

HOW TO BACKDOOR DIFFIE-HELLMAN

David Wong



NCC Group

TLS

- *pre-2007: Absence of TLS*

TLS

- * *pre-2007: **Absence** of TLS*
- * *2007: TLS only for login forms (Graham sniffs gmail
cookies live at Blackhat)*

HAMISTER 1.0 Side-Jacking

The following is a list of instructions you can use reading the root. Click on one of them as often as you want then go to services. After that point, you can either select from the list of URLs that will appear on the left, or type the right in between a address bar.

- 192.168.2.111
- 192.168.2.12
- 192.168.2.122
- 192.168.2.13
- 192.168.2.147
- 192.168.2.15
- 192.168.2.169
- 192.168.2.17
- 192.168.2.184
- 192.168.2.19

TLS

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- * *2010: **HSTS** introduced in Firefox / Firesheep*

Mozilla Firefox

(Untitled) +

Google   

X Firesheep ||| Stop Capturing

eric+google@codebutler.com

Google

Ian Gallagher

Facebook

neg9

Twitter

cdine

Flickr

facebook 1

Ian Gallagher  Edit My Profile

News Feed

Messages

Events 1

Friends

Create Group...

Search

News Feed

What's on your mind?

Ashley Winter  realized i really for some fake r indeed.

ABP FoxyProxy: Disabled

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- * 2009: Moxie releases **SSLstrip** at Blackhat
- * 2010: **HSTS** introduced in Firefox / Firesheep
- * 2013: Facebook is **full-https** / **Snowden** leaks
- * 2010/2014: **preloaded-HSTS** introduced in Chrome

Mozilla Security Blog

APR
30
2015

Deprecating Non-Secure HTTP



Richard Barnes

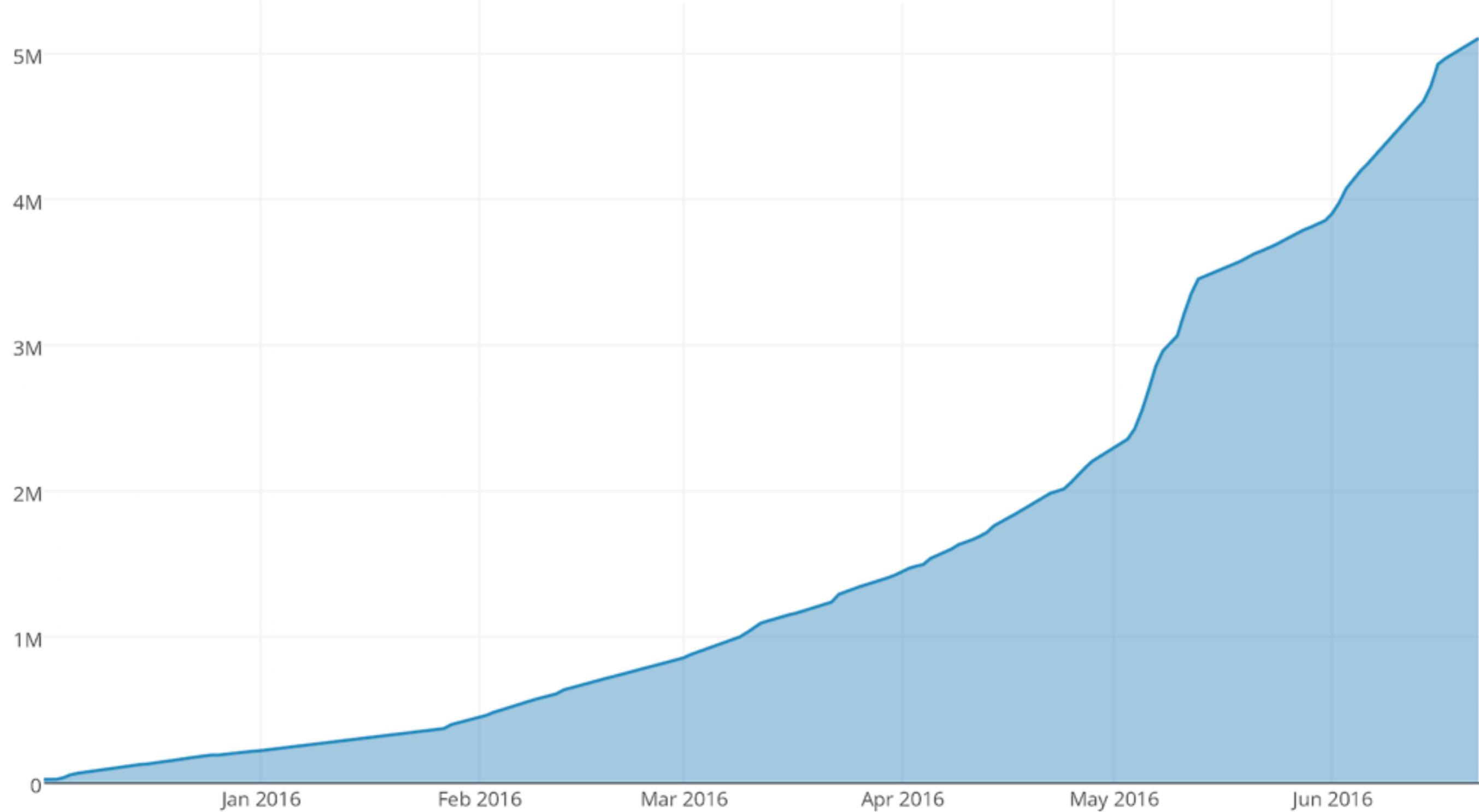
288 responses

Today we are announcing our intent to phase out non-secure HTTP.

There's pretty broad agreement that HTTPS is the way forward for the web. In recent months, there have been statements from [IETF](#), [IAB](#) (even the [other IAB](#)), [W3C](#), and the [US Government](#) calling for universal use of encryption by Internet applications, which in the case of the web means HTTPS.

