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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
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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/

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Microservices

Microservices evolution to a family's evolution…

Payment Processing

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

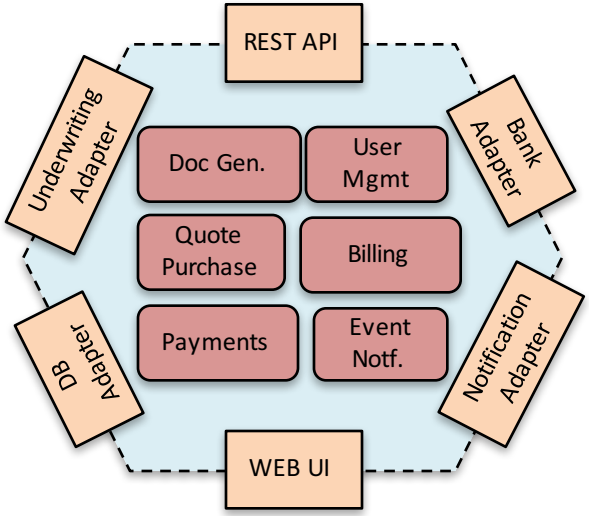
List<Payment>
processPayments (List<Integer>)

List<StudentPayment>
processStudentLoan
(List<Integer>)

Micro-services concepts and value proposition

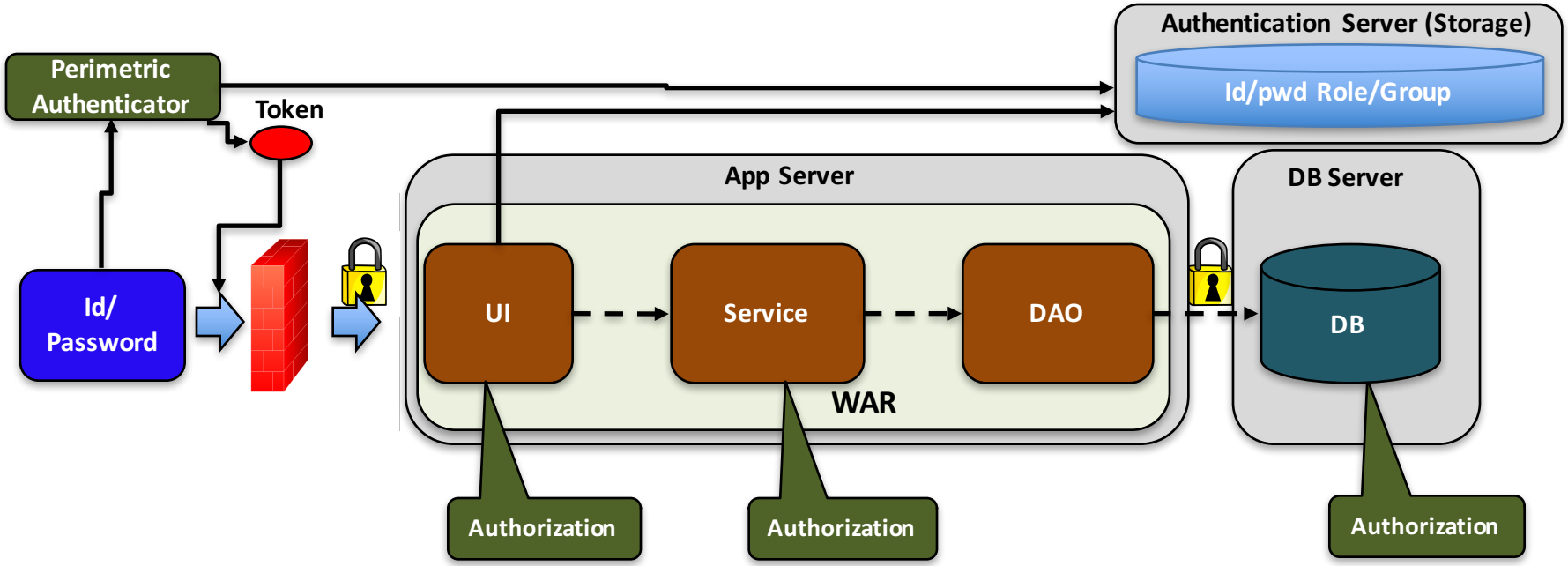
- Service with single business capability
- Scalable
- Separate process and self-contained
- Share nothing model
- Independently deployed
- Atomic and idempotent
- Performant
- Usually REST based
- Smart endpoint using dumb messaging

