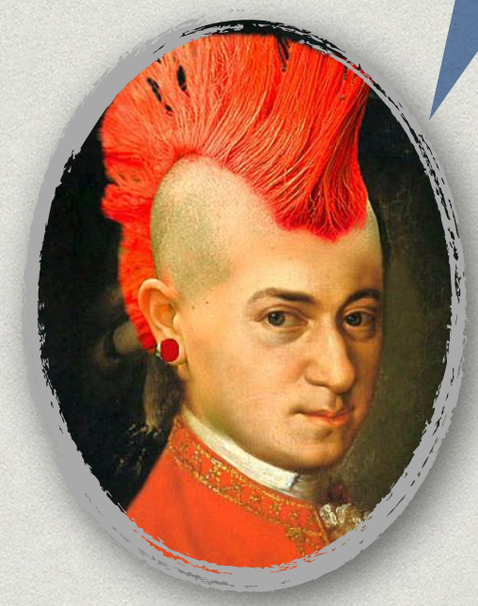
- Secure online build of the EDB
- Only one existing scheme so far [SPS'14]
  - ➡ ORAM-like construction
  - ✗ Inefficient updates
  - ✗ Large client storage

Σοφος

- Forward private index-based scheme
- Low search and update overhead
- Simpler than [SPS’14]



Add (ind_1,…,ind_c) to w

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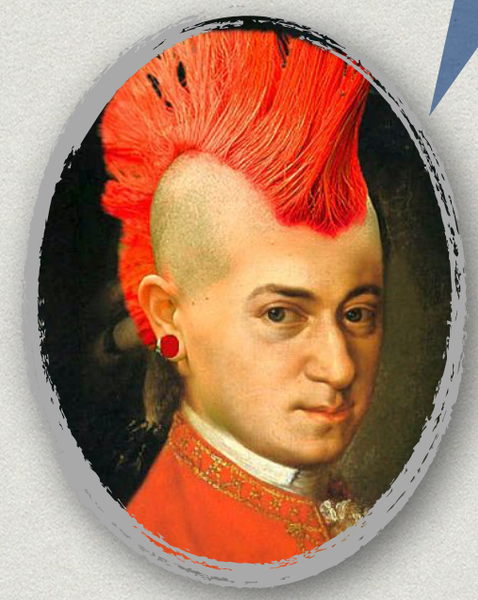
$UT_1(w)$

$UT_2(w)$

…

$UT_c(w)$



Add (ind_1,…,ind_c) to w

Search w

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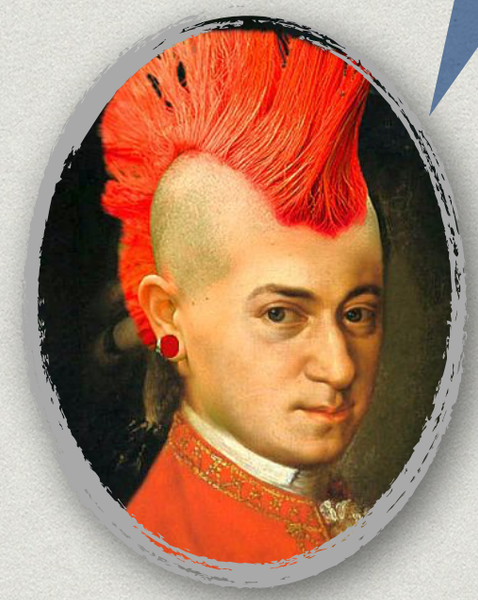

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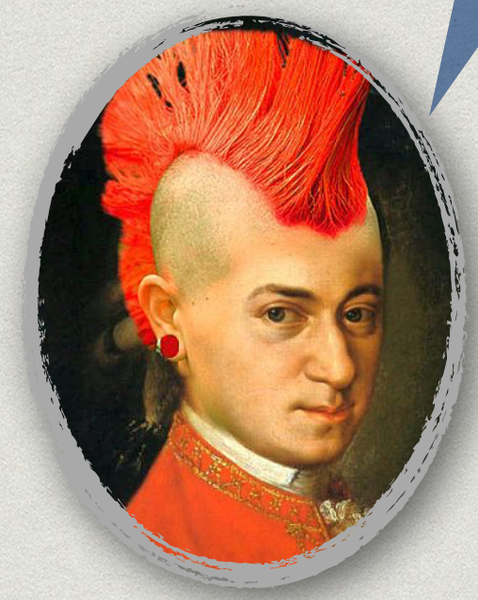
$ST(w)$



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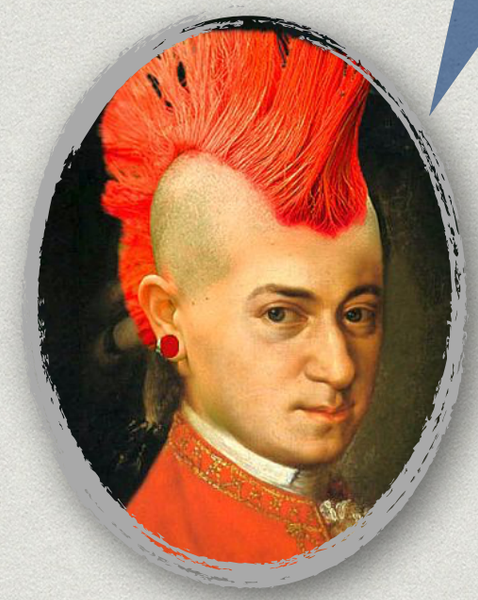

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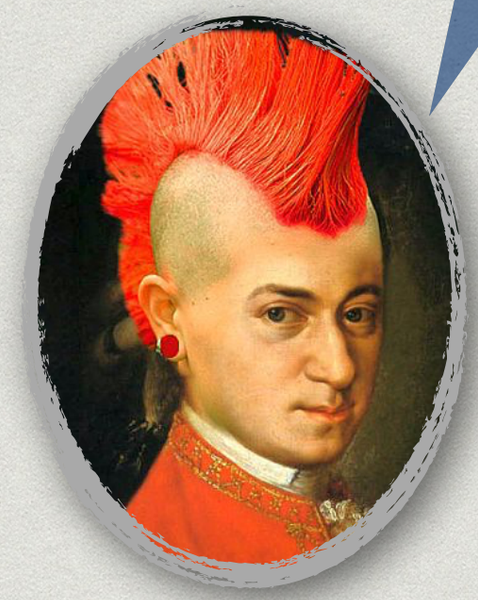

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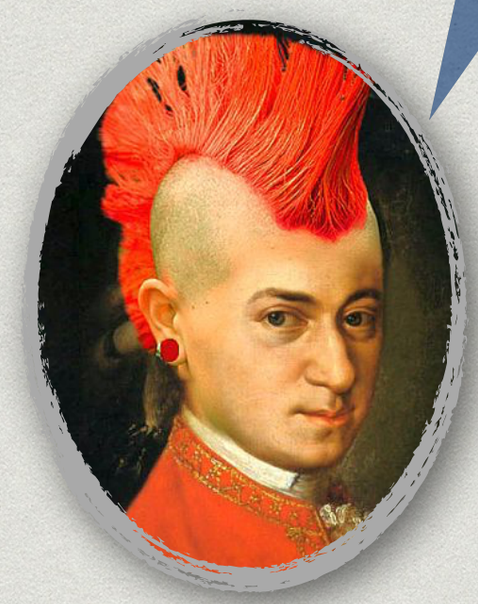

