



Presents...

Securing your JavaEE Microservice with HMAC

Scott Kramer

A little about Presenter...

- Currently
 - STA Architect and “hands on” coder
 - Our biz is Business Transformation
- Also...
 - Tinker-er
 - JavaOne Speaker 2014 & 2015
 - Volunteer(ed) for iJUG, cJUG, Chicago Coder Conference, Police, etc...
 - Married to woman of my dreams
 - Certifications: SCJP & wrote several CBT's, coding 25 years+, and published stuff...



Scott Kramer
Hands-On Architect
STA Group Inc.

Agenda

- **Micro-services**
 - Concept and value proposition
 - Monolithic architecture
 - Micro-service architecture
 - Security and data architecture
- **Securing Micro-services**
 - Cryptology Concepts
 - HMAC
 - When, Why, and How to use
- **Technical implementation**
 - Examples



Source: <http://www.phaidon.com/>

Microservices

Microservices evolution to a family's evolution...



Payment Processing

```
Map<Object, Object>  
process (Map<Object, Object>)
```

```
List<Payment>  
processPayments (List<Integer>)
```

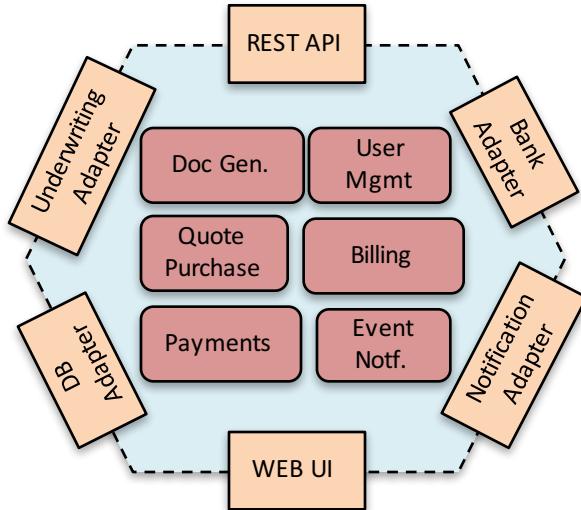
```
List<StudentPayment>  
processStudentLoan  
(List<Integer>)
```

Micro-services concepts and value proposition

- Service with single business capability
- Scalable
- Separate process and self-contained
- Share nothing model
- Independently deployed
- Atomic and idempotent
- Performant
- Usually REST based
- Smart endpoint using dumb messaging