After a [robust discussion](#) on our community mailing list, Mozilla is committing to focus new development efforts on the secure web, and start removing capabilities from the non-secure

Certificates Issued by Let's Encrypt



Let's Encrypt has issued more than 5 million certificates in total since we launched to the general public on December 3, 2015. Approximately 3.8 million of those are active, meaning unexpired and unrevoked. Our active certificates cover more than 7 million unique domains.

Logjam

Imperfect Forward Secrecy: How Diffie-Hellman Fails in Practice

David Adrian^{*} Karthikeyan Bhargavan^{*} Zakir Durumeric^{*} Pierrick Gaudry[†] Matthew Green[§]
J. Alex Halderman[†] Nadia Heninger[‡] Drew Springall[†] Emmanuel Thomé[†] Luke Valenta[‡]
Benjamin VanderSloot[†] Eric Wustrow[†] Santiago Zanella-Béguelin^{||} Paul Zimmermann[†]

^{*} INRIA Paris-Rocquencourt [†] INRIA Nancy-Grand Est, CNRS, and Université de Lorraine
^{||} Microsoft Research [‡] University of Pennsylvania [§] Johns Hopkins [¶] University of Michigan

For additional materials and contact information, visit WeakDH.org.

ABSTRACT

We investigate the security of Diffie-Hellman key exchange as used in popular Internet protocols and find it to be less secure than widely believed. First, we present Logjam, a novel flaw in TLS that lets a man-in-the-middle downgrade connections to “export-grade” Diffie-Hellman. To carry out this attack, we implement the number field sieve discrete log algorithm. After a week-long precomputation for a specified 512-bit group, we can compute arbitrary discrete logs in that group in about a minute. We find that 82% of vulnerable servers use a single 512-bit group, allowing us to compromise connections

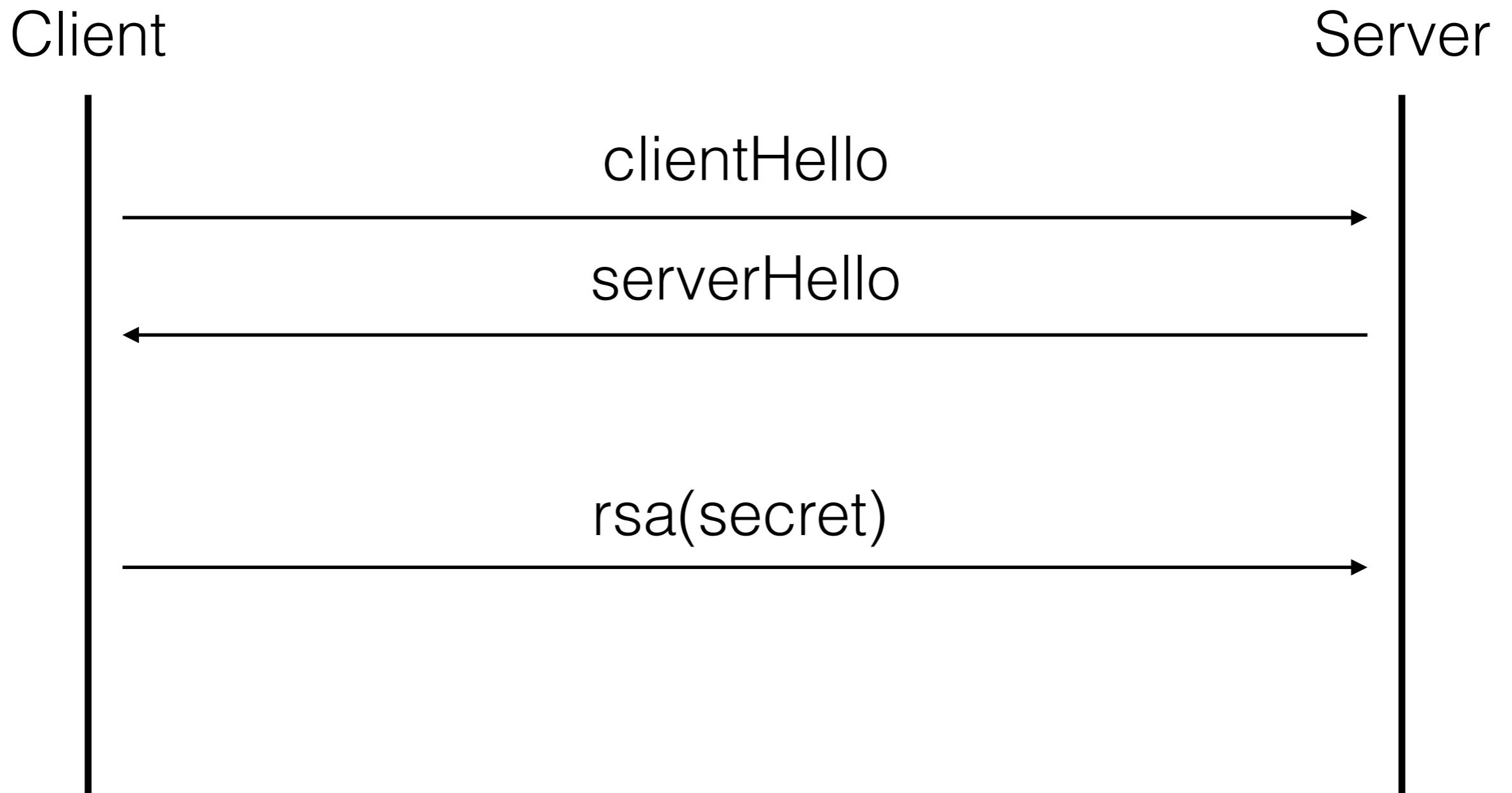
coded, or widely shared Diffie-Hellman parameters has the effect of dramatically reducing the cost of large-scale attacks, bringing some within range of feasibility today.