Monolithic architecture – High Level

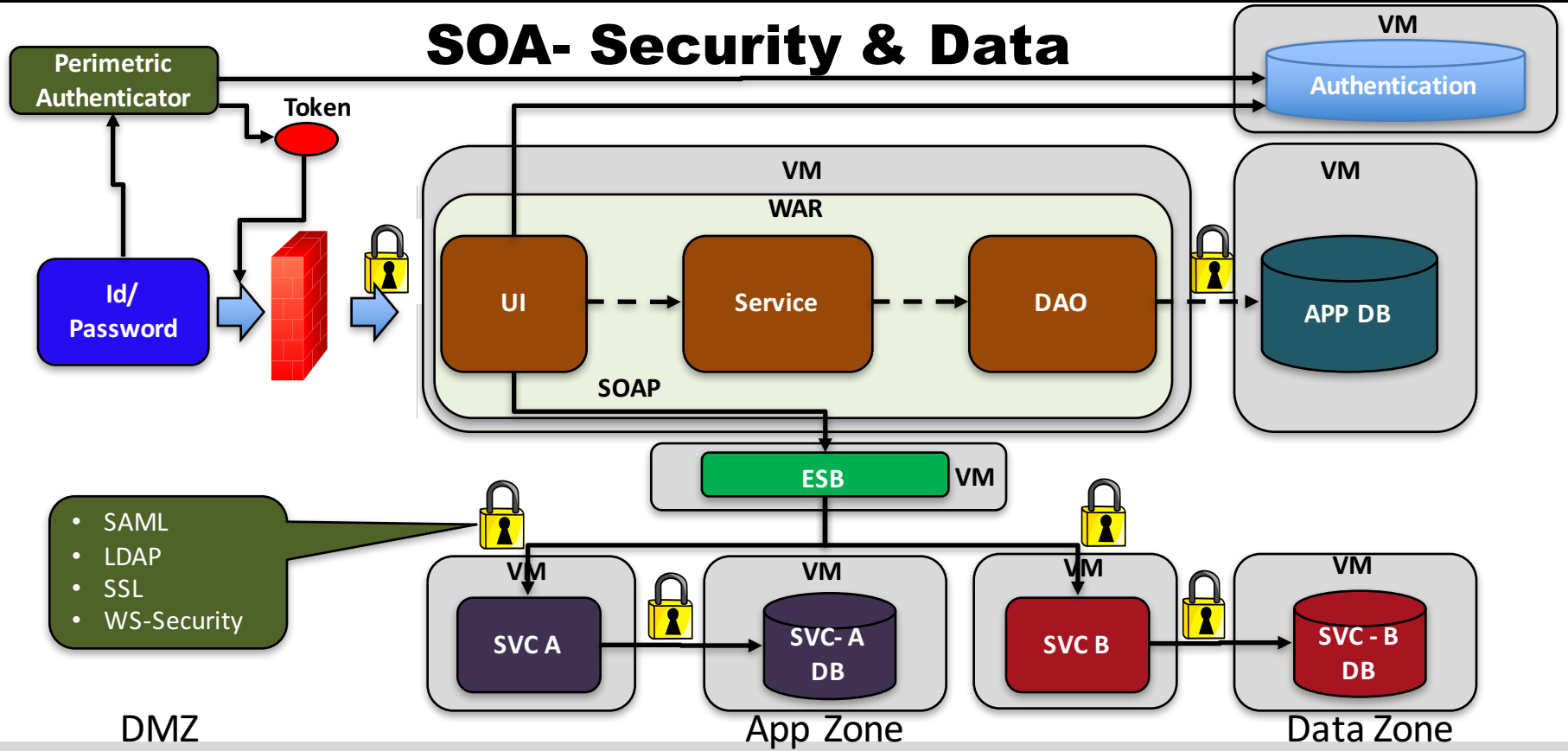


- Encompasses all functionality
- Modular architecture
- Supports multiple interfaces
- All dependencies are well defined and contained
- Security
- Data Architecture