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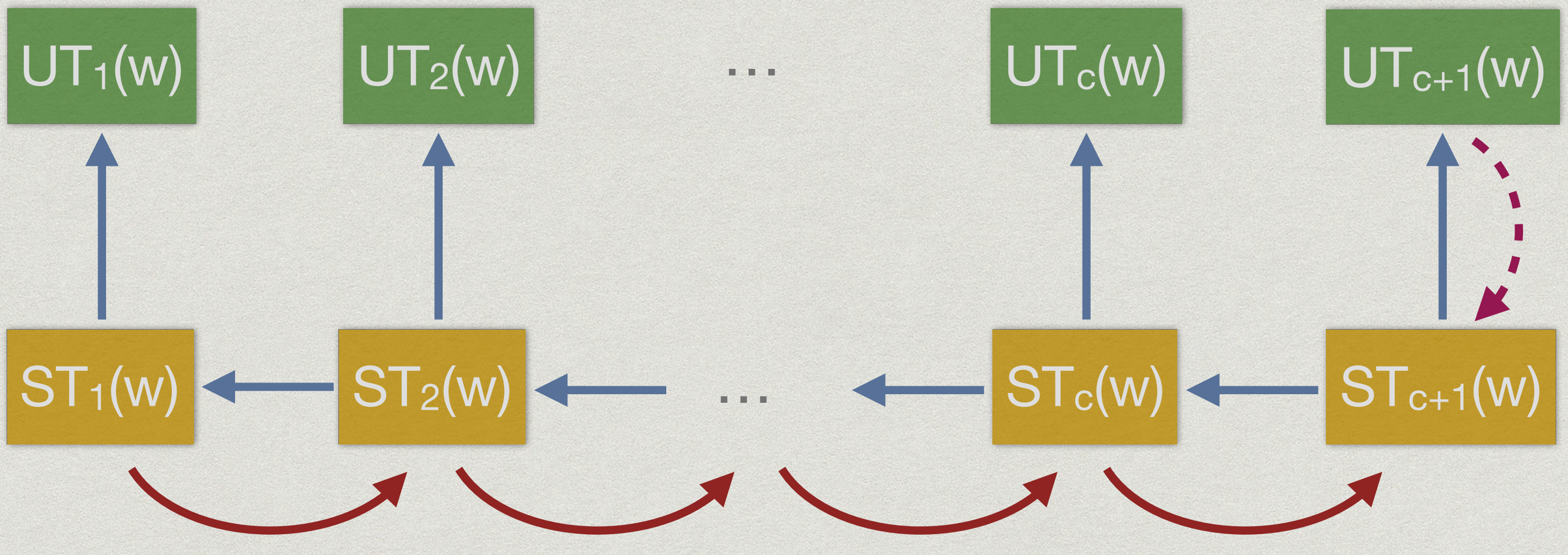
UT1(w)
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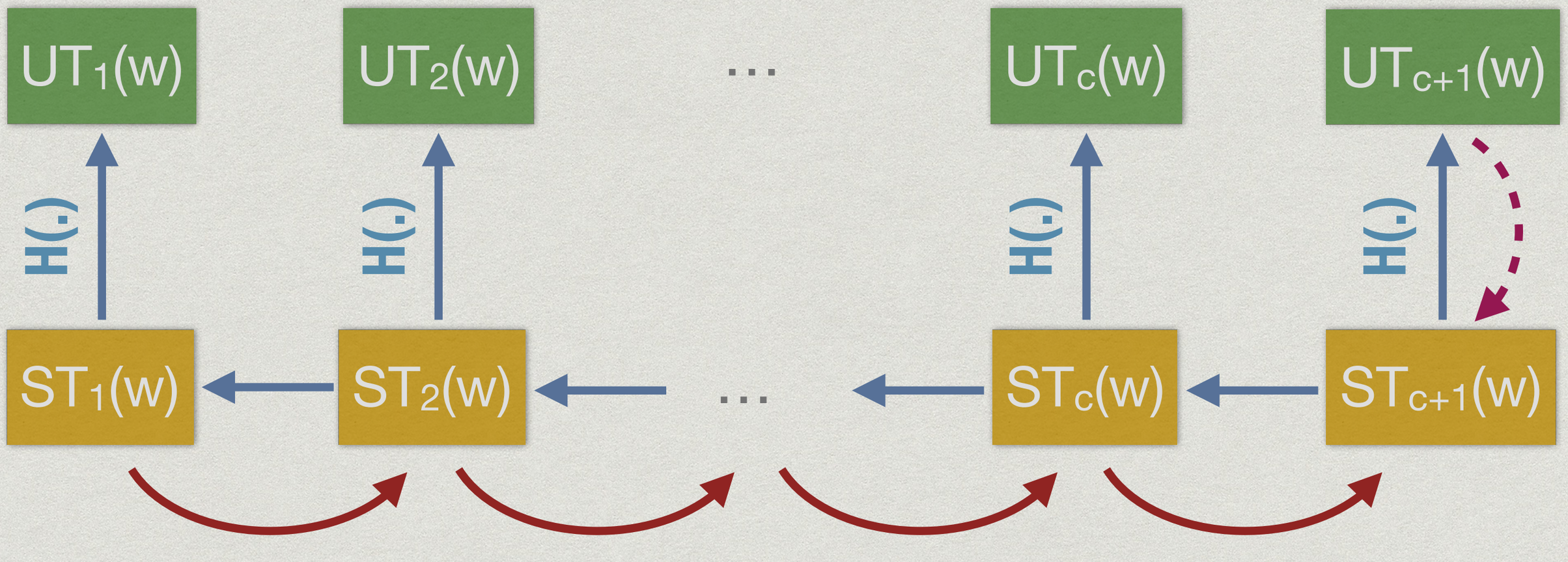
UT1(w)
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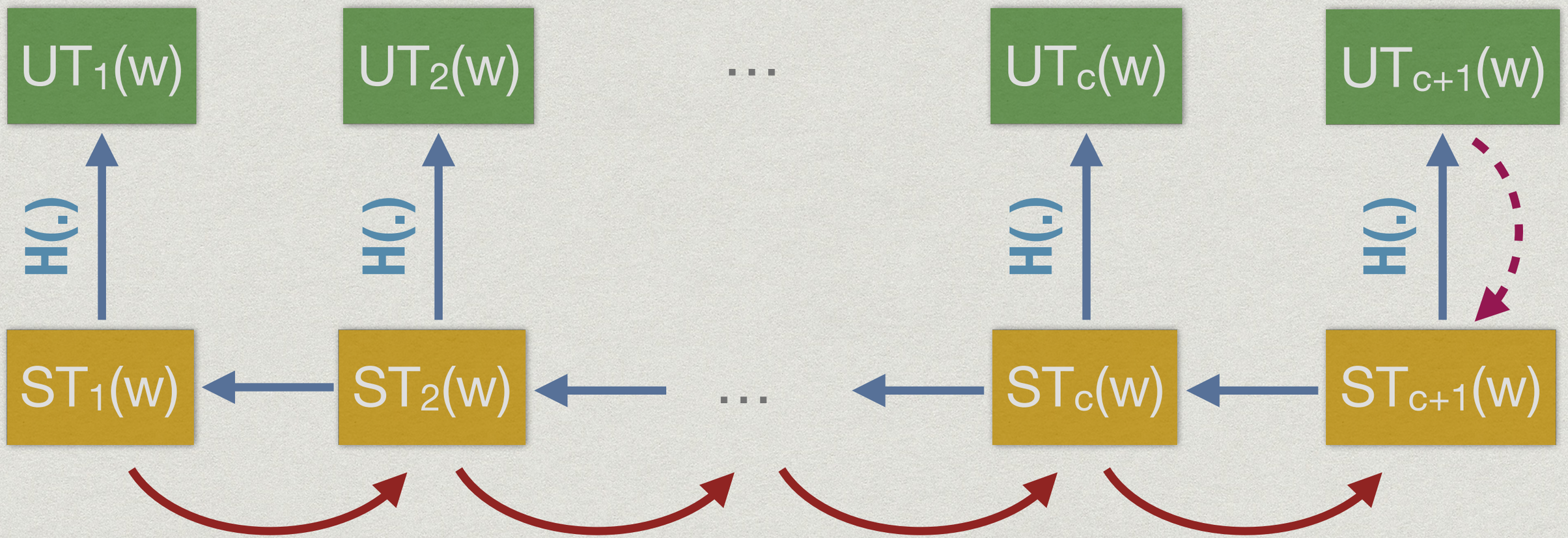
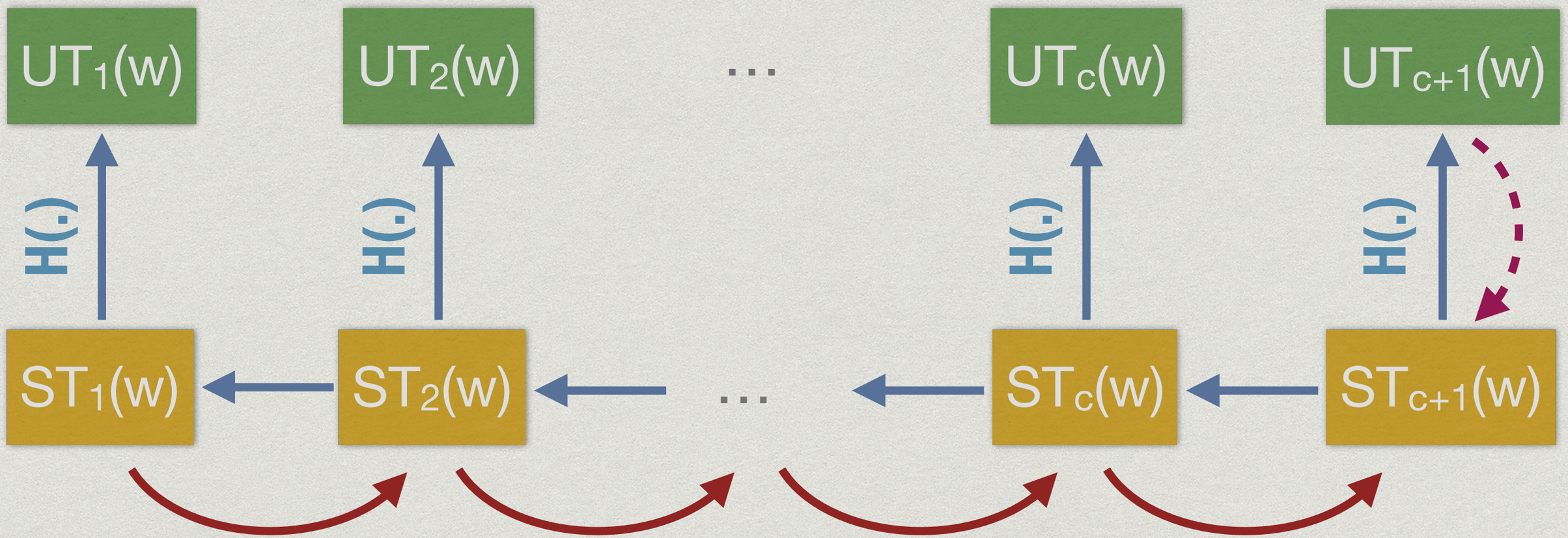


