Thresholding Symmetric-Key Primitives Based on General-Purpose Actively Secure MPC

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Our Goal

Subcategory: Type	(Sub)subcategory #: Family of primitives	Some [Primitives] and/or {Threshold Modes}
C1.4: Symmetric	C1.4.1: AES (en/de)cipher	[encipher, decipher]
	C1.4.2: KDM/KC (for 2KE)	[Hash, CMAC, HMAC, KMAC]

- With support of all I/O interfaces
  - {NSS, SSI, SSO, SSIO}
  -
- With support of all primitives
  - AES, SHA[23], [CHK]MAC, etc
- With possibility to support C2.4

  – C2.4, for symmetric-key primitives (e.g., TF enciphering/deciphering), and hashing-related primitives for key derivation and key confirmation;

Our Solution

Based on generic multi-party computation protocols for Boolean circuits!

Pros:

- Only need to handle one protocol and one implementation
- Usable in other applications

Cons: May not be as efficient as customized protocols

- But the gap is small: most symmetric-key primitives have little structure for improvement

Our Philosophy

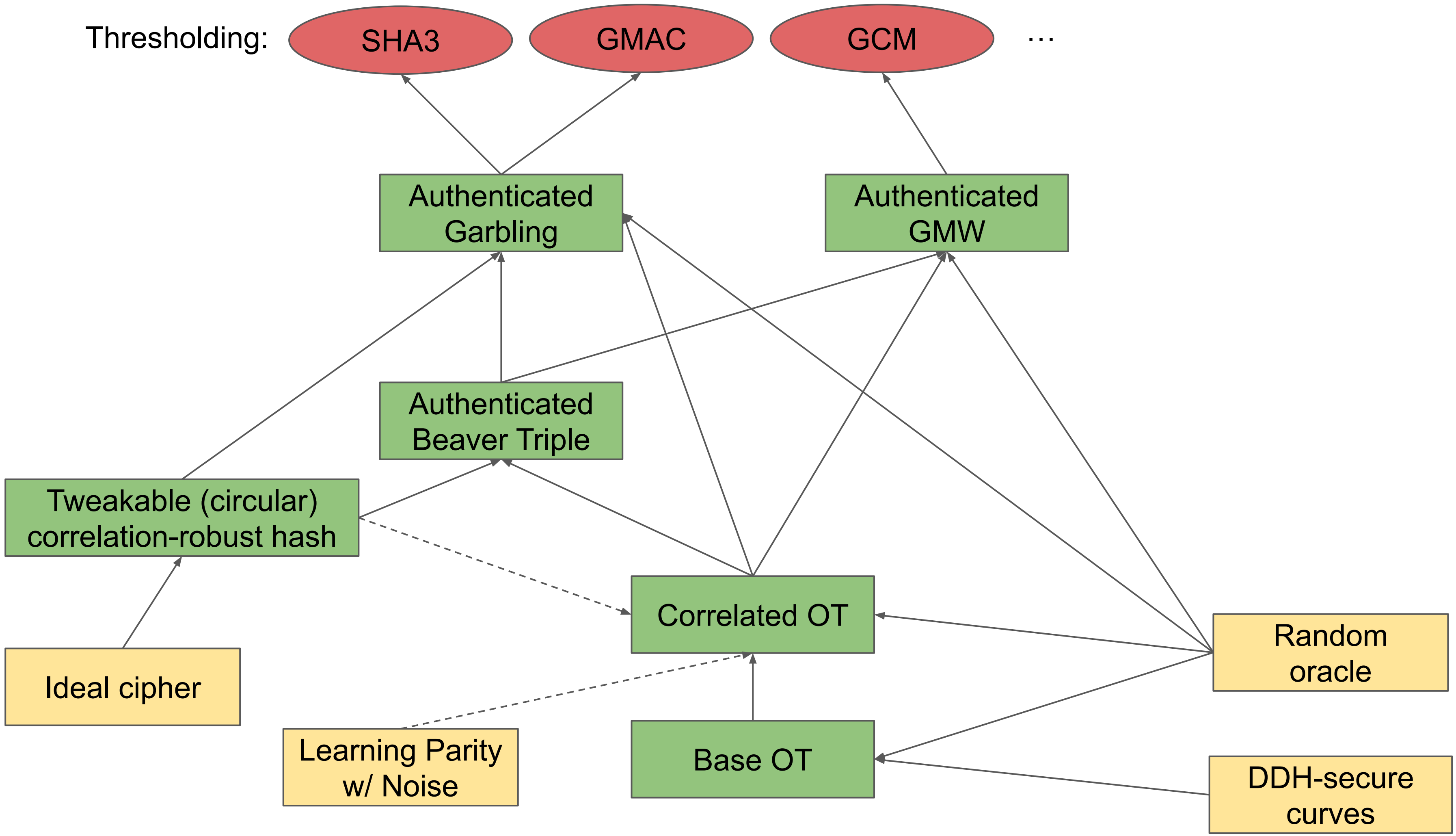
As fast as possible with high security confidence.