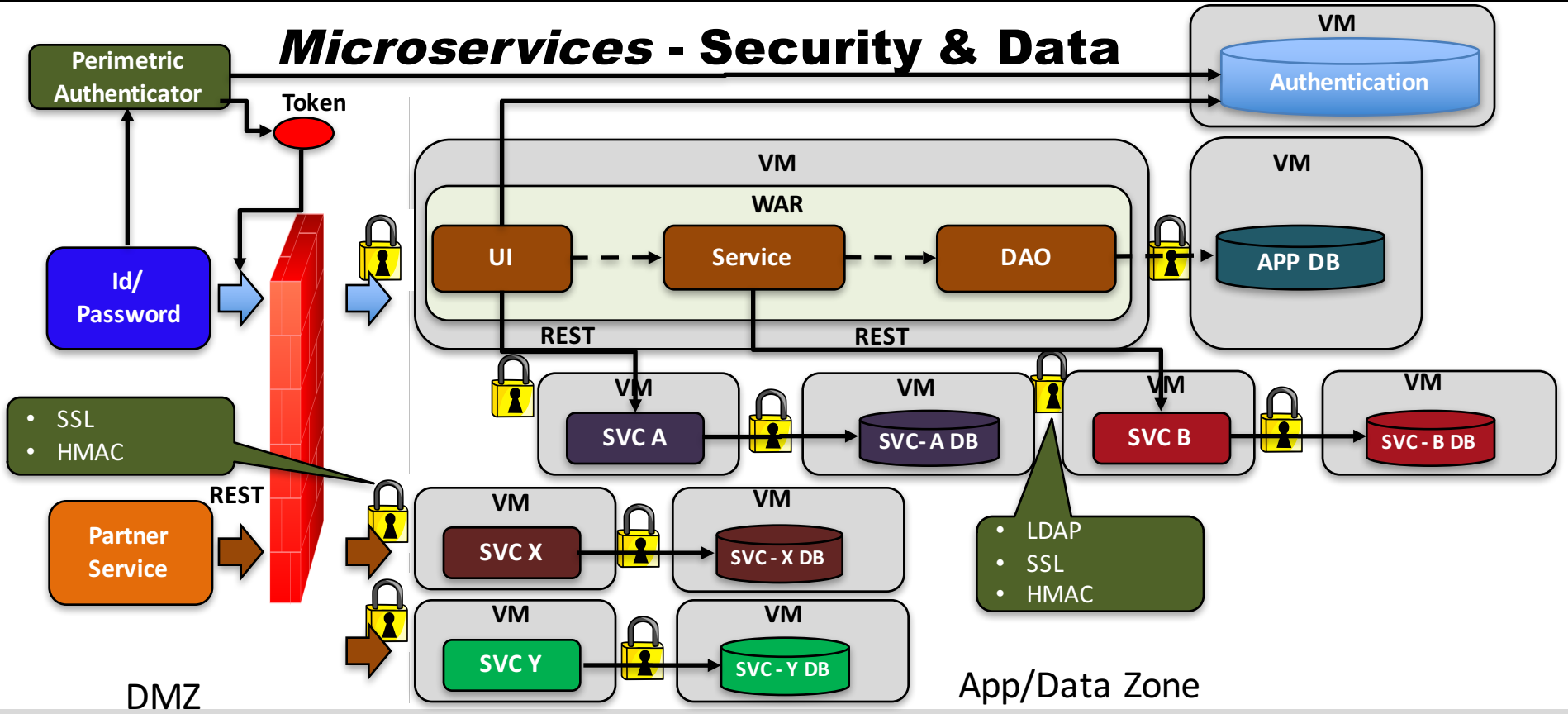
Monolithic Architecture - Security & Data