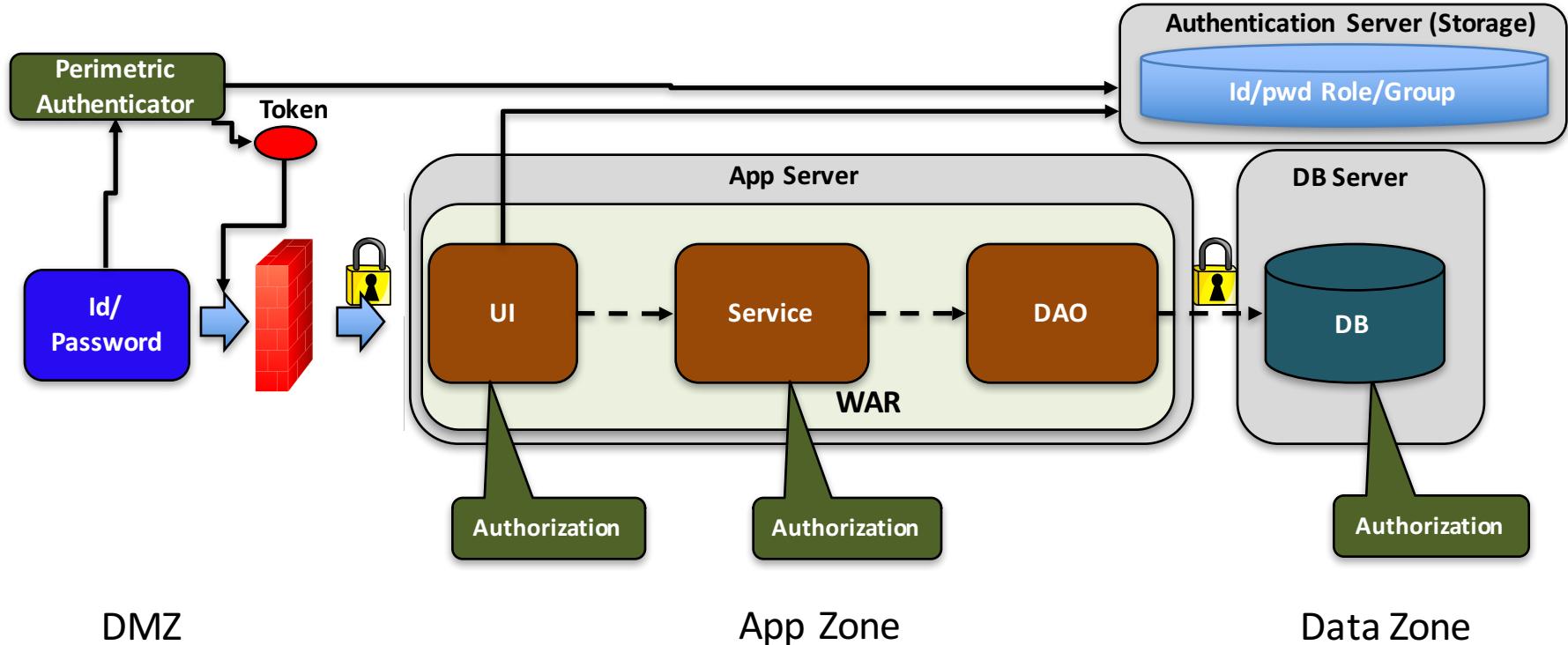


Monolithic architecture – High Level

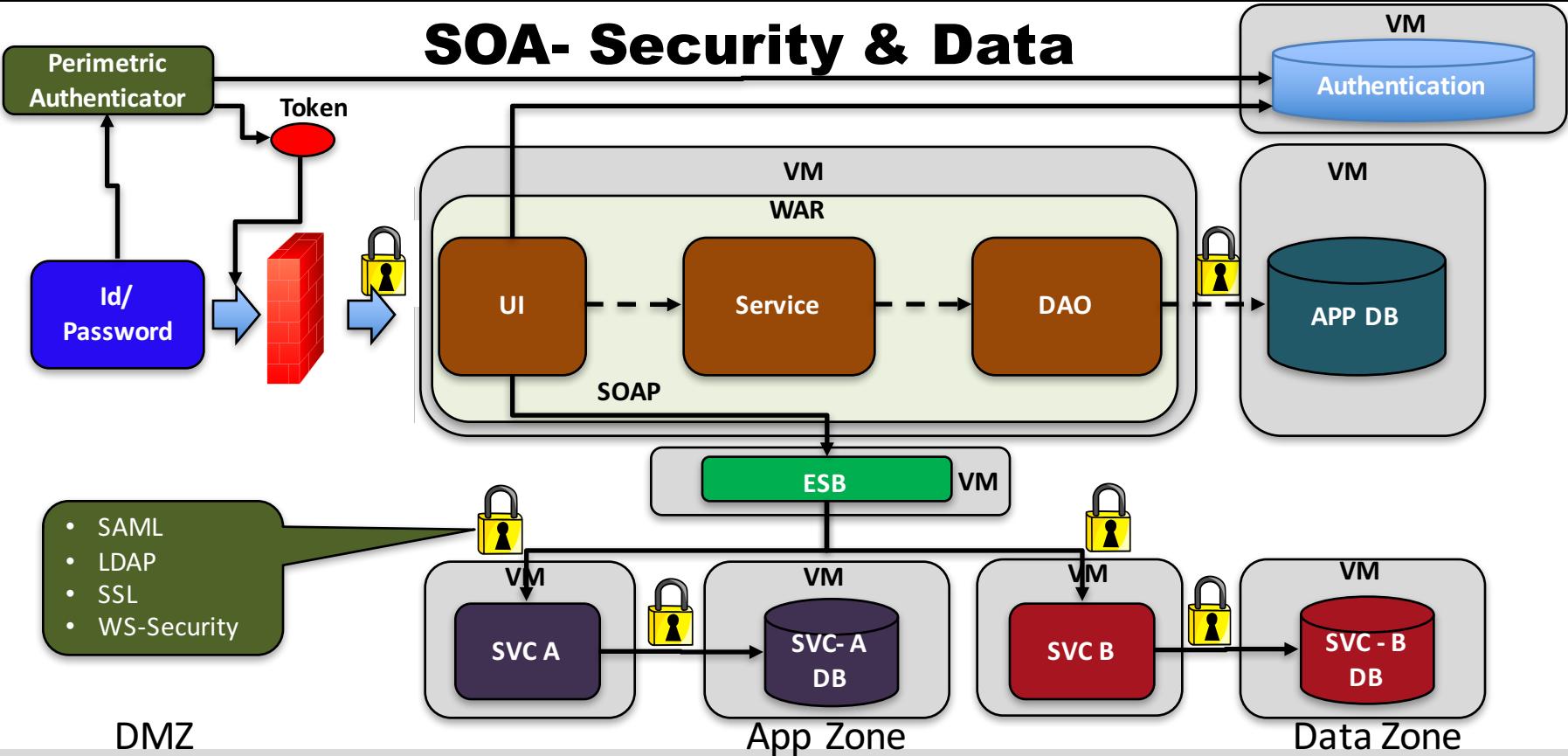


- **Encompasses all functionality**
- **Modular architecture**