The current best technique for attacking Diffie-Hellman relies on compromising one of the private exponents (a, b) by computing the discrete log of the corresponding public value ($g^a \bmod p, g^b \bmod p$). With state-of-the-art number field sieve algorithms, computing a single discrete log is more difficult than factoring an RSA modulus of the same size. However, an adversary who performs a large precomputation for a prime p can then quickly calculate arbitrary discrete logs in that group, amortizing the cost over all targets that share

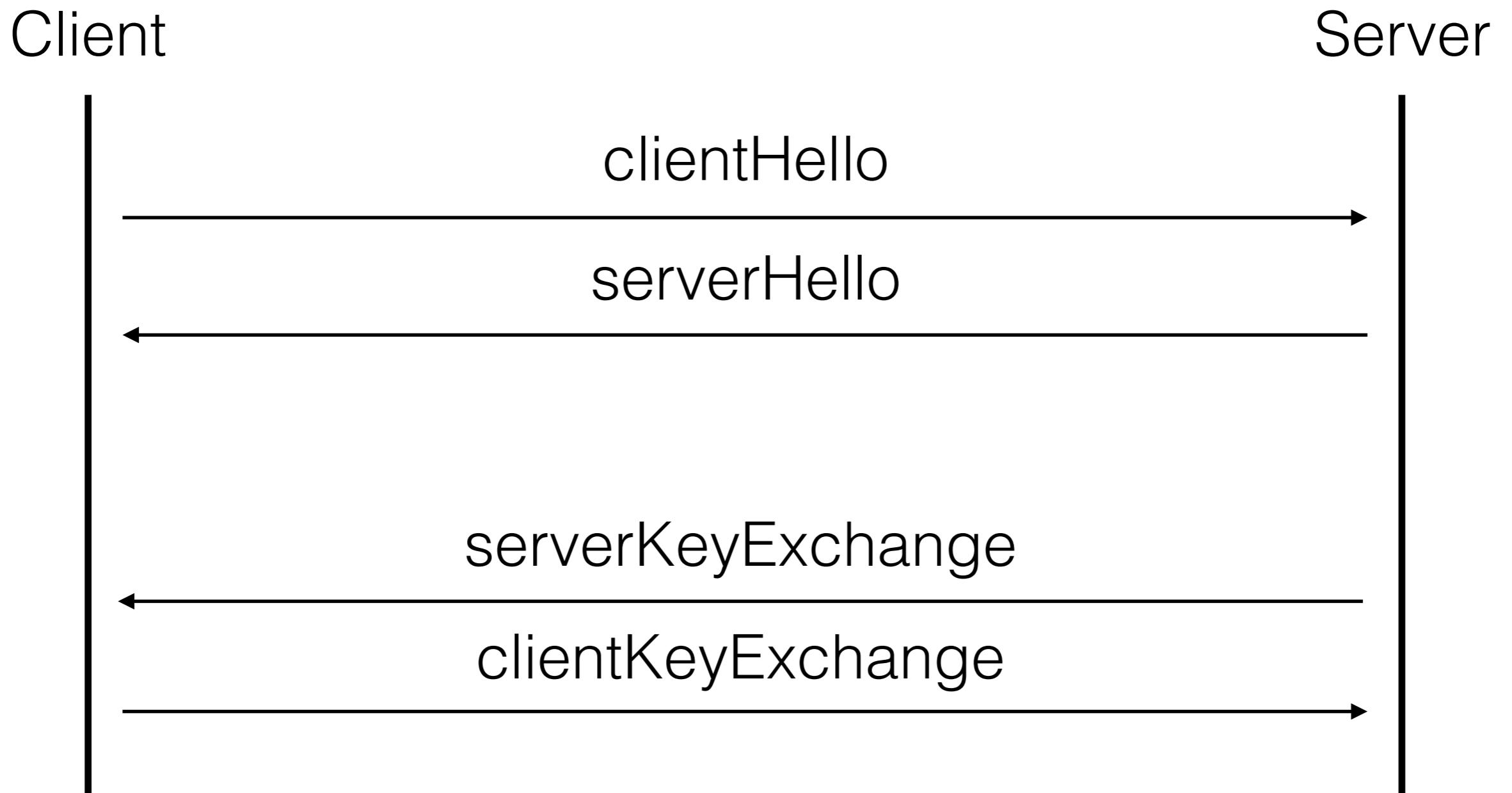
Logjam

- **hardcoded** DHE parameters in Apache

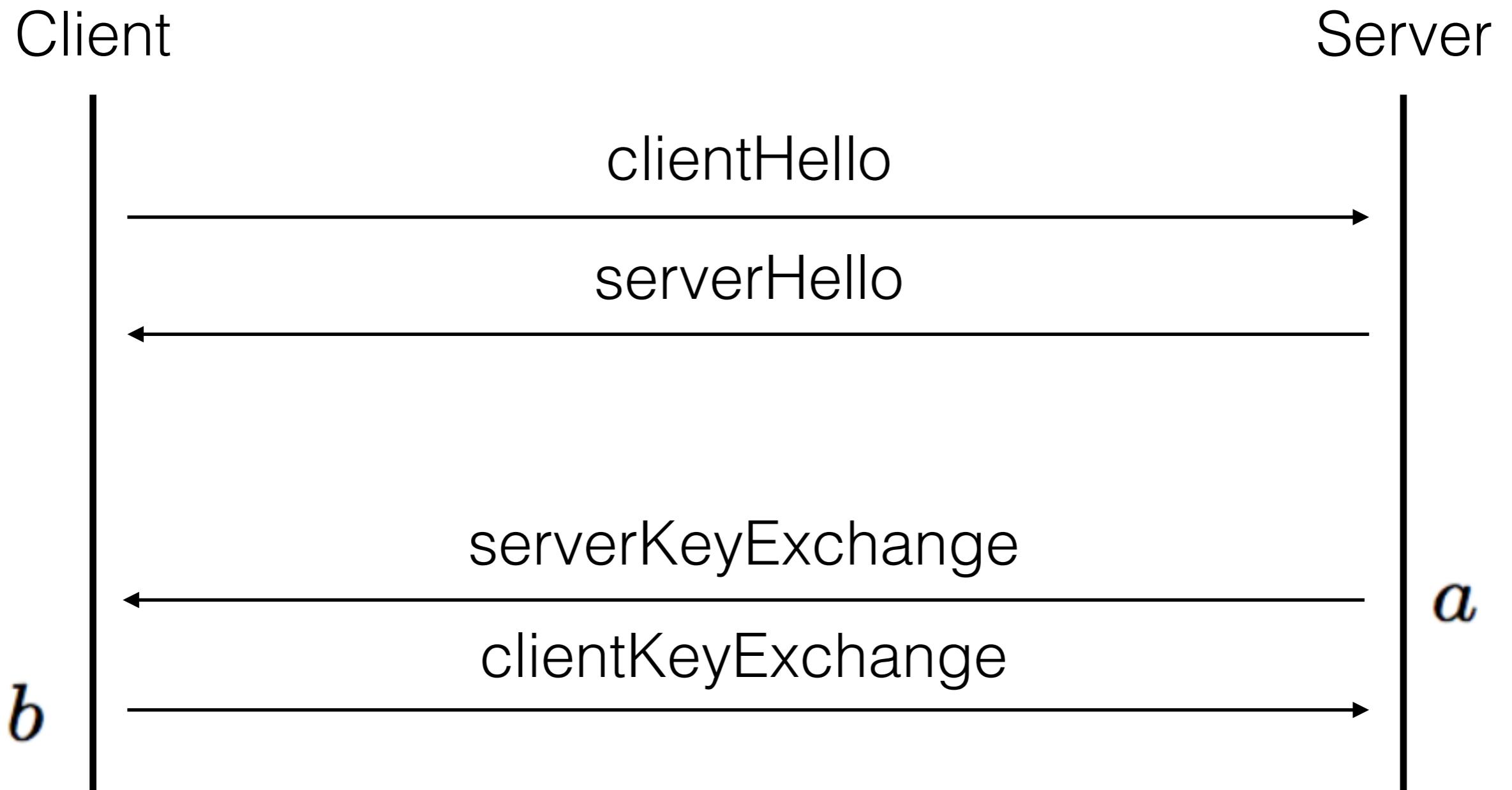
Logjam



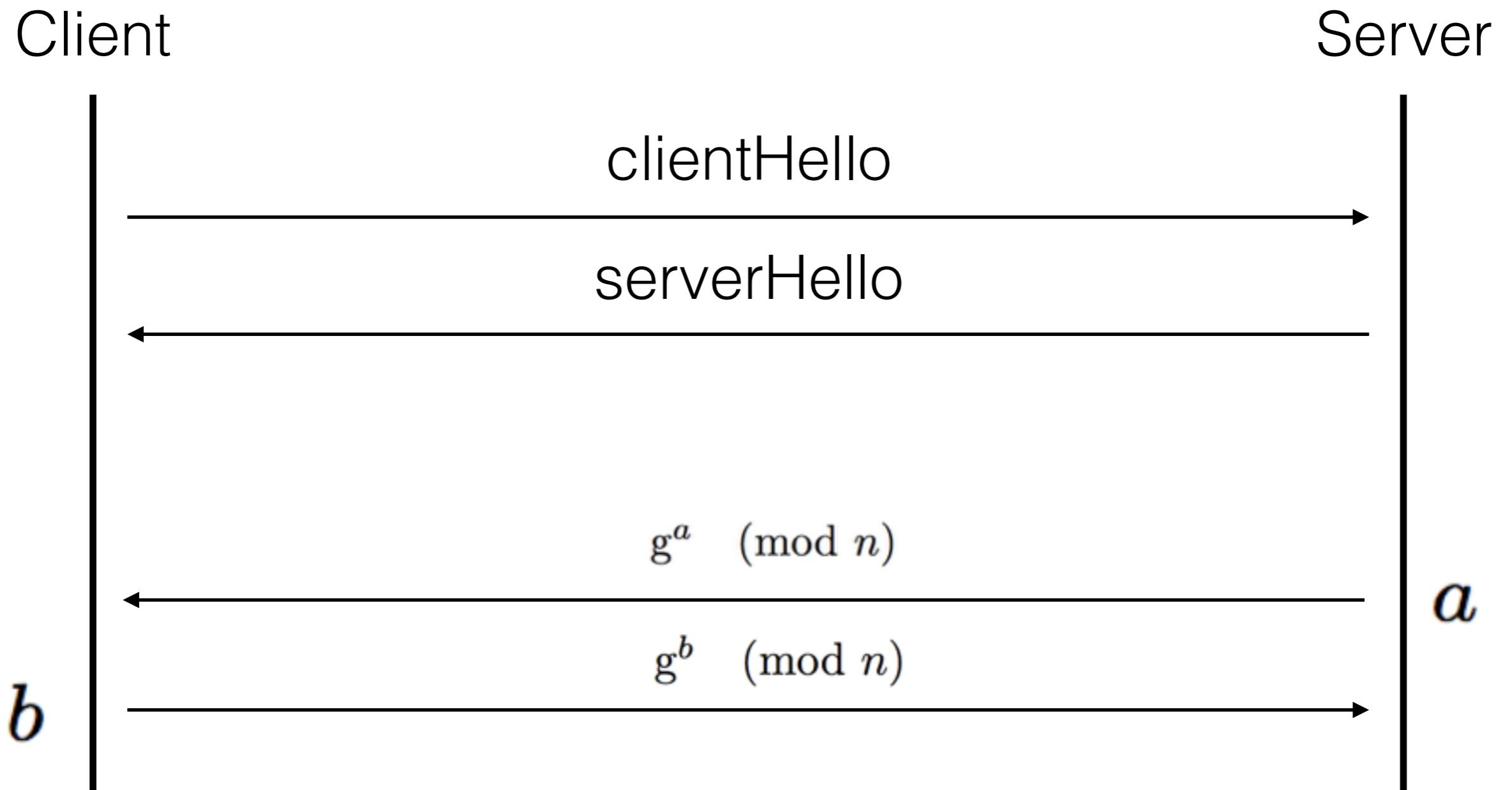
Logjam



Logjam



Logjam



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$$g^a \pmod{n}$$

Logjam

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- NSA believed to be able to compute discrete logarithm in modulo **1024-bit integers**