- Naïve solution: $ST_i(w) = F(K_w, i)$



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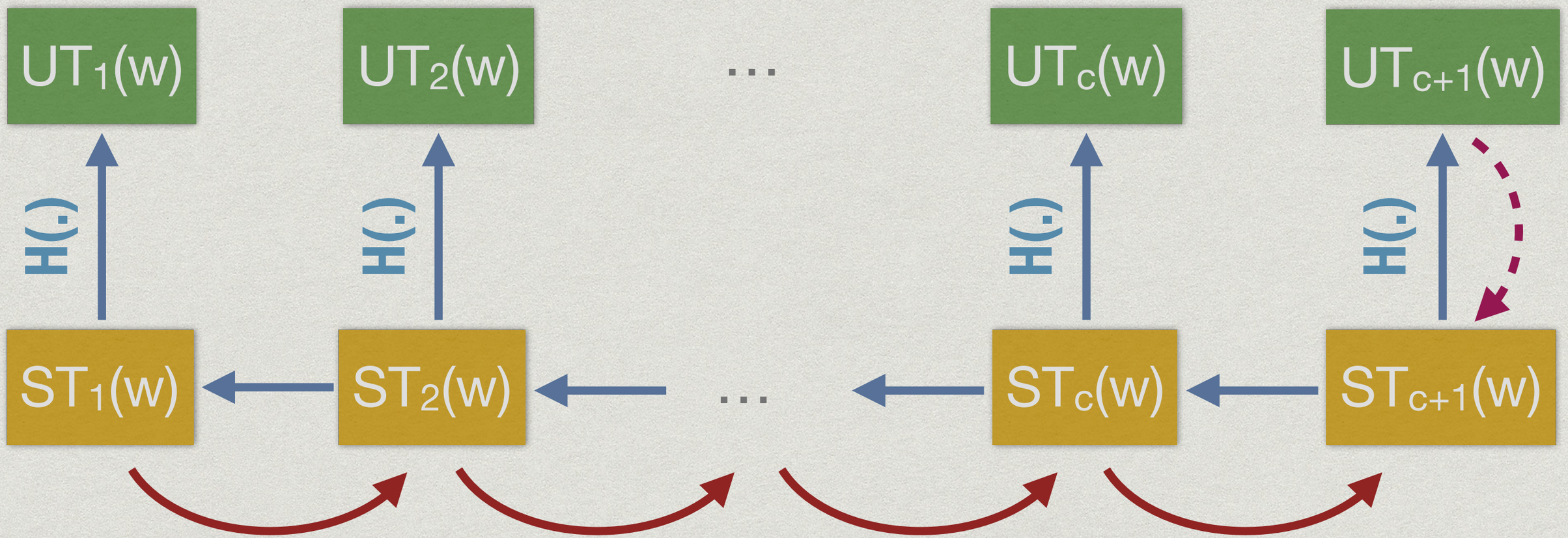