- **Supports multiple interfaces**
- **All dependencies are well defined and contained**
- **Security**
- **Data Architecture**

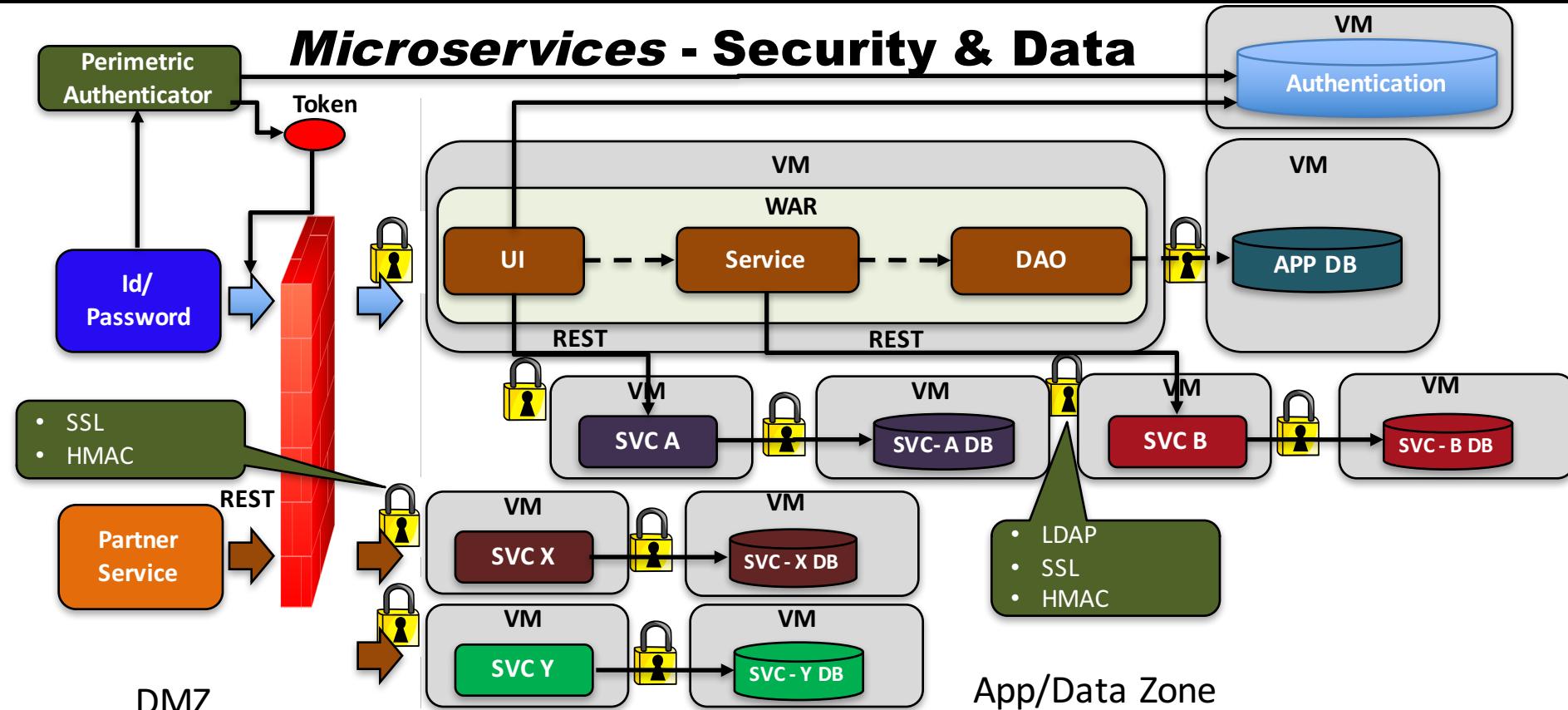
Monolithic Architecture - Security & Data