SOA- Security & Data



Microservices - Security & Data



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Cryptology Concepts

Basic Cryptology Concepts, Techniques, and Algorithms

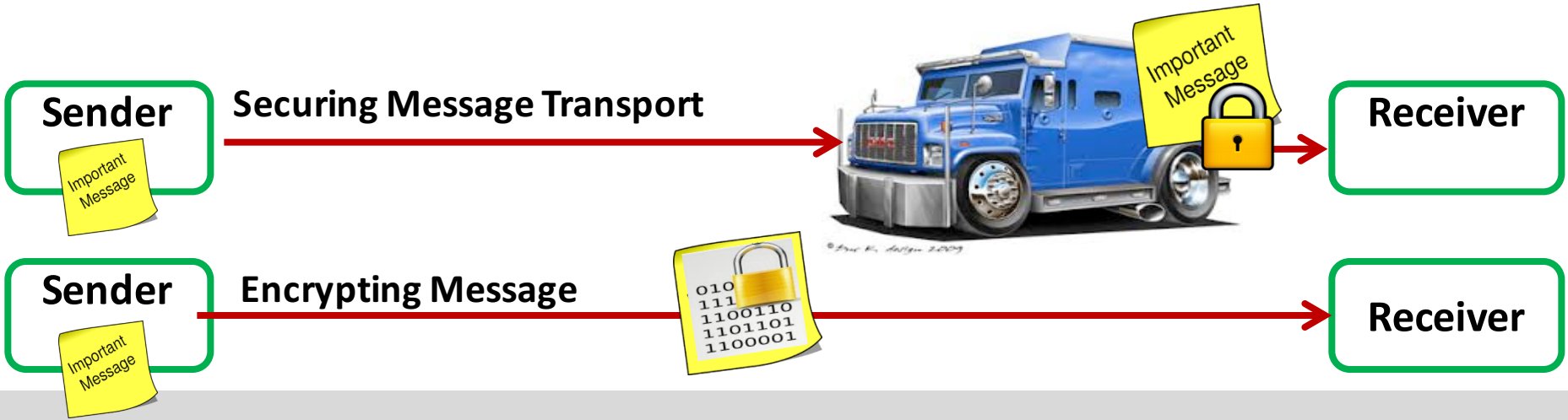
Locks n' Keys

- 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.

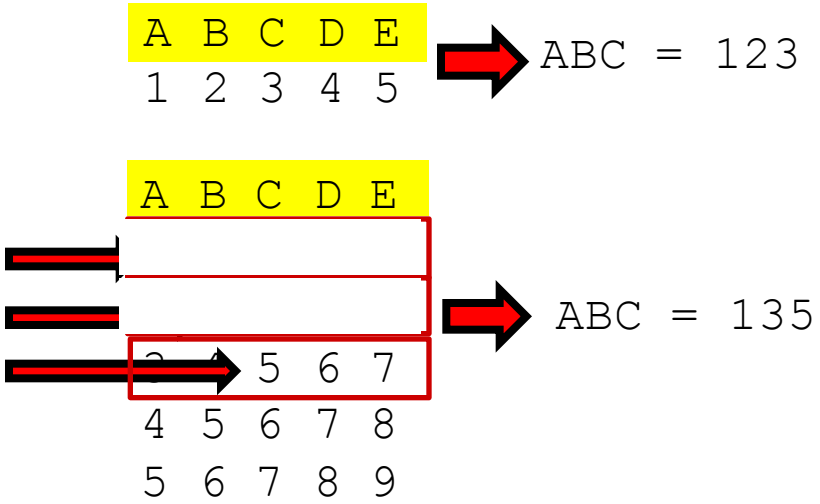
- Quick - What is the strongest lock?
  - Computer locks rely on crazy difficult math problems.
  - Todays strong lock is tomorrows brute force victim
  - Longer keys = more processing time to encode/decode

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.