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- NSA believed to be able to compute discrete logarithm in modulo **1024-bit integers**
- **too much work**

U.S. export rules

- **weak** “Export” Cipher Suites

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- **512-bit primes** for Diffie-Hellman

U.S. export rules

- **weak** “Export” Cipher Suites
- **512-bit primes** for Diffie-Hellman
- **40-bit keys** for DES

Mail - Inbox - IBM Lotus Notes



File Edit View Create Actions Tools Window Help

Open



Home

Christine Costner - Mail



Search All Mail

Christine Costner

domino

Inbox (7)

Drafts

Sent

Follow Up

All Documents

Junk

Trash

Chat History

Views

Folders

Archive

Tools

Follow Up

Remove Flag

When Who



New Unified Messaging Actions... Call Manager Reply Reply to All Show

Search for New Fax New Text Message XPhone UM Settings

Indexed ? More

Sender	Subject	Date	Size
Kevin Kramer	Purchase Order 115116114	06/02/2010 09:14	31K
UMServer	Voicemail from Pete Wursch +491762226700	06/02/2010 06:01	51K
UMServer	Fax from Christine Costner +4989840798131	05/02/2010 17:23	33K
UMServer	Fax to +4989840194 Sent successfully	05/02/2010 16:32	117K
UMServer	Voicemail from Kevin Kramer +4989840798	05/02/2010 15:37	130K
UMServer	Fax from Peter Walker +49898407981	05/02/2010 15:23	133K
UMServer	Fax from Pete Wursch +498984079	05/02/2010 14:14	333K
Kevin Kramer	Re: Marketing Meeting Feb	05/02/2010 12:14	3K
UMServer	SMS to +790393997	05/02/2010 10:52	2K



Online

LOTUS NOTES

- 64-bit crypto allowed...

LOTUS NOTES

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- ...if **24 bits of the key are encrypted to the NSA**

LOTUS NOTES

- 64-bit crypto allowed...
- ...if **24 bits of the key are encrypted to the NSA**
- NSA's RSA public key O=MiniTruth CN=Big Brother

Kleptography

- A kleptographic attack is an attack which uses **asymmetric cryptography** to implement a cryptographic **backdoor**.

Kleptography

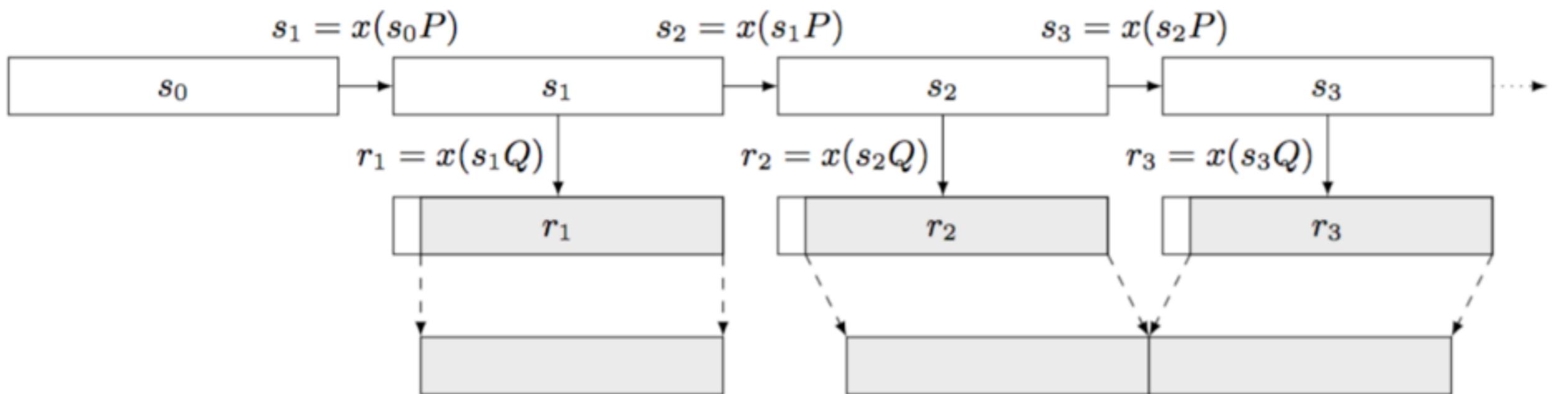
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- A secure kleptographic attack is undetectable **as long as the cryptosystem is a black-box**.