SOA- Security & Data



Microservices - Security & Data



Cryptology Concepts

Basic Cryptology Concepts, Techniques, and Algorithms



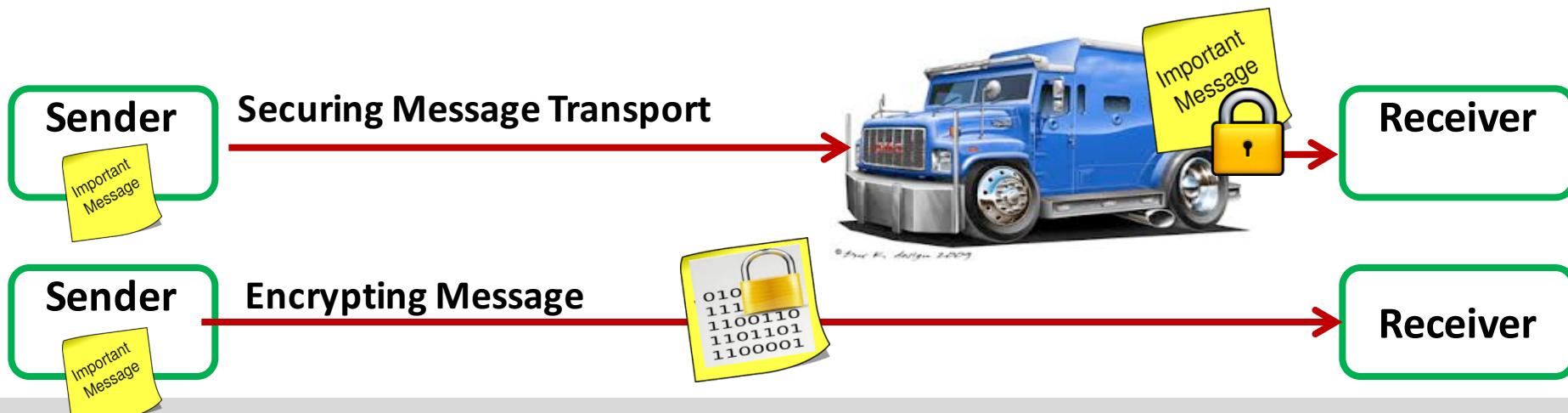
- Locking with a combination number (“key”) is susceptible to someone the guessing answer.
 - Automated computer guessing is called “brute force”.
 - Cryptology locking = encryption, unlocking = decryption.

- Quick - What is the strongest lock?
 - Computer locks rely on crazy difficult math problems.
 - Todays strong lock is tomorrows brute force victim ←
 - Longer keys = more processing time to encode/decode



Ongoing Security Challenge...

- Message authentication and encryption is simple, fast and stateless.
- Easy to change access control based on shared secret keys.
- Security is not dependent on the application communication topology.



Basic Cryptology Concepts

A	B	C	D	E
1	2	3	4	5



ABC = 123

A	B	C	D	E
2	5	6	7	
4	5	6	7	8
5	6	7	8	9



ABC = 135



Solution: How two people securely exchange a message ?