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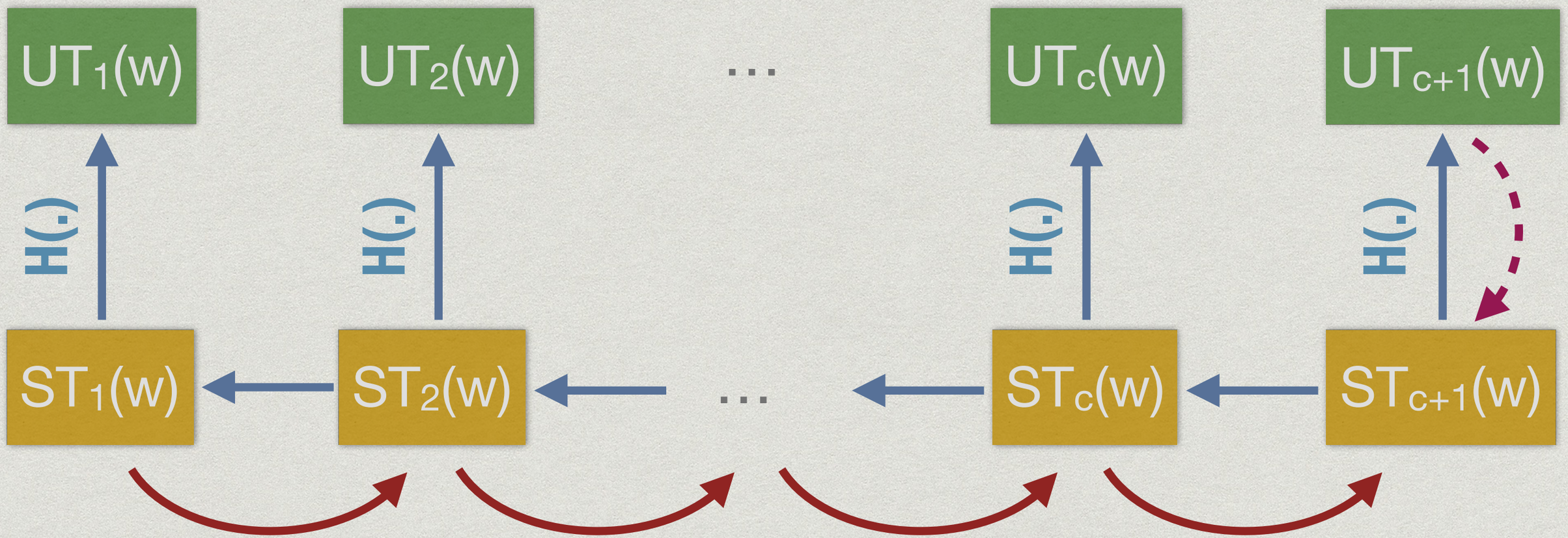

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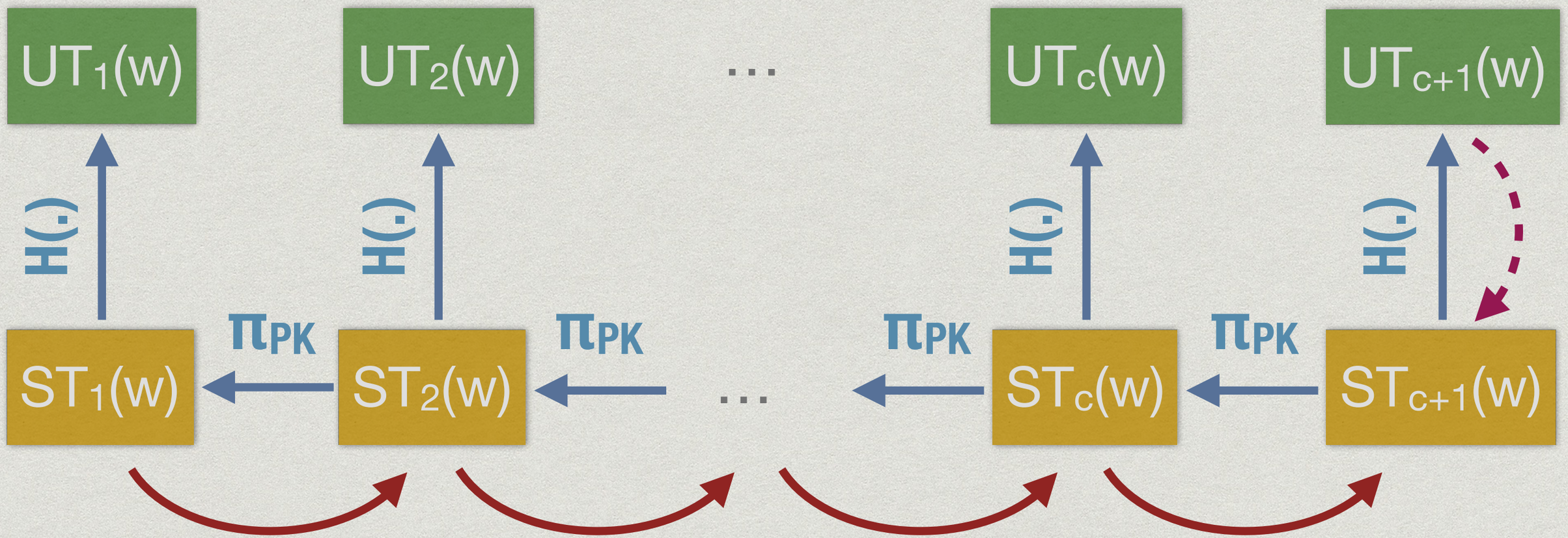

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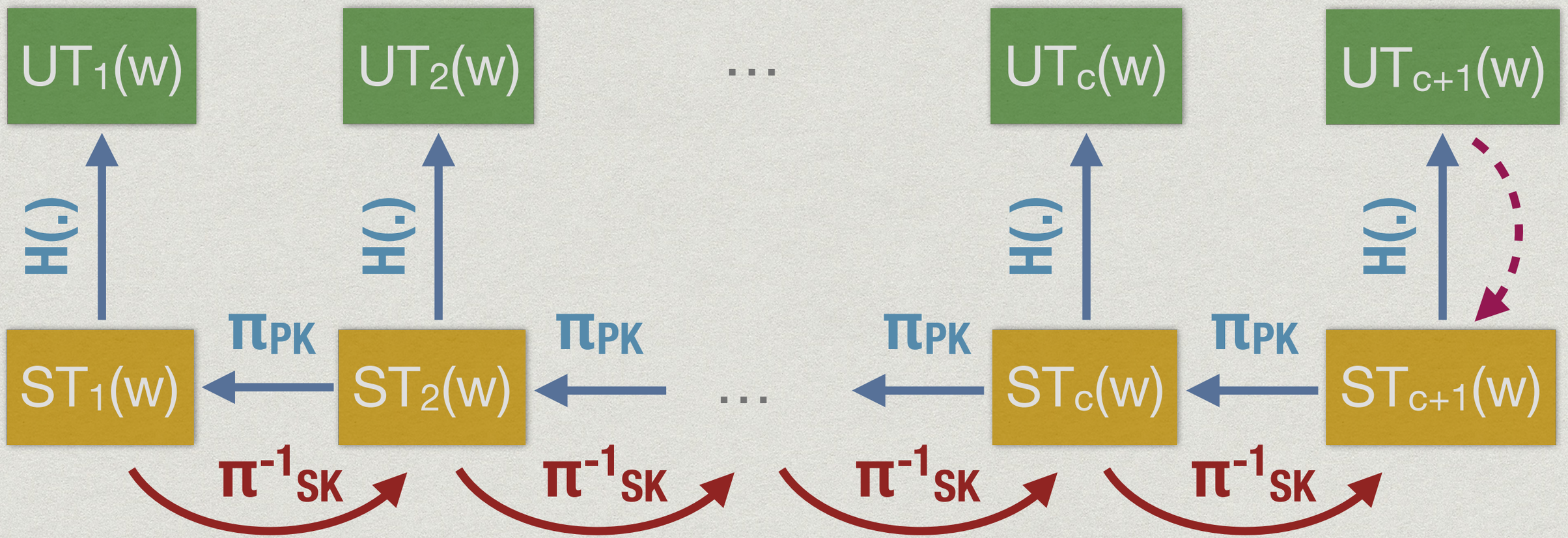