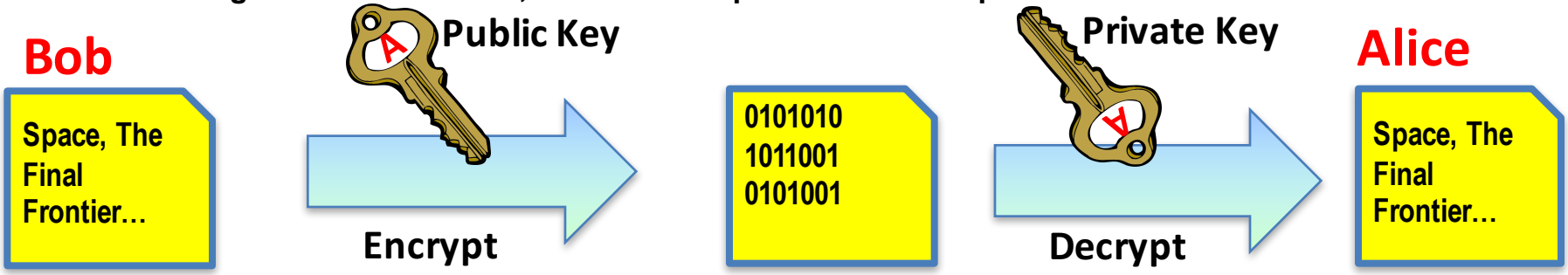


Basic Cryptology Concepts



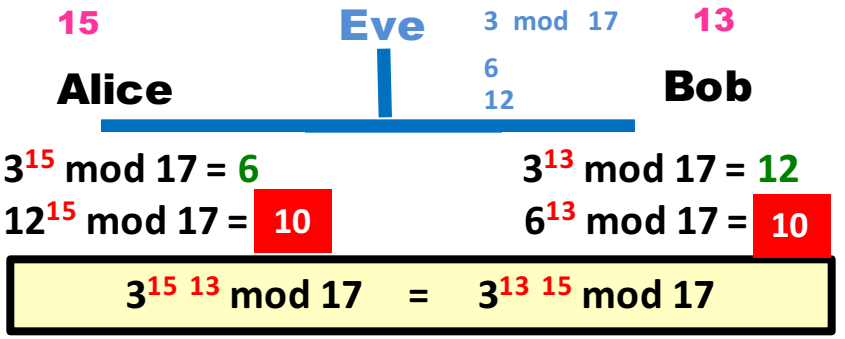
Solution: How two people securely exchange a message ?

- 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



Solution:

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



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

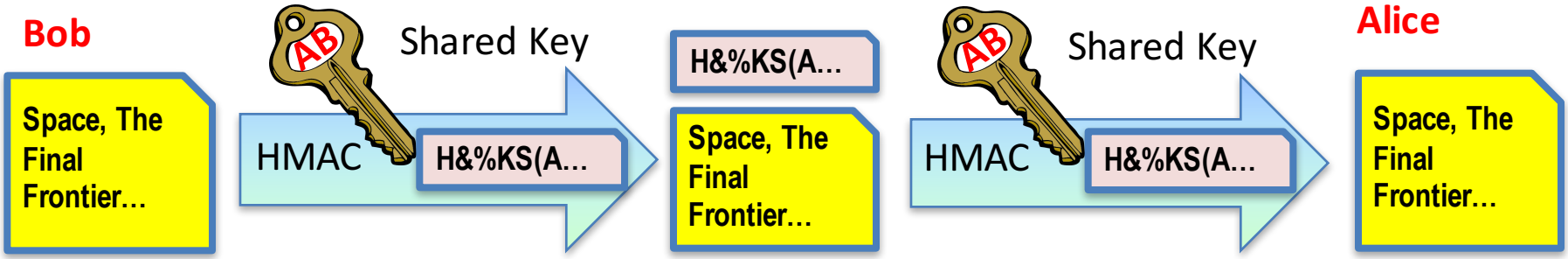
  <primitive-root>$^{X * Y}$ mod <base-number> ≡ <result>

- 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.

  HMAC = Hash(key // Hash(*key* // *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

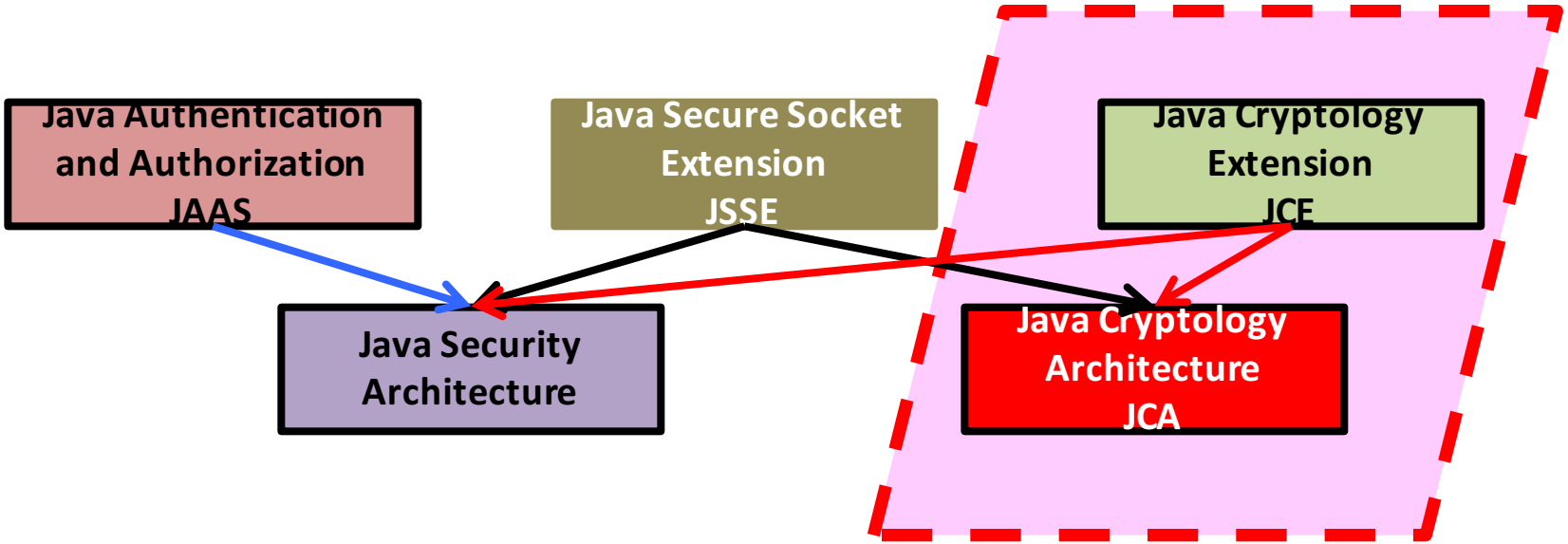
    LDAP; OWASP2; SAML; Certificate Authority, etc.
- Usage?
  - Based on design, its an implementation issue.
  - Factors: Length; Distribution; Replacement; Time Constraints, etc.