- Clifford Cox solved this via complex mathematics
 - RSA, basis for Public key and Private key and more....
 - Multiplying two numbers is easy, determining the original prime numbers from result is hard.
 - Factoring large integers that are product of multiplying two large prime numbers is complex.
 - Can be slow; needs setup (Software Install; Key Locations; Certificate Authority, etc.)
 - When to use?
 - Certificate Authority setup;
 - Configuration not a issue; Protocol independence not required

Bob

Space, The
Final
Frontier...



Encrypt

0101010
1011001
0101001



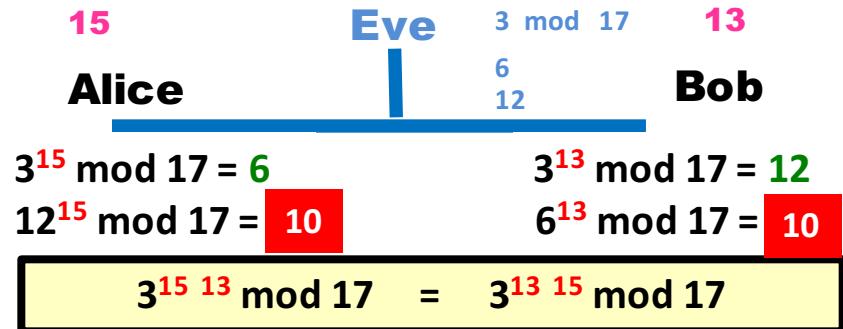
Decrypt

Alice

Space, The
Final
Frontier...

Solution:

2 People (*who never met*)
create a secret key *publicly*.



- Diffie-Hellman used “Discreet Logarithm” math to solve.

`<primitive-root>X * Y mod <base-number> ≡ <result>`

- One-way encoding is fast even with large numbers
- Reversing the encoding without keys is very, very difficult



Designing a better encryption technique...

- Faster than Public/Private; protection from known attacks; simple to implement.
- Hashed Method Authentication Code (RFC-2104) – basic idea is to concatenate key and message then hash them together.
$$\text{HMAC} = \text{Hash}(\text{key} // \text{Hash}(\text{key} // \text{message})).$$
- Unlike SSL it can be transmitted via any protocol with headers, is machine/router independent, and stateless.





Cryptology Algorithm Summary...

- **RSA** – Asymmetric algorithm; Public/Private Key. Basis for SSL, SSH, PGP, TLS.
- **DIFFIE-HELLMAN** – Public secure key exchange between 2 parties who have never met.
- **HMAC** – Hashed Message Authentication Code; Very fast symmetric key algorithm (*10 to 100000x*).
- **AES** - Advanced Encryption Standard, fast symmetric key algorithm supersedes DES is based on substitution permutation network.
- **SHA-2** - Secure Hash algorithm, replaced SHA-1(vulnerable) and considered a better choice than *MD5*. One way computation of hash from message.

HMAC: Making it better...

- While HMAC is a fast algorithm, the ability to send additional data with the HMAC allows for more benefits (Timestamps, Keys, UserID's, etc).
 - When decoding data, quickly discard inauthentic messages
 - Limits denial of service attacks
 - It reduces your "attack surface" (*areas where attack can occur.*)
- Encrypt-then-MAC is provably secure (similar to IPSEC).
- Only possible attack against HMACs is brute force to get the secret key....
- HMAC-MD5 does not suffer from weaknesses that have been found in MD5.



