Random-Index ORAM

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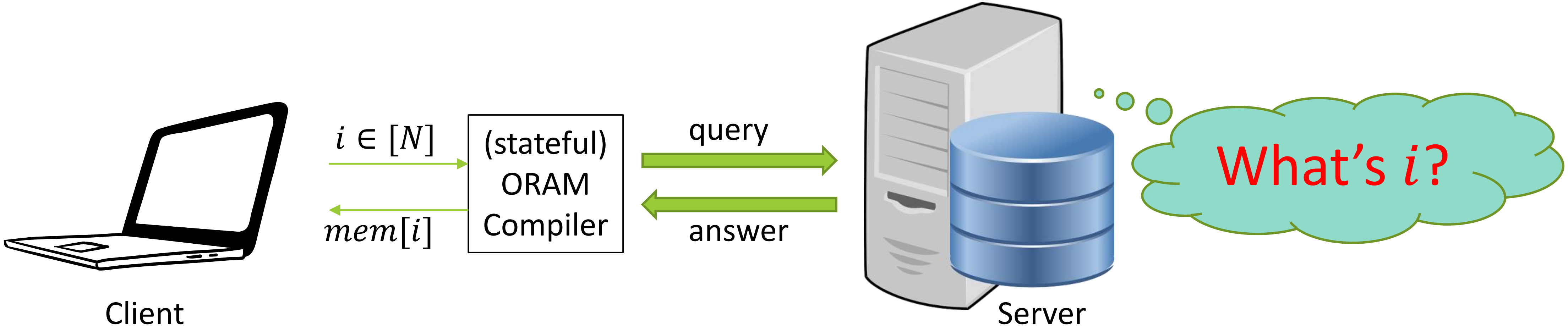
https://eprint.iacr.org/2022/982

Recall Oblivious RAM

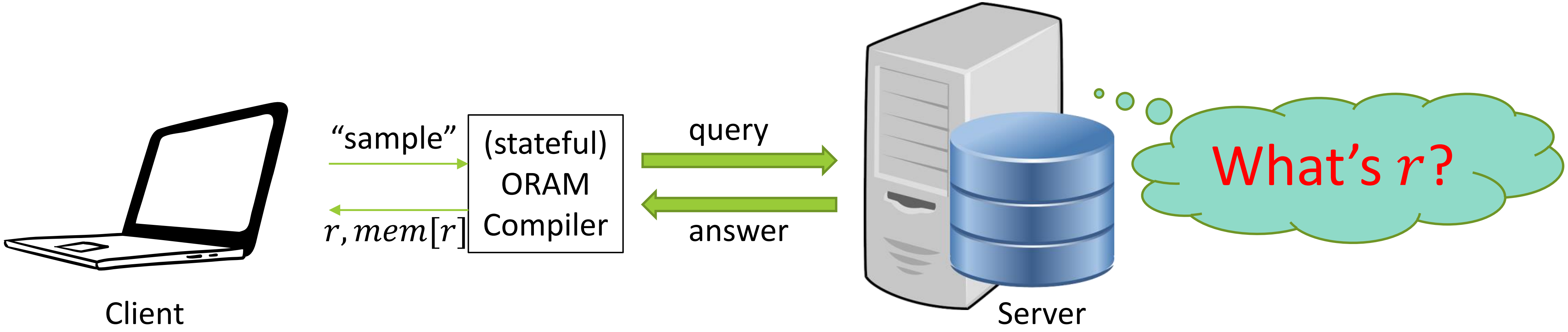
- Introduced by Goldreich and Ostrovsky [G87,O90,GO96]



- Server should not learn the indexes that are accessed
- Compiler should use little space, little communication
- Server's space should not be much more than N

This Work: ORAM with a Twist

- Client accesses **random** indexes, not specific ones



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Random-Index ORAM (RORAM)

- Weaker than ORAM, perhaps it can be made faster?
  - Sufficient for some applications
- Computing statistics
- Sub-sampling
  - Can then run arbitrary computation on smaller sub-sample
  - Perhaps using full ORAM if even sub-sample is too big

Lottery-type applications

- People sign up with the server
- Client chooses one/few of them to get the jackpot
  - Server shouldn't know who won

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- In the paper: application to massive-scale MPC
  - Choosing random parties for committees
  - RORAM-client implemented via secure-MPC
  - Same motivating application as for RPIR [GHMNY21]

Defining RORAM Security –Two Notions

- Future randomness: next index looks random to the server
  - (Can settle for high-entropy rather than truly random)
- Randomness: All sequence looks random (or high entropy)
  - Including past indexes
- The difference: future-randomness scheme can reveal the j'th index in query $j+1$
  - Can help efficiency
  - Still enough for lottery-type applications