Code

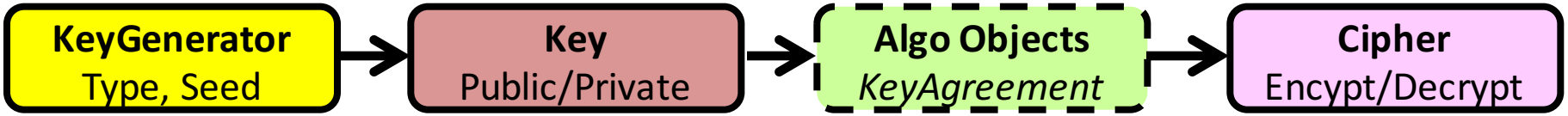
Quick Trip Down *"Java Crypto Lane"* & Some Code Examples

Java Security

- 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

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DH Code: Shared Key Calculation

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

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());

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

Mutual

Key Generator

Random Key

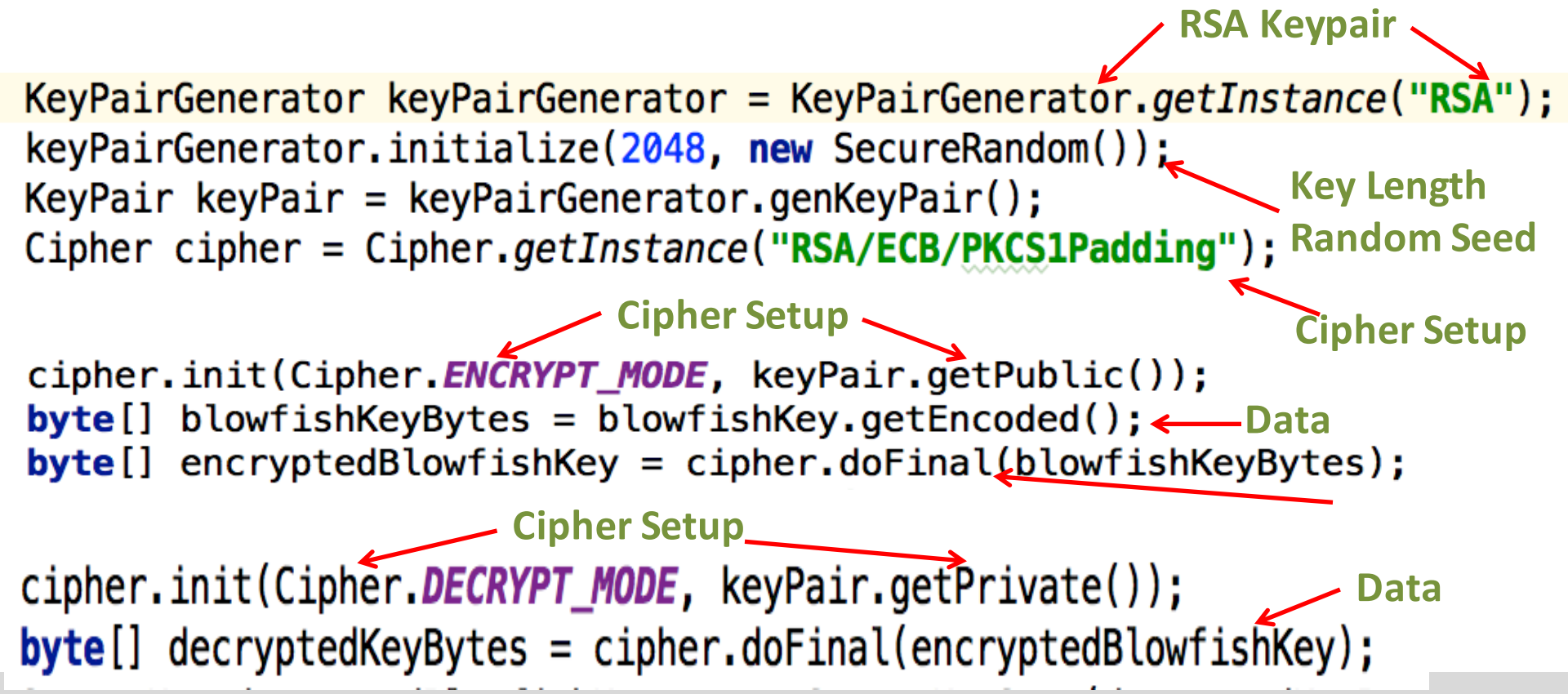