Kleptography

- A kleptographic attack is an attack which uses **asymmetric cryptography** to implement a cryptographic **backdoor**.
- A secure kleptographic attack is undetectable **as long as the cryptosystem is a black-box**.
- what about **white-box? Reverse Engineering?**

- Weak crypto
- Kleptography

Dual EC



NIST Special Publication 800-90A

**Recommendation for Random Number
Generation Using Deterministic
Random Bit Generators**

Elaine Barker and John Kelsey

**Computer Security Division
Information Technology Laboratory**

C O M P U T E R S E C U R I T Y

On the Possibility of a Back Door in the NIST SP800-90 Dual Ec Prng

Dan Shumow
Niels Ferguson
Microsoft

NSA's BULLRUN

TOP SECRET//SI//REL TO USA, FVEY 

CLASSIFICATION GUIDE TITLE/NUMBER: (U//FOUO) PROJECT
BULLRUN/2-16

PUBLICATION DATE: 16 June 2010

OFFICE OF ORIGIN: (U) Cryptanalysis and Exploitation Services

POC: (U) Cryptanalysis and Exploitation Services (CES) Classification
Advisory Officer

PHONE: [REDACTED]

ORIGINAL CLASSIFICATION AUTHORITY: [REDACTED]

1. (TS//SI//REL) Project BULLRUN deals with NSA's abilities to defeat the encryption used in specific network communication technologies. BULLRUN involves multiple sources, all of which are extremely sensitive. They include CNE, interdiction, industry

A black short-sleeved t-shirt is displayed against a white background. The shirt features a large, solid red rectangular graphic centered on the chest. Inside this red box, the letters "NSA" are printed in a bold, white, sans-serif font. Below the red box, the words "BSAFE TOOLKIT®" are printed in a smaller, white, sans-serif font.

NSA
BSAFE TOOLKIT®

2015-12 Out of Cycle Security Bulletin: ScreenOS: Multiple Security issues with ScreenOS (CVE-2015-7755, CVE-2015-7756)

▼ [JSA10713] Show KB Properties

PRODUCT AFFECTED:

Please see below for details.

PROBLEM:

During an internal code review, two security issues were identified.

Administrative Access (CVE-2015-7755) allows unauthorized remote administrative access to the device. Exploitation of this vulnerability can lead to complete compromise of the affected device.

This issue only affects ScreenOS 6.3.0r17 through 6.3.0r20. **No other Juniper products or versions of ScreenOS are affected by this issue.**

Upon exploitation of this vulnerability, the log file would contain an entry that 'system' had logged on followed by password authentication for a username.

Example:

Normal login by user **username1**:

```
2015-12-17 09:00:00 system warn 00515 Admin user username1 has logged on via SSH from ....  
2015-12-17 09:00:00 system warn 00528 SSH: Password authentication successful for admin  
user 'username1' at host ...
```

Compromised login by user **username2**:

```
2015-12-17 09:00:00 system warn 00515 Admin user system has logged on via SSH from ....  
2015-12-17 09:00:00 system warn 00528 SSH: Password authentication successful for admin  
user 'username2' at host ...
```

Note that a skilled attacker would likely remove these entries from the local log file, thus effectively eliminating any reliable signature that the device had been compromised.

This issue has been assigned [CVE-2015-7755](#)

patched

```
[λ ~/Tests/juniper/ strings ssg5ssg20.6.3.0r19b.0.bin | grep -C5 -i "6b17d1f2e12c4247f8bce6e563a440f277037d812deb33a0f4a13945d898c296\\|]  
aa87ca22be8b05378eb1c71ef320ad746e1d3b628ba79b9859f741e082542a385502f25dbf55296c3a545e3872760ab7\\|c6858e06b70404e9cd9e3ecb662395b4429c  
648139053fb521f828af606b4d3dbaa14b5e77efe75928fe1dc127a2ffa8de3348b3c1856a429bf97e7e31c2e5bd66"  
CLOSING  
TIME_WAIT  
FFFFFFFF00000001000000000000000000000000000000FFFFFFFFFFFFFFFFFFFFFF  
FFFFFFFF00000001000000000000000000000000000000FFFFFFFFFFFFFFFFFC  
5AC635D8AA3A93E7B3EBBD55769886BC651D06B0CC53B0F63BCE3C3E27D2604B  
6B17D1F2E12C4247F8BCE6E563A440F277037D812DEB33A0F4A13945D898C296  
FFFFFFFFFF0000000FFFFFFFFFFFBCE6FAADA7179E84F3B9CAC2FC632551  
2c55e5e45edf713dc43475effe8813a60326a64d9ba3d2e39cb639b0f3b0ad10 ←  
EC PRNG KAT failure  
CLOSE  
LISTEN
```

