# SCAPI: The Secure Computation API

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- Most implementation projects are aimed at solving a specific problem more efficiently or with better security
- SCAPI is an implementation project with no specific problem in mind (it is a general-purpose secure computation library)
- SCAPI is open source; we have a long-term commitment (as long as we have money) to the project (bug fixes, additional functionality, improve existing implementations etc.)

# Basic Design Decisions

- SCAPI is written in Java
  - Suitable for large projects, and quick implementation
  - Portability (e.g., secure computation between a mobile device and a server)
  - Existing libraries (e.g., Bouncy Castle)
  - The JNI framework: can use libraries and primitives written in native code (and thus inherit their efficiency)

# Design Principles

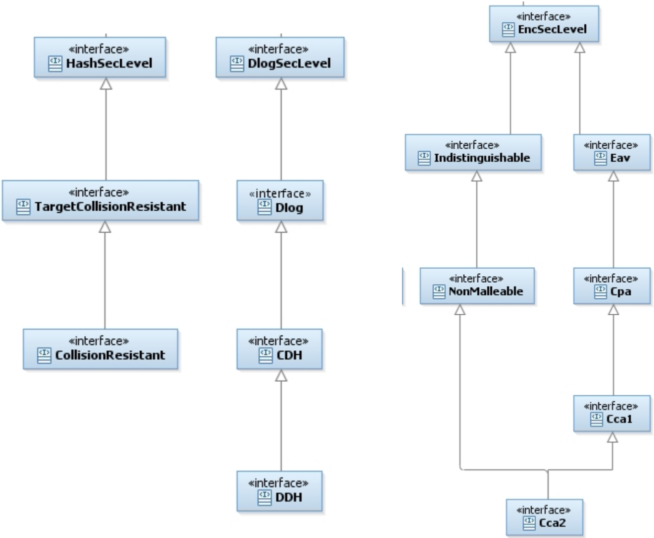
- **Flexibility:**
  - Cryptographers write protocols in abstract terms (OT, commitment, PRF, etc.)
  - SCAPI encourages implementation at this abstract level (work with any "DLOG group" and afterwards instantiate with concrete group and concrete library; e.g. EC-group from Miracl)
  - Can work at many different levels of abstraction, as desired
- **Extendibility:** can add support for any new libraries and implementation by providing wrappers that implement the defined interfaces (we are now adding openSSL)
- **Efficiency:** via JNI can access fast low-level libraries like Miracl, but work at the level of Java and with abstract objects
- **Ease of use:** SCAPI uses terminology that cryptographers are used to; SCAPI is well documented and has been written explicitly with other users in mind

# Security Levels

- Consider an oblivious transfer protocol that uses a group, a commitment scheme, and a hash function
- The theorem stating security of the protocol would say:
  - Assume that DDH is hard in the group, the commitment is perfectly binding, and the hash function is collision resistant.
  - Then, the OT protocol is secure.
- SCAPI differentiates between security levels by defining **hierarchies of interfaces**, and protocol constructors can check them

# Security Levels

SCAPI defines **hierarchies of interfaces** for security levels



# Security Level Use

- The OT protocol receives a dlog group, commitment and hash function in its constructor
- It checks that:
  - The dlog group is an instance of DDH
  - The commitment is an instance of PerfectBinding
  - The hash function is an instance of CollisionResistant
- Security levels are also defined for protocols (semi-honest, covert, malicious, stand-alone, UC secure, and so on)

# Layers and Primitives

SCAPI has three layers

- Basic primitives (discrete log groups, PRFs, PRPs, hash, universal hash, etc.)
- Non-interactive schemes (symmetric and asymmetric encryption, MACs, signatures)
- Interactive protocols (oblivious transfer, garbled circuits, sigma protocols, ZK, ZKPOK, commitments, etc.)
  - We are continually adding: OT extensions for semi-honest (ACM CCS 13), JustGarble, wrapper for OpenSSL

# Example Usage

## The Cramer-Shoup Encryption Scheme

```
public interface CramerShoupDDHEnc extends AsymmetricEnc, Cca2 {
}

public CramerShoupAbs(DlogGroup dlogGroup, CryptographicHash hash, SecureRandom random){
 //The Cramer-Shoup encryption scheme must work with a Dlog Group that has DDH security level
 //and a Hash function that has CollisionResistant security level. If any of this conditions is not
 //met then cannot construct an object of type Cramer-Shoup encryption scheme; therefore throw exception.

 if(!(dlogGroup instanceof DDH)){
    throw new IllegalArgumentException("The Dlog group has to have DDH security level");
    }

 if(!(hash instanceof CollisionResistant)){
    throw new IllegalArgumentException("The hash function has to have CollisionResistant security level");
    }

 // Everything is correct, then sets the member variables and creates object.
 this.dlogGroup = dlogGroup;
 qMinusOne = dlogGroup.getOrder().subtract(BigInteger.ONE);
 this.hash = hash;
 this.random = random;
}
```

# Results – Average of 1000 Runs

## The Cramer-Shoup Encryption Scheme

| Dlog Group Type | Dlog Provider | Dlog Param | Hash Function | Hash Provider | Encrypt Time (ms) | Decrypt Time (ms) |
|---|---|---|---|---|---|---|
| DlogZpSafePrime | CryptoPP | 1024 | SHA-256 | BC | 6.072 | 3.665 |
| DlogZpSafePrime | CryptoPP | 2048 | SHA-256 | BC | 43.818 | 26.289 |
| DlogECFp | BC | P-224 | SHA-1 | BC | 54.171 | 31.662 |
| DlogECF2m | BC | B-233 | SHA-1 | BC | 107.316 | 65.185 |
| DlogECF2m | BC | K-233 | SHA-1 | BC | 25.292 | 14.886 |
| DlogECFp | Miracl | P-224 | SHA-1 | BC | 6.571 | 3.929 |
| DlogECF2m | Miracl | B-233 | SHA-1 | BC | 5.819 | 3.652 |
| DlogECF2m | Miracl | K-233 | SHA-1 | BC | 2.753 | 1.787 |