Key Problems *(pun intended)...*

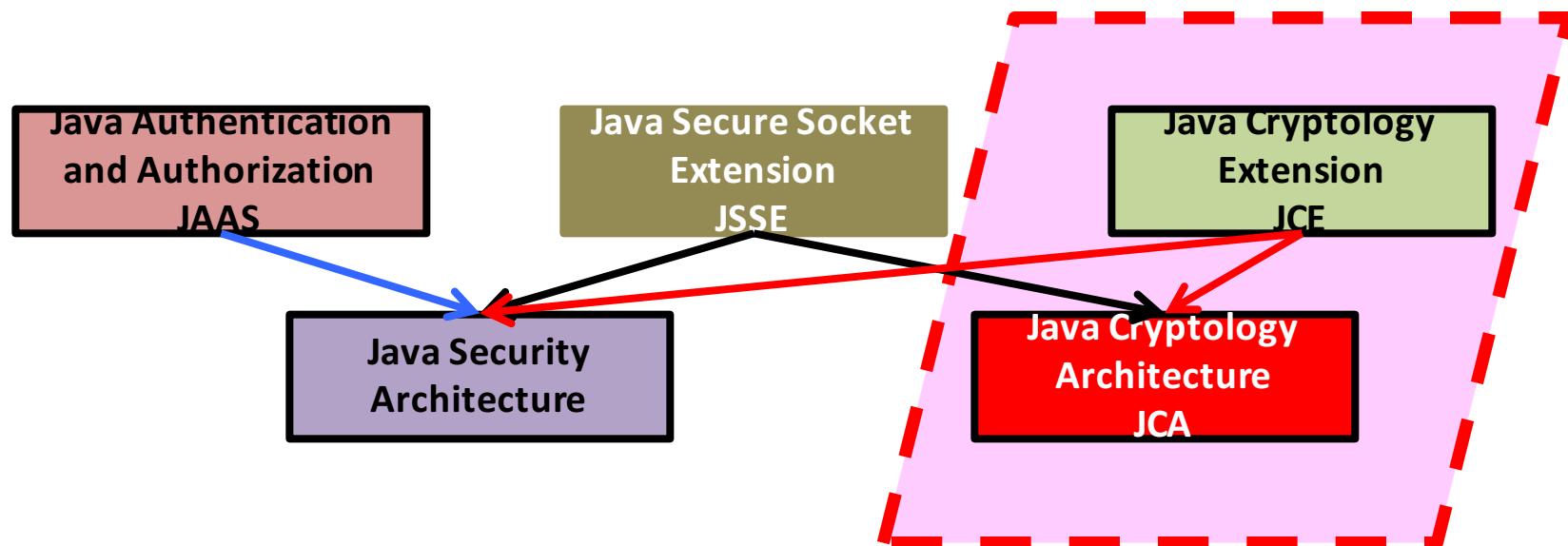
- Distribution & Exchange?
 - Variety of solutions for distribution
LDAP (MD5), Diffie-Hellman, SSL (PGP, AWS, Azure), etc.
- Management & Authentication?
 - Design and Implementation Decision
LDAP; OWASP2; SAML; Certificate Authority, etc.
- Usage?
 - Based on design, its an implementation issue.
 - Factors: Length; Distribution; Replacement; Time Constraints, etc.

Code

Quick Trip Down “Java Crypto Lane” & Some Code Examples

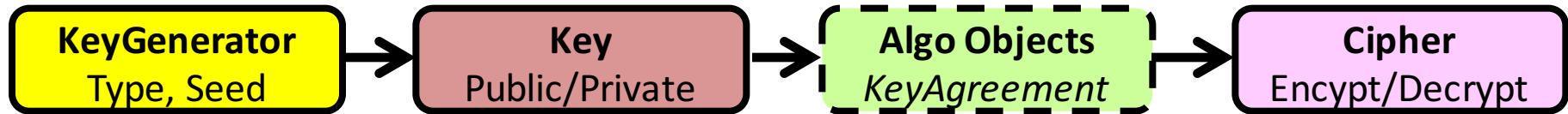


Java Security Architecture Overview





Java: Important Objects.



- **KeyGenerator** (`KeyPairGenerator`) – Generates Algo's Keys
 - `.getInstance()` → `.initialize(Algo, Rnd)` → `.generate...()`
- **Key** (`KeyPair`) – Top level interface for all keys
 - `.getPrivate()/getPrivate()` – Gets Key based on Algorithm
- **Cipher** – provides encryption and decryption
 - `.getInstance(algorithm)` – Gets an instance of algorithm's cipher
 - `.init(mode, key)` – initialize cipher with mode and key info
 - `.doFinal(data)` – encrypt or decrypt data

DH Code: Shared Key Calculation



```
BigInteger base = BigInteger.valueOf(2);  
BigInteger modulus = new BigInteger(s, 16);  
javax.crypto.spec.DHPublicKeySpec sharedModulusAndBase = new DHPublicKeySpec(modulus, base);
```