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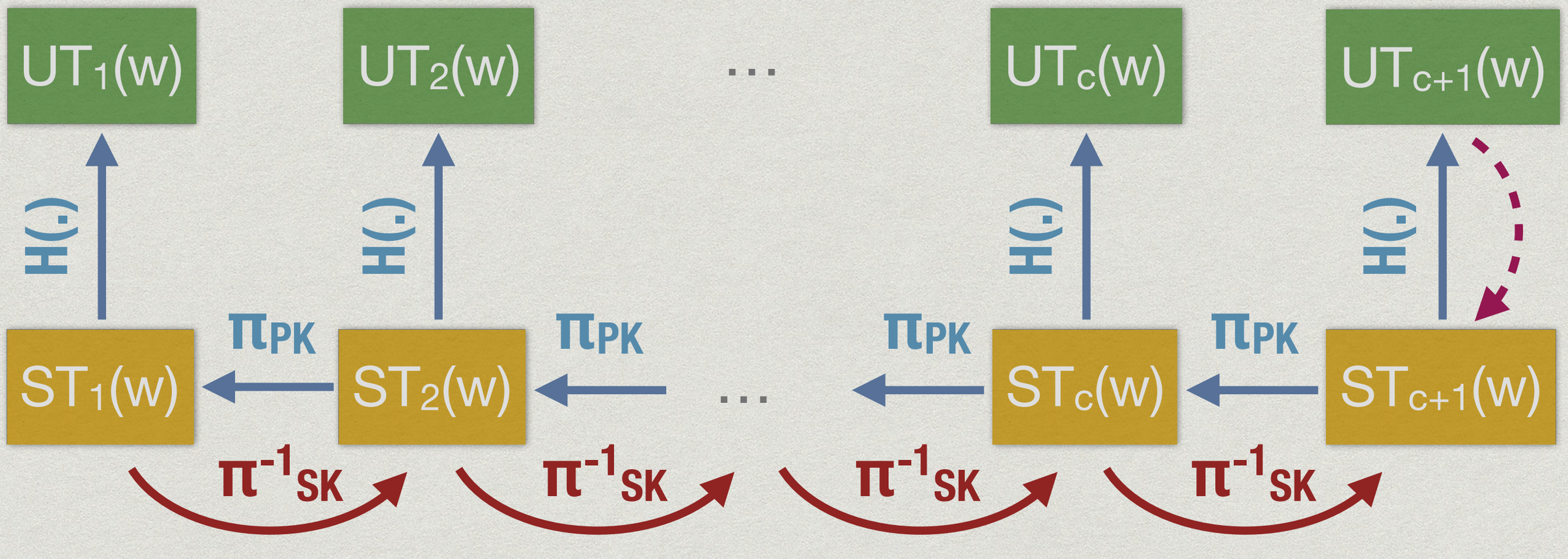
UT1(w)
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UTc(w)
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πPK
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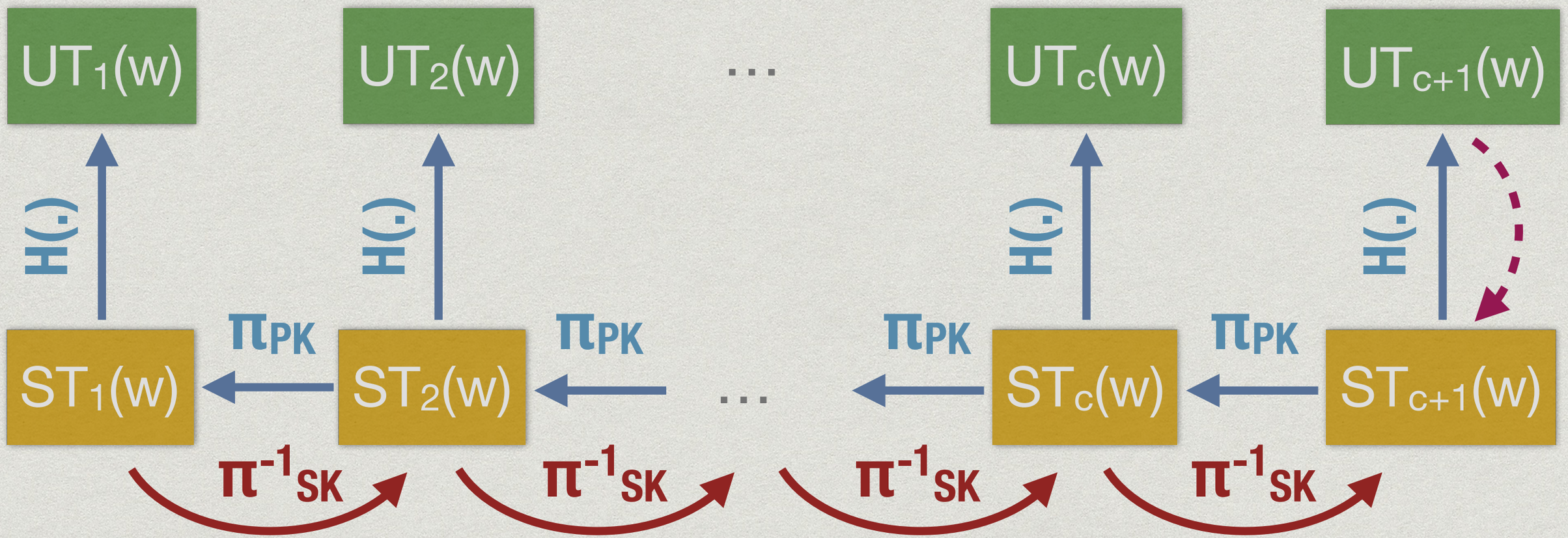