Defining RORAM Security –Two No… ons

Also batch notions: multiple indexes in each query

Also another (even weaker) notion – guessing resilience

- F… server
- … opy)
- T… can reveal the j'th … query $j+1$
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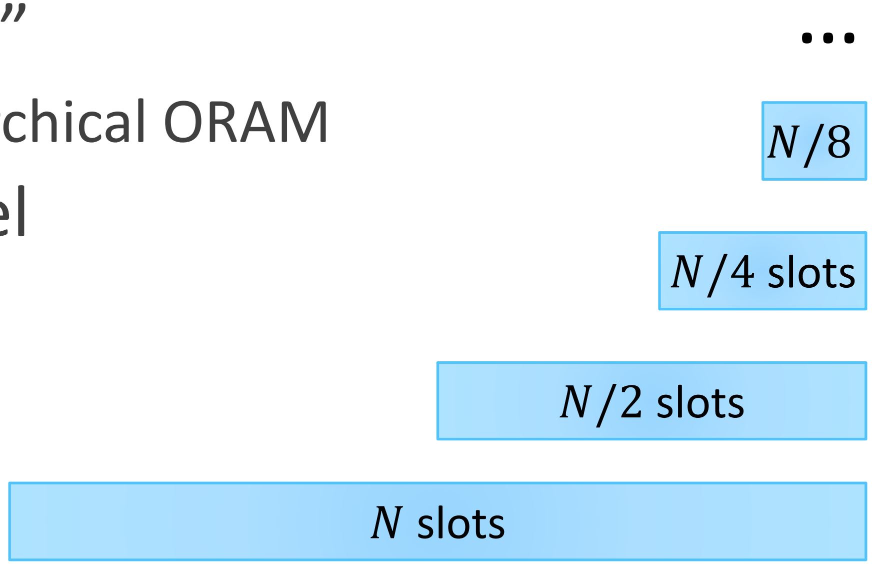
  - Still enough for lottery-type applications

Constructions

- Based on Hierarchical ORAM
  - Most efficient yields future randomness
  - Slightly less efficient yields randomness
- Based on Tree ORAM
  - Very simple, efficient, for batch RORAM
  - Only yields guessing resilience

Recall Hierarchical ORAM

- Server's storage consists of $O(\log N)$ levels
  - Level i has $O(2^i)$ slots
- Query returns one slot from each level
  - One of them contains the "right element"
    - Finding it (via hashing) is the "smarts" of hierarchical ORAM
  - Fetched element is placed at the top level



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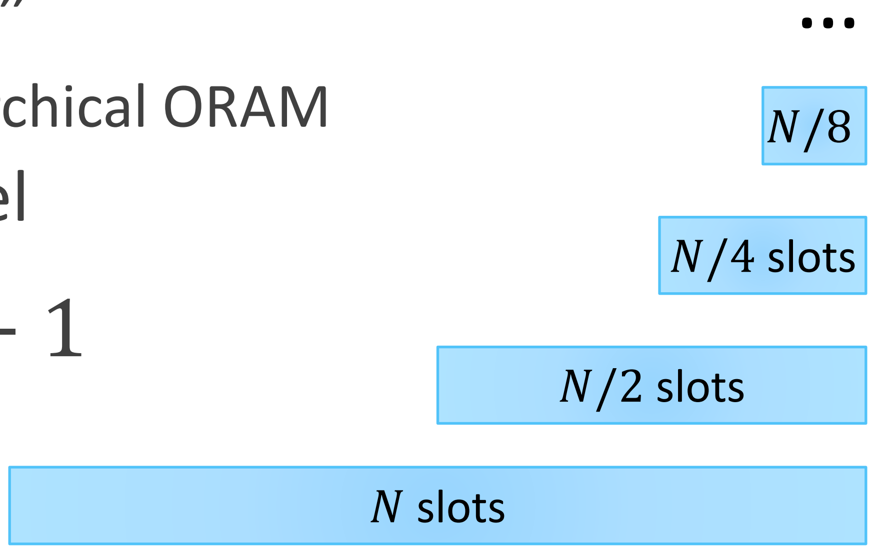
- Every 2^i queries, all levels $1,2,\ldots,i-1$ are merged into level i
  - That's where a lot of the complexity lies



Hierarchical RORAM – Future Randomness

- No need to find “the right element”, so no hashing
- Each query contains the index from the previous one
  - Server knows exactly what elements reside in what level
  - But not how they are ordered in the levels
- Server just returns last element in each level
  - Client chooses one level at random (weighted appropriately)
  - Top level is re-written entirely in each step

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- Server just returns last element in each level
  - Client chooses one level at random (weighted appropriately)
  - Top level is re-written entirely in each step
- Merge down every 2^i queries a little simpler than ORAM
  - Since elements only need to be in a random order, not a specific one

Hierarchical RORAM – Randomness

- The server doesn't know the size of level anymore
  - So cannot just read the last element of each level
- But it still knows the size approximately (whp)
  - The next element to read is in some not-too-large window
  - The server just sends the entire window in each level
    - Can use client-side caching to save a bit more

Also in the Paper

- Tree-based RORAM
  - Saves on the recursive position map - $O(\log N)$ factor
  - Very simple scheme, but complicated analysis
- Open problems
  - Better schemes, better analysis
  - Hybrid ORAM/RORAM: support both, pay for what you use
  - Can you build ORAM from RORAM?
  - and more


THANK YOU!