vulnerable

```
[λ ~/Tests/juniper/ strings ssg5ssg20.6.3.0r19.0.bin | grep -C5 -i "6b17d1f2e12c4247f8bce6e563a440f277037d812deb33a0f4a13945d898c296\|a]a87ca22be8b05378eb1c71ef320ad746e1d3b628ba79b9859f741e082542a385502f25dbf55296c3a545e3872760ab7\|c6858e06b70404e9cd9e3ecb662395b4429c648139053fb521f828af606b4d3dbaa14b5e77efe75928fe1dc127a2ffa8de3348b3c1856a429bf97e7e31c2e5bd66"
CLOSING
TIME_WAIT
FFFFFFFFFF0000000100000000000000000000000000000000FFFFFFFFFFFFFFFF
FFFFFFFFFF0000000100000000000000000000000000000000FFFFFFFFFF
5AC635D8AA3A93E7B3EBBD55769886BC651D06B0CC53B0F63BCE3C3E27D2604B
6B17D1F2E12C4247F8BCE6E563A440F277037D812DEB33A0F4A13945D898C296
FFFFFFFFFF00000000FFFFFFFFFFFBCE6FAADA7179E84F3B9CAC2FC632551
9585320EEAF81044F20D55030A035B11BECE81C785E6C933E4A8A131F6578107 ←
EC PRNG KAT failure
CLOSE
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```

Dual EC is **obvious**.

- ~~Weak crypto~~
- ~~Kleptography~~
- ~~New Backdoored Algorithms~~

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[<prev] [next>] [thread-next>] [day] [month] [year] [list]

Date: Mon, 1 Feb 2016 16:32:55 +0100

From: Gerhard Rieger <gerhard@...t-unreach.org>

To: oss-security@...ts.openwall.com

Subject: Socat security advisory 7 - Created new 2048bit DH modulus

Socat security advisory 7 - Created new 2048bit DH modulus