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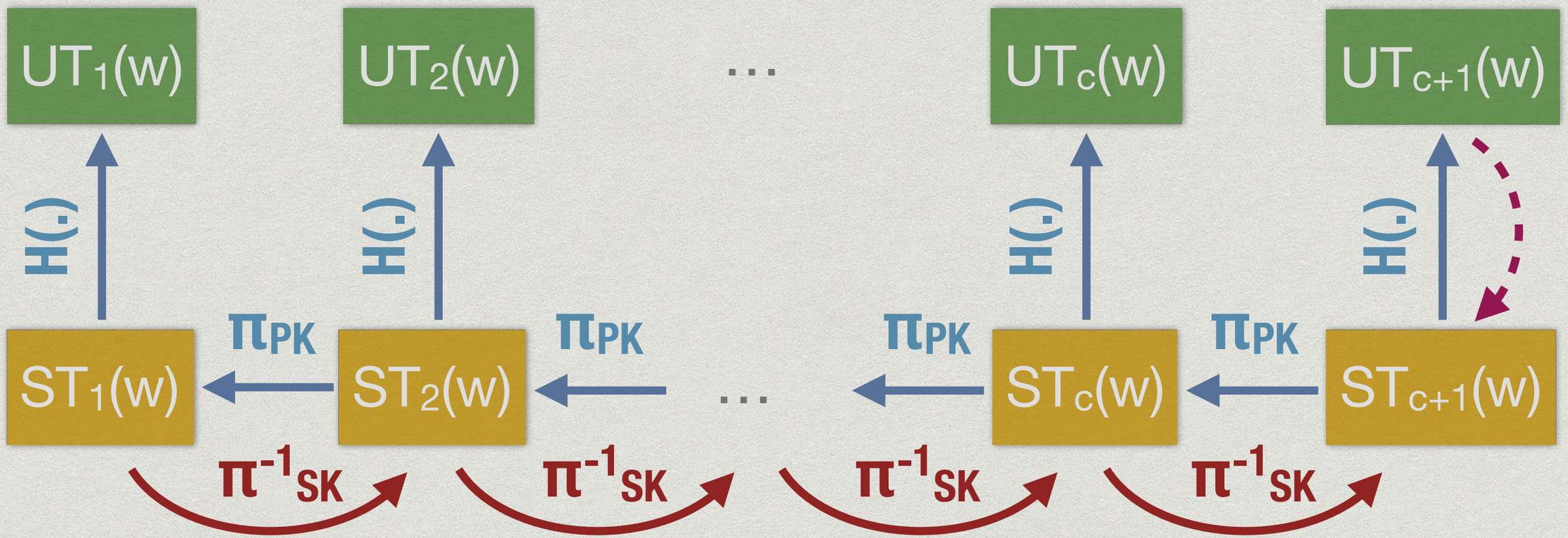
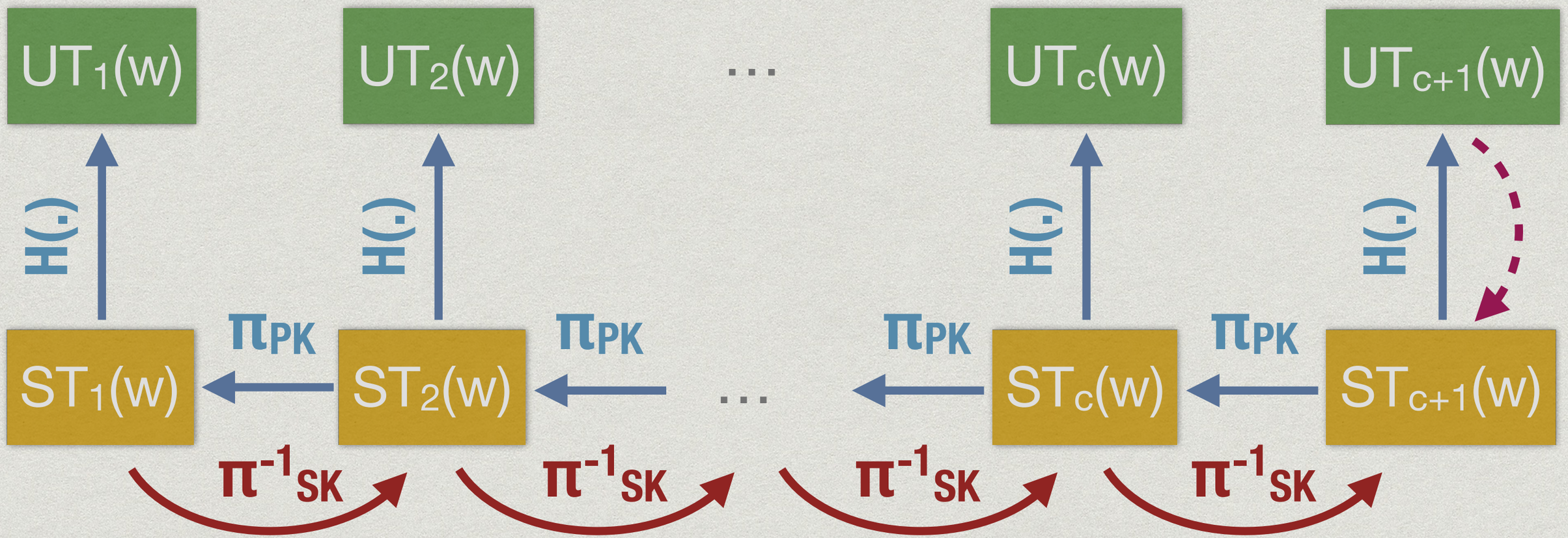
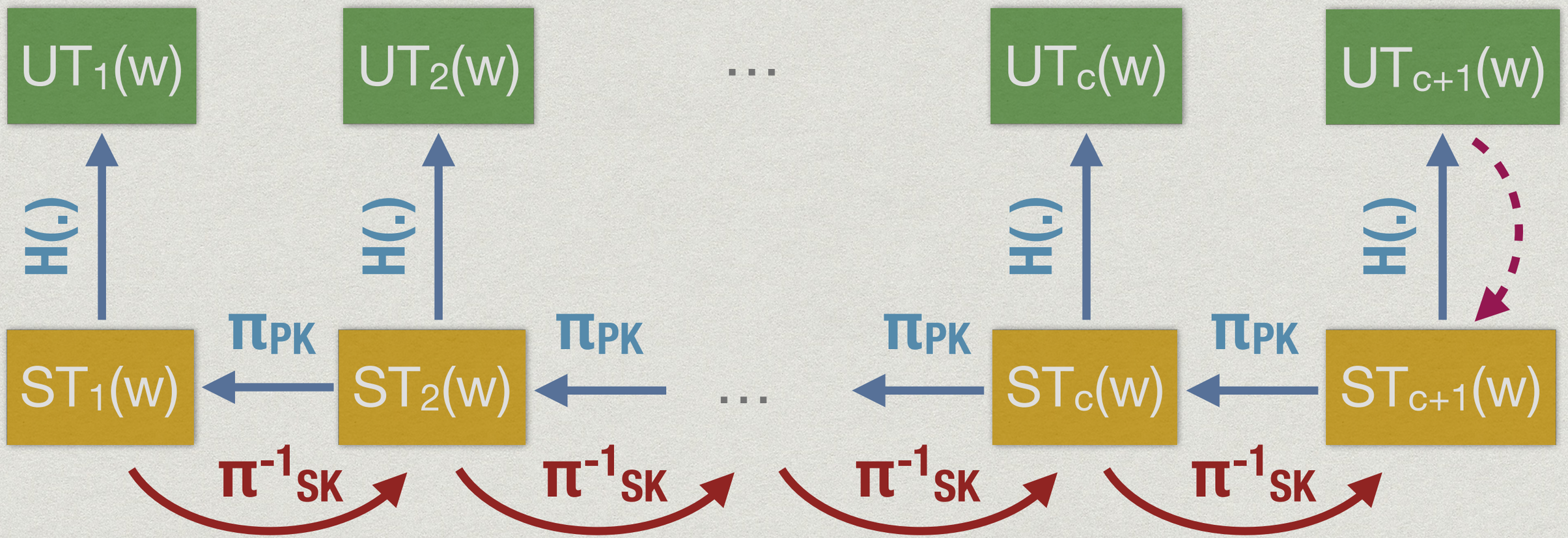