Mutual
Key Generator

```
KeyPairGenerator aliceKeyPairGenerator = KeyPairGenerator.getInstance("DH");  
aliceKeyPairGenerator.initialize(sharedModulusAndBase);  
KeyPair aliceKeyPair = aliceKeyPairGenerator.generateKeyPair();  
KeyAgreement aliceKeyAgreement = KeyAgreement.getInstance("DH");  
DHPrivateKey alicePrivateKey = (DHPrivateKey) aliceKeyPair.getPrivate();  
DHPublicKey alicePublicKey = (DHPublicKey) aliceKeyPair.getPublic();  
aliceKeyAgreement.init(alicePrivateKey);  
System.out.println("Alices Public Key: " + alicePublicKey.getY());
```

Random Key
Key Pairs
DH Type
Result of Prime/Modulus using Alices Private Key

```
aliceKeyAgreement.doPhase(bobPublicKey, true);  
SecretKey alicesDHSharedKey = aliceKeyAgreement.generateSecret("DES");
```

Using Bob's Init result of Secret/Prime/Modulus yields shared key.

RSA Code: Public Private Key

```
KeyPairGenerator keyPairGenerator = KeyPairGenerator.getInstance("RSA");
keyPairGenerator.initialize(2048, new SecureRandom());
KeyPair keyPair = keyPairGenerator.genKeyPair();
Cipher cipher = Cipher.getInstance("RSA/ECB/PKCS1Padding");
```

RSA Keypair
Key Length
Random Seed

```
cipher.init(Cipher.ENCRYPT_MODE, keyPair.getPublic());
byte[] blowfishKeyBytes = blowfishKey.getEncoded();
byte[] encryptedBlowfishKey = cipher.doFinal(blowfishKeyBytes);
```

Cipher Setup
Data

```
cipher.init(Cipher.DECRYPT_MODE, keyPair.getPrivate());
byte[] decryptedKeyBytes = cipher.doFinal(encryptedBlowfishKey);
```

Cipher Setup
Data

HMAC Code: Creating a Hash

- The sender generates a HMAC code that is sent with the message, the receiver calculates the HMAC for the message to authenticate it against senders HMAC.

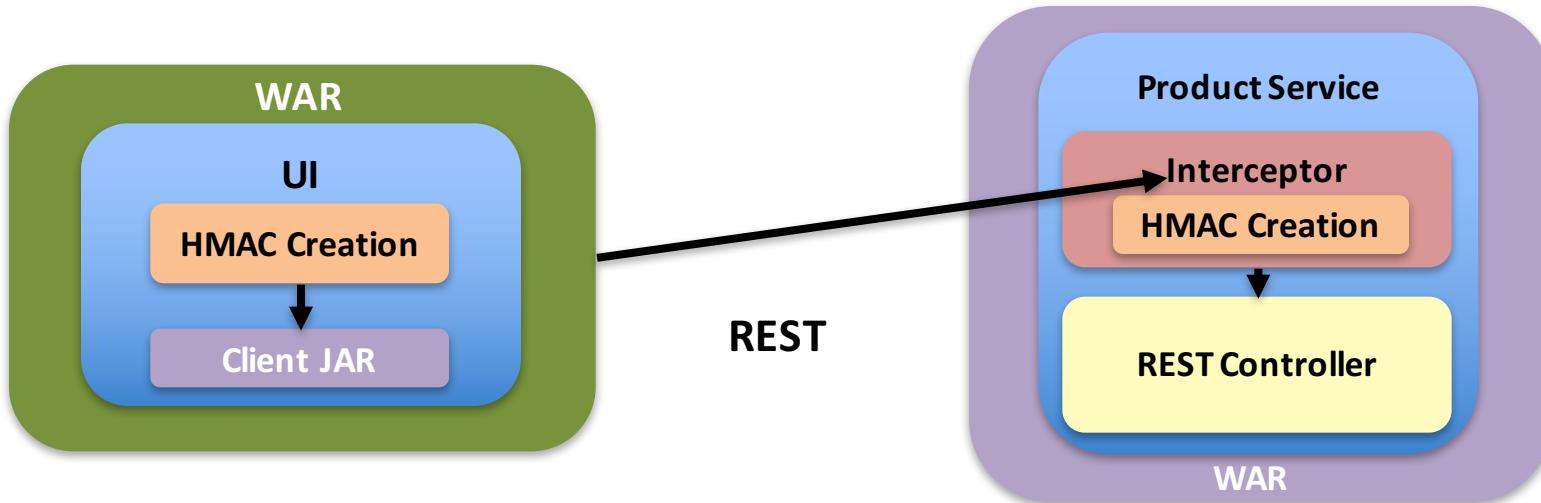
```
String secret = "secretKey";
String message = "Message of Space the final frontier...";  

Mac sha256_HMAC = Mac.getInstance("HmacSHA256");  

SecretKeySpec secret_key = new SecretKeySpec(secret.getBytes(), "HmacSHA256");
sha256_HMAC.init(secret_key);
String hash = Base64.encodeBase64String(sha256_HMAC.doFinal(message.getBytes()));
```