High security confidence:

- Active security in the universal composability model
- Tolerate a static corruption of *n-1* parties out of *n* parties.
- Concrete security
- Conservative assumptions

Two solutions

- A solution using only NIST-standardized primitives
  - E.g, AES as ideal cipher, SHA3 as random oracle, and NIST-approved curves.
- A (more efficient) solution using primitives close to what NIST already standardized


Thresholding:
SHA3
GMAC
GCM
...
Authenticated Garbling
Authenticated GMW
Authenticated Beaver Triple
Tweakable (circular) correlation-robust hash
Correlated OT
Random oracle
Ideal cipher
Learning Parity w/ Noise
Base OT
DDH-secure curves

Tweakable (circular) correlation-robust hash

- Use of Fixed-key AES by Bellare et al. [SP:BHKR13], and then by Zahur et al. [EC:ZahRosEva16] for garbling
    - Then, a lot of unprincipled used
- Modular proof by Guo et al. [SP:GKWY20]
    - Still suffer from birthday bound
- Near optimal concrete security by Guo et al. [C:GKWWY20]

Correlated OT

- [C:IKNP03] is the most widely used correlated OT with passive security
  - [C:KelOrsSch15] is the most widely used COT with active security

- Silent OT [C:BCGIKS19, CCS:BCGIKRS19, CCS:SGRR19, CCS:YWLZW20, …]
  - All based on some variations of Learning Partiy w/ Noise
  - Very small communication, moderate computation

- SoftSpokenOT [C:Roy22]
  - No LPN assumption, more rigours analysis of consistency check
  - Smaller communication in trade of more AES-like computation