Key Pairs

DH Type

Result of Prime/Modulus using *Alices* Private Key

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

RSA Code: Public Private Key



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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()));
```

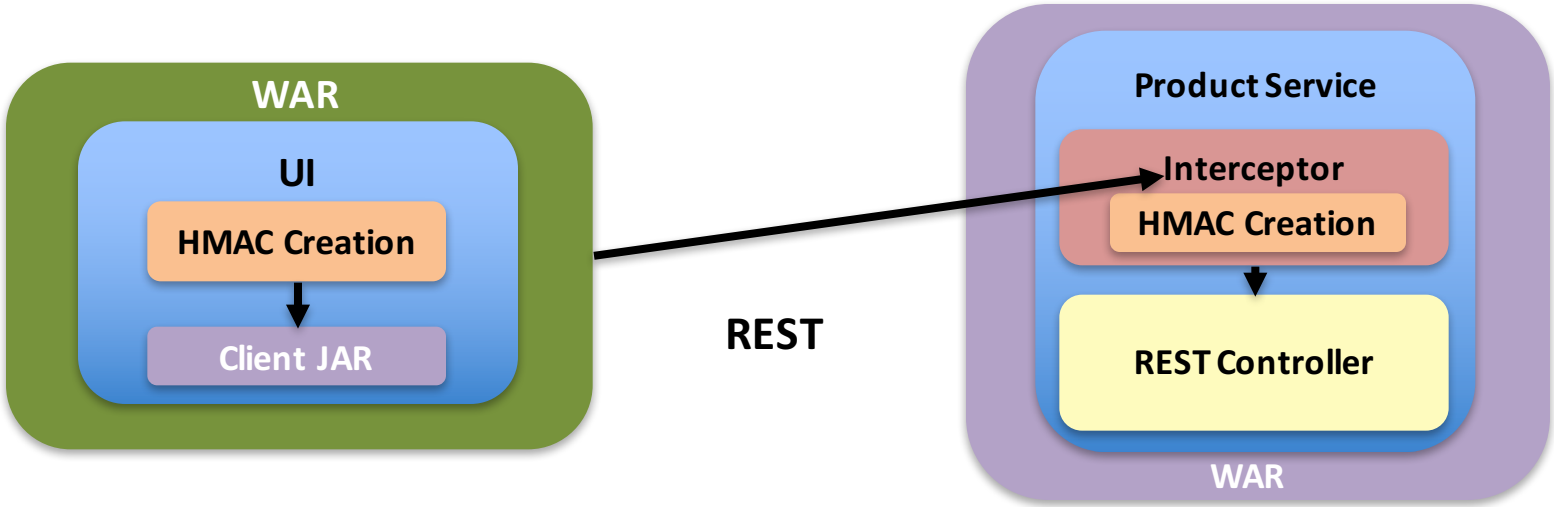
Create HMAC Object

Create a Key

Initialize HMAC with that key

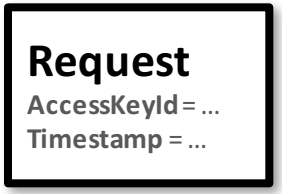
Create HMAC Code

Sample HMAC Implementation



Client

1 Create a request:



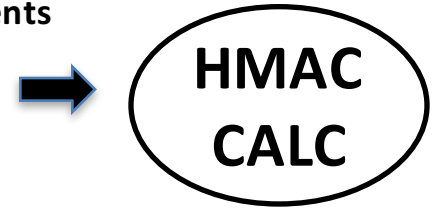
2 Create HMAC-SHA signature:

String based on request contents

+

Secret Access Key

wJalrXUtnFEMI/K7MDENG/
bPxRfiCYzEXAMPLEKEY

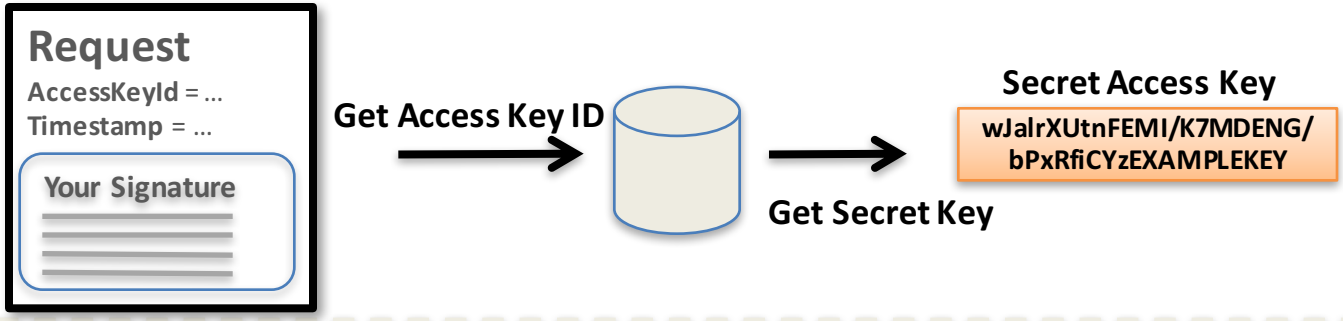


3 Send request and signature to Service:

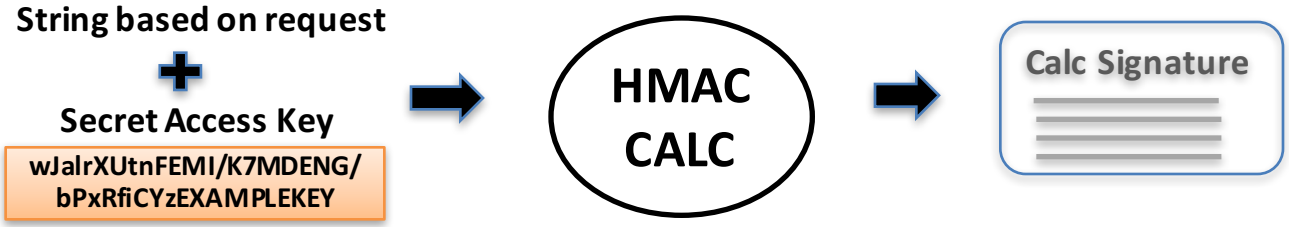
Service

Service

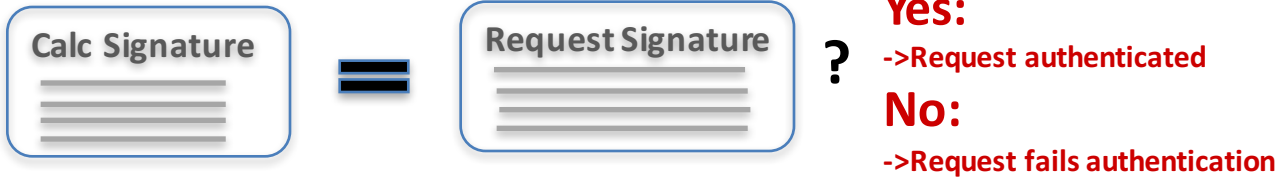
4 **Retrieve Secret Access Key:**



5 **Create HMAC-SHA signature:**



6 **Compare the two signatures:**



Client

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