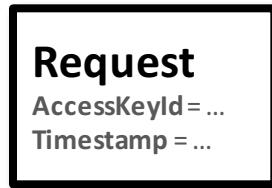
Create HMAC Object
Create a Key
Initialize HMAC with that key
Create HMAC Code

Sample HMAC Implementation



Client

- 1 Create a request:



- 2 Create HMAC-SHA signature:

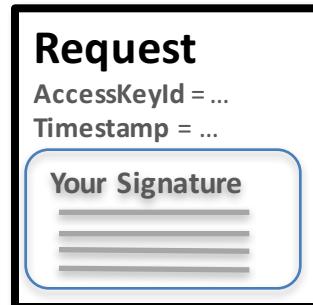
String based on request contents

+
Secret Access Key
wJalrXUtnFEMI/K7MDENG/
bPxRfiCYzEXAMPLEKEY

HMAC
CALC

Your Signature
[REDACTED]

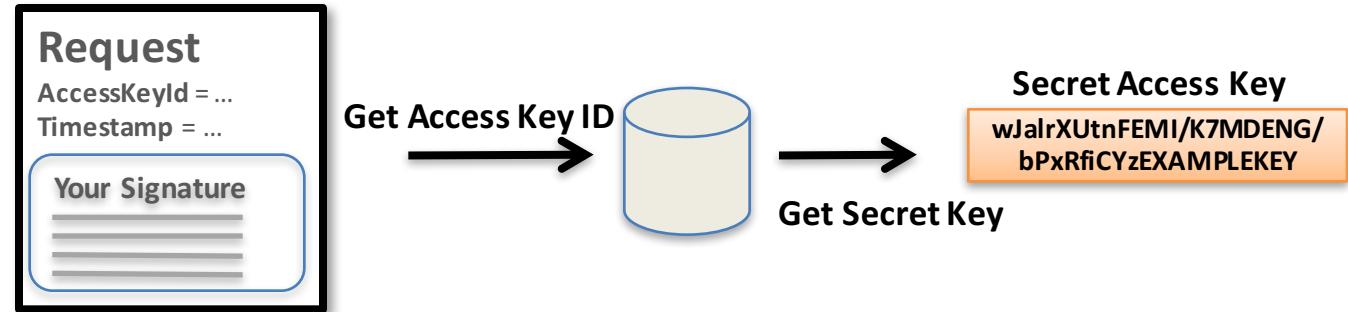
- 3 Send request and signature to Service:



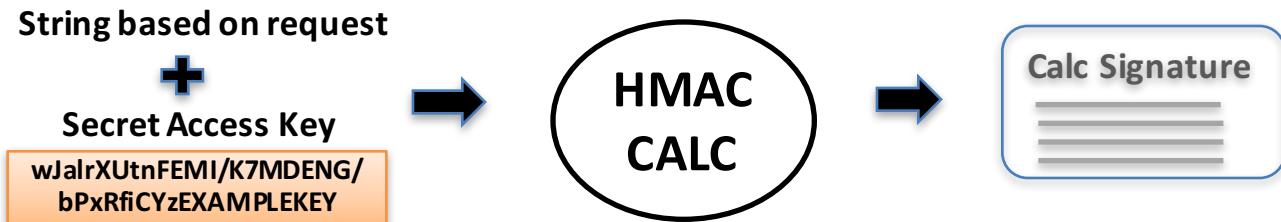
Service

Service

4 Retrieve Secret Access Key:



5 Create HMAC-SHA signature:



6 Compare the two signatures:



Client



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