- Client stores W[w] := $ST_c(w)$
- Search w: send $ST_c(w)$

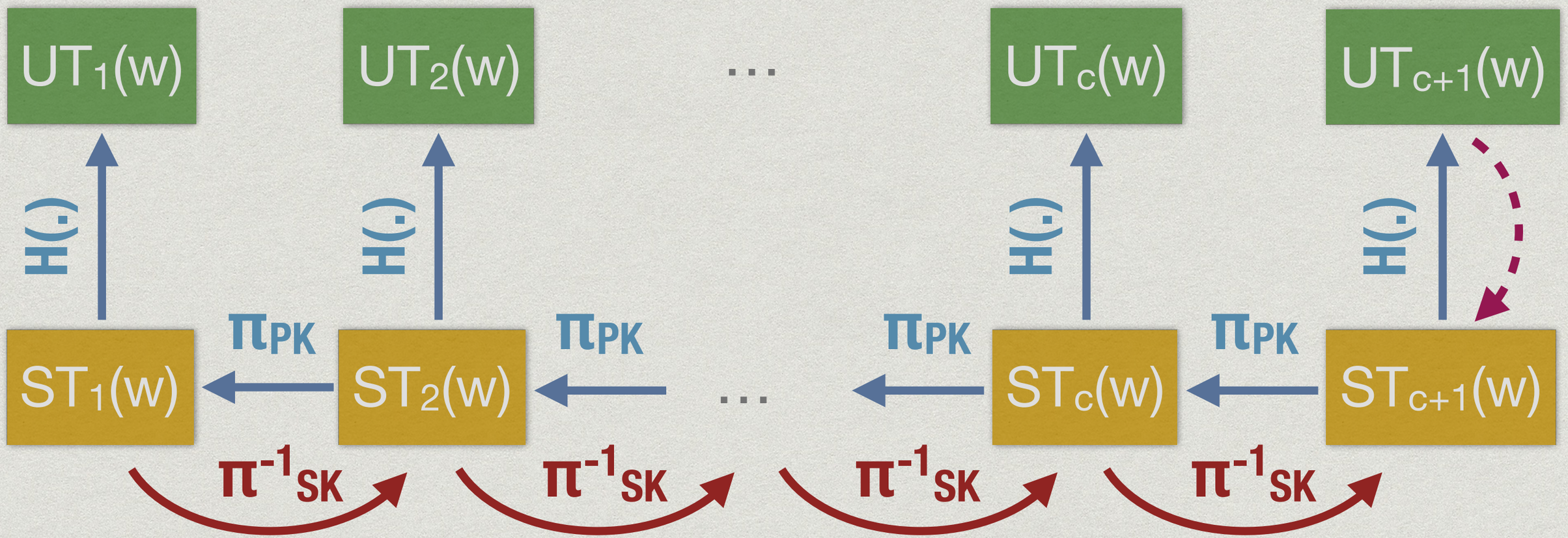


- Client stores $W[w] := ST_c(w)$
- Search w: send $ST_c(w)$
- Update: $W[w] := \pi^{-1}_{SK}(ST_c(w))$



Search:

- Client: constant
- Server: O(|DB(w)|)



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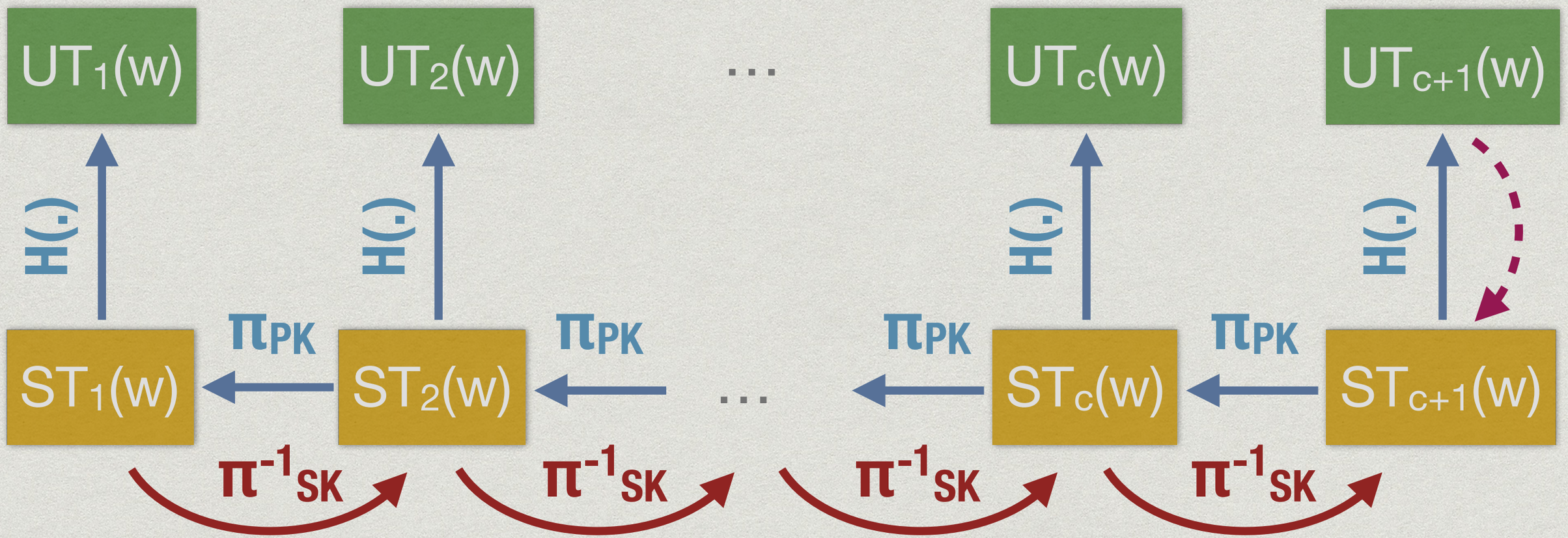
- Client: constant
- Server: O(|DB(w)|)

Update:

- Client: constant
- Server: constant



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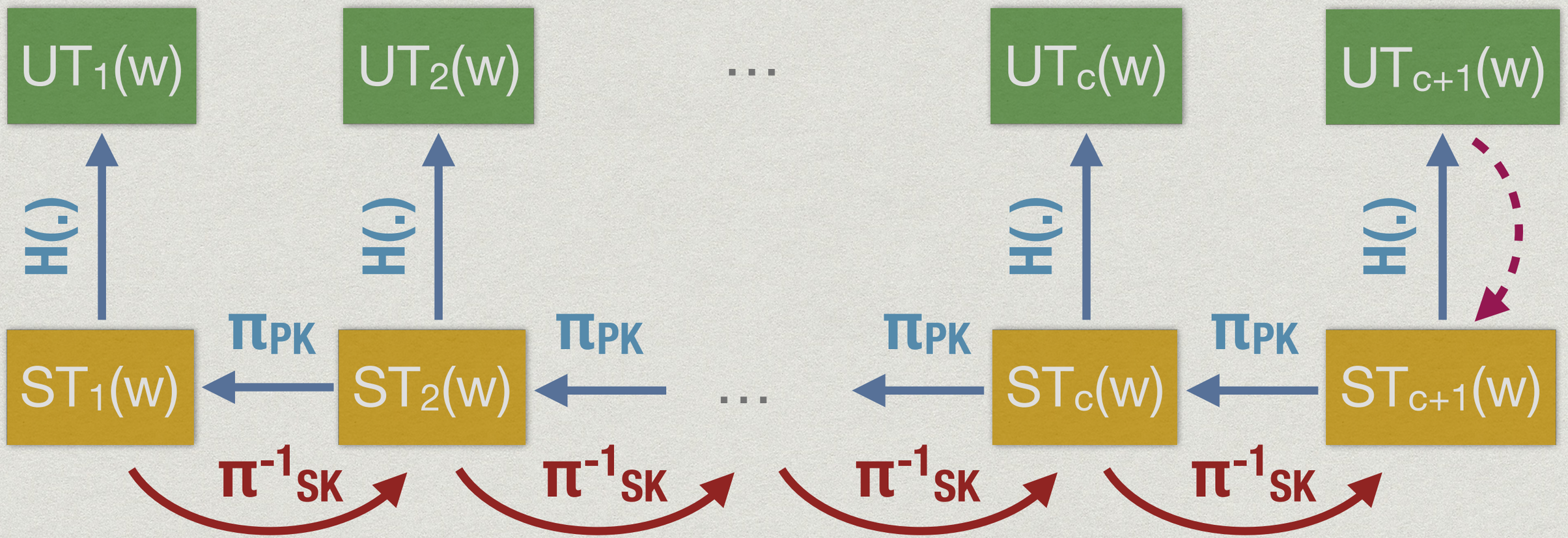
- Client: constant
- Server: O(|DB(w)|)

Update:

- Client: constant
- Server: constant

Optimal



Storage:

- Client: O(K)
- Server: O(|DB|)

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  - ✗ Elements (STs) are large (2048 bits).
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- Client only stores c, pseudo-randomly generates $ST_1(w)$, computes $ST_c(w)$ on the fly
  - ✓ Efficient (non-iterative) using RSA
- Search is embarrassingly parallelizable

$$x^{d^{\cdot^{\cdot^{\cdot^{d}}}}} = x^{(d^c \bmod \phi(N))} \bmod N$$

Σοφος - Security

- Update leakage: nothing **Forward private!**
- Search leakage:
  - search pattern
  - ‘history’ of w: the timestamped list of updates of keyword w

Adaptive security (ROM)

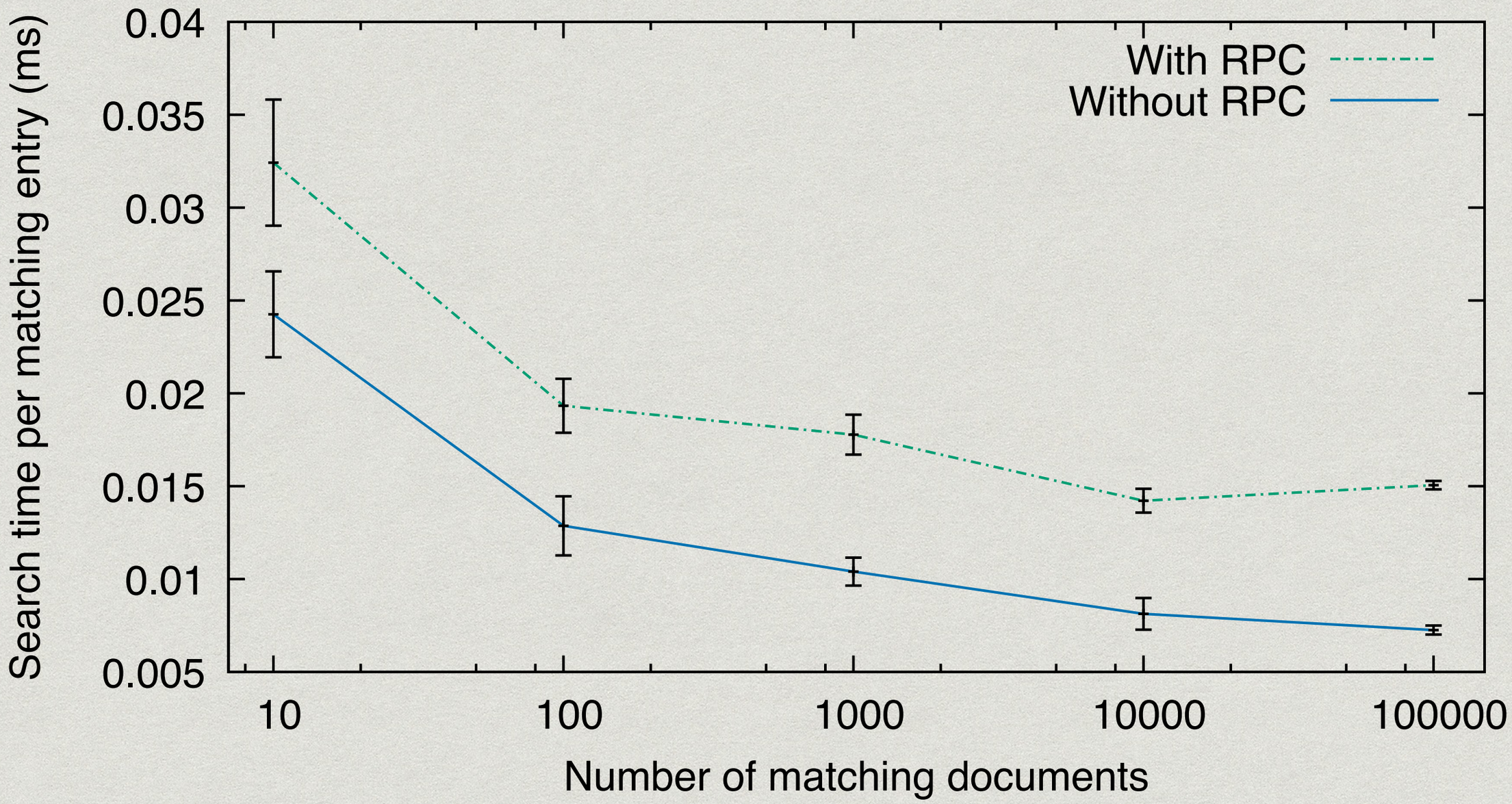
Σοφος - Evaluation

- C/C++ full fledged implementation
- Server KVS: RocksDB
- Evaluated on a desktop computer
  4 GHz Core i7 CPU, 8GB RAM, SSD

https://gitlab.com/sse/sophos

Σοφος - Evaluation

2M keywords, 140M entries
5.25GB server storage, 64.2 MB Client storage



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- Provable forward privacy
- Very simple
- Efficient search (IO bounded)
- Asymptotically efficient update (optimal)
- In practice, very low update throughput (4300 p/s - 20x slower than other work)

THANKS!