Authenticated Beaver Triples

Pairwise IT-MAC on “normal” Boolean Beaver Triples

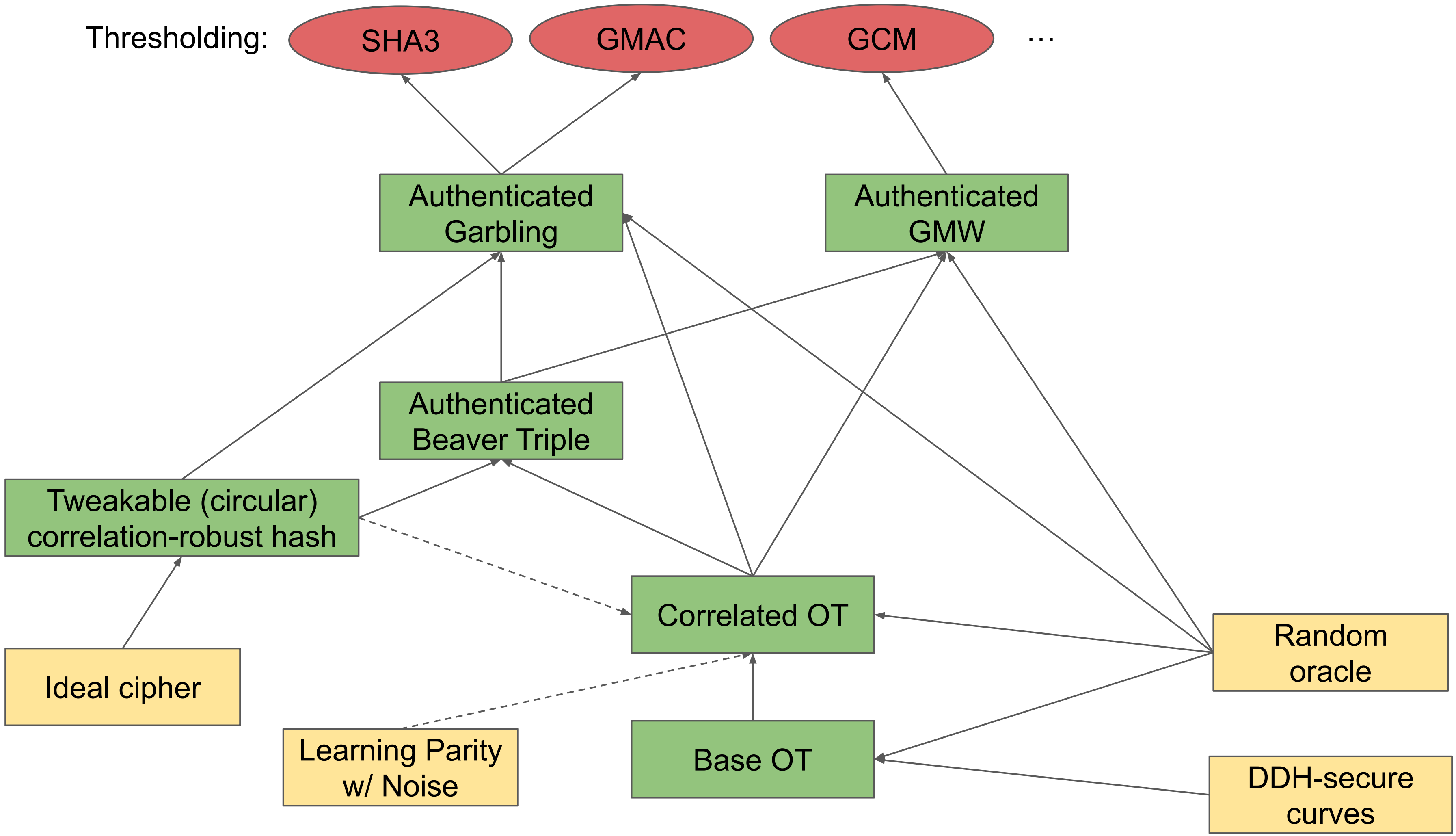
- [C:NNOB12] – Concept and first construction
- [AC:FKOS15], [JC:BLNNOOSS21] – Improved efficiency, two layers of bucketing
- [CCS:WanRanKat17], [CCS:YanWanZha20] — Improved efficiency, one layers of bucketing, w/ a row of GC-like table

Authenticated Garbling

- [CCS:WanRanKat17] – Original Protocol
  - Concurrent to the multi-party extension of WRK: [AC:HazSchSor17]

- [C:KRRW, CCS:YanWanZha20] — Improved online and offline
  - Online can be as small as a half-gate + O(1)
  - Offline works with “leaky” COTs

- [C:DLIO22, EC:CWYY23]
  - Rely on single-sided secure authenticated triples and cheap COT/VOLEs
  - Nearly optimal in communication in trade of high computation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Planned Submission

Protocols

- Authenticated garbling
- Authenticated GMW “TinyOT”

Gadgets:

- Tweakable robust hash
- Correlated OT
- Garbling scheme
- Authenticated triples