Overview

In the OpenSSL address implementation the hard coded 1024 bit DH p parameter was not prime. The effective cryptographic strength of a key exchange using these parameters was weaker than the one one could get by using a prime p. Moreover, since there is no indication of how these parameters were chosen, the existence of a trapdoor that makes possible for an eavesdropper to recover the shared secret from a key exchange that uses them cannot be ruled out.

A new prime modulus p parameter has been generated by Socat developer using OpenSSL dhparam command.

In addition the new parameter is 2048 bit long.

Vulnerability Ids:

Socat security issue 7

MSVR-1499

Severity: Unknown

Affected versions

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DHE backdoor?

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- Everyone **trust** DHE already

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- *Logjam*: **hardcoded** DHE everywhere

DHE backdoor?

- Everyone **trust** DHE already
- *Logjam*: **hardcoded** DHE everywhere
- Everyone is **upgrading to 2048-bit parameters**

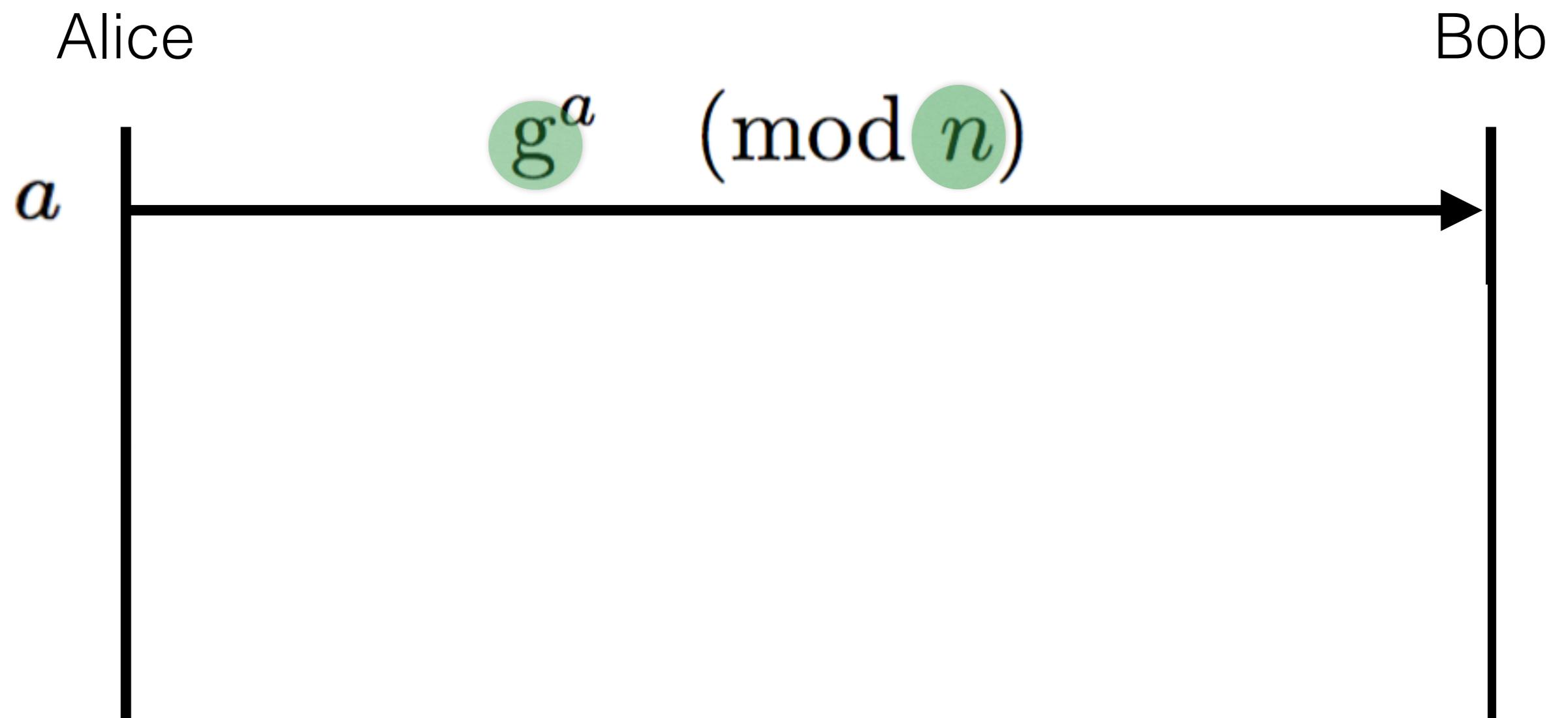
Diffie-Hellman

Alice

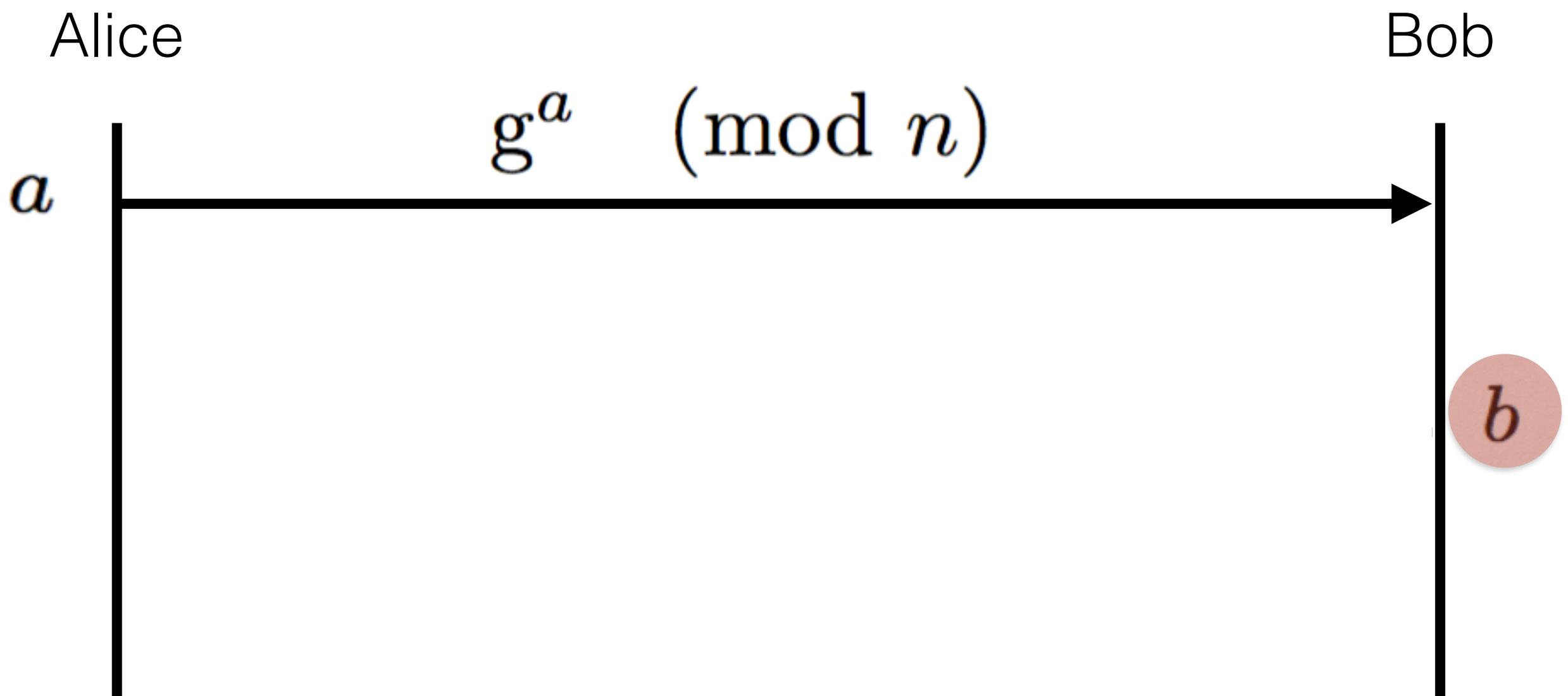
a

Bob

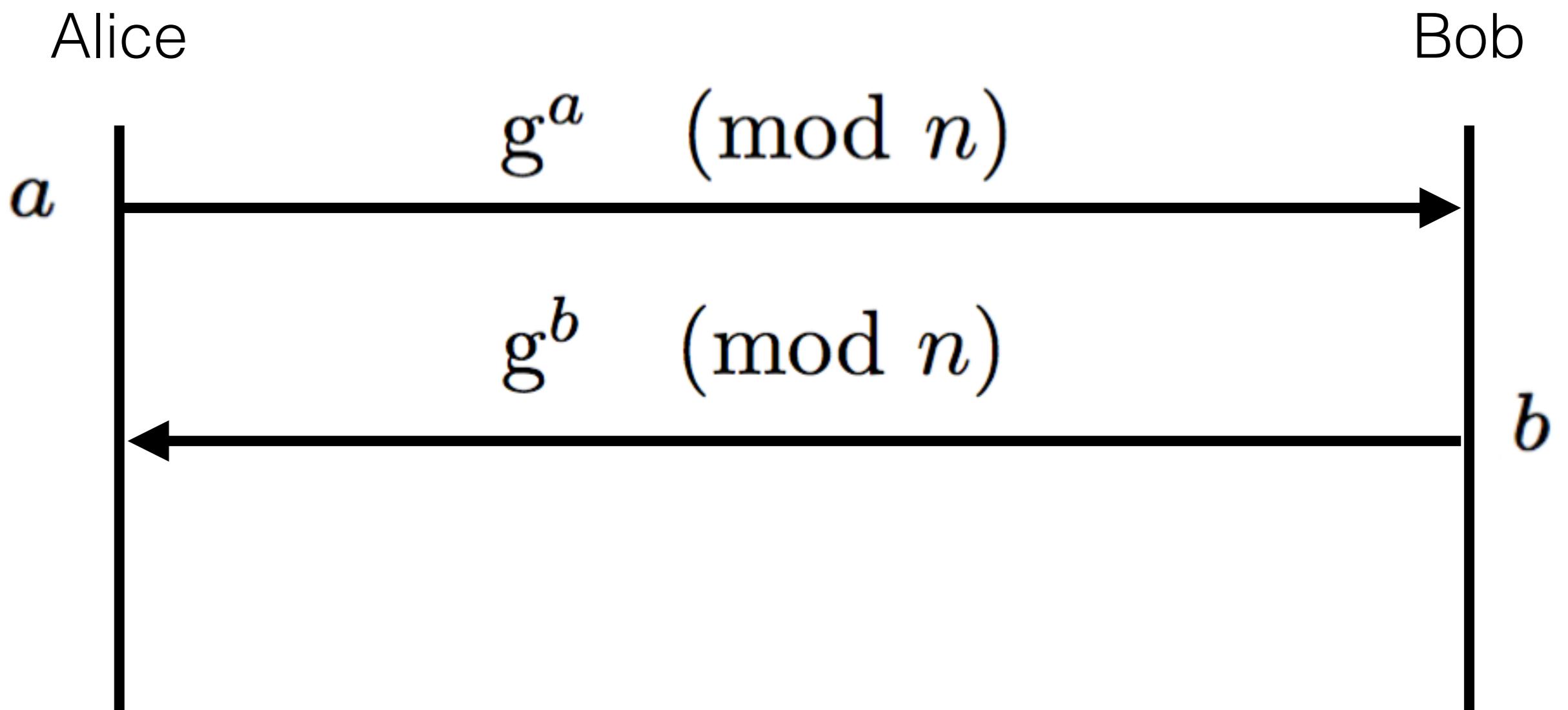
Diffie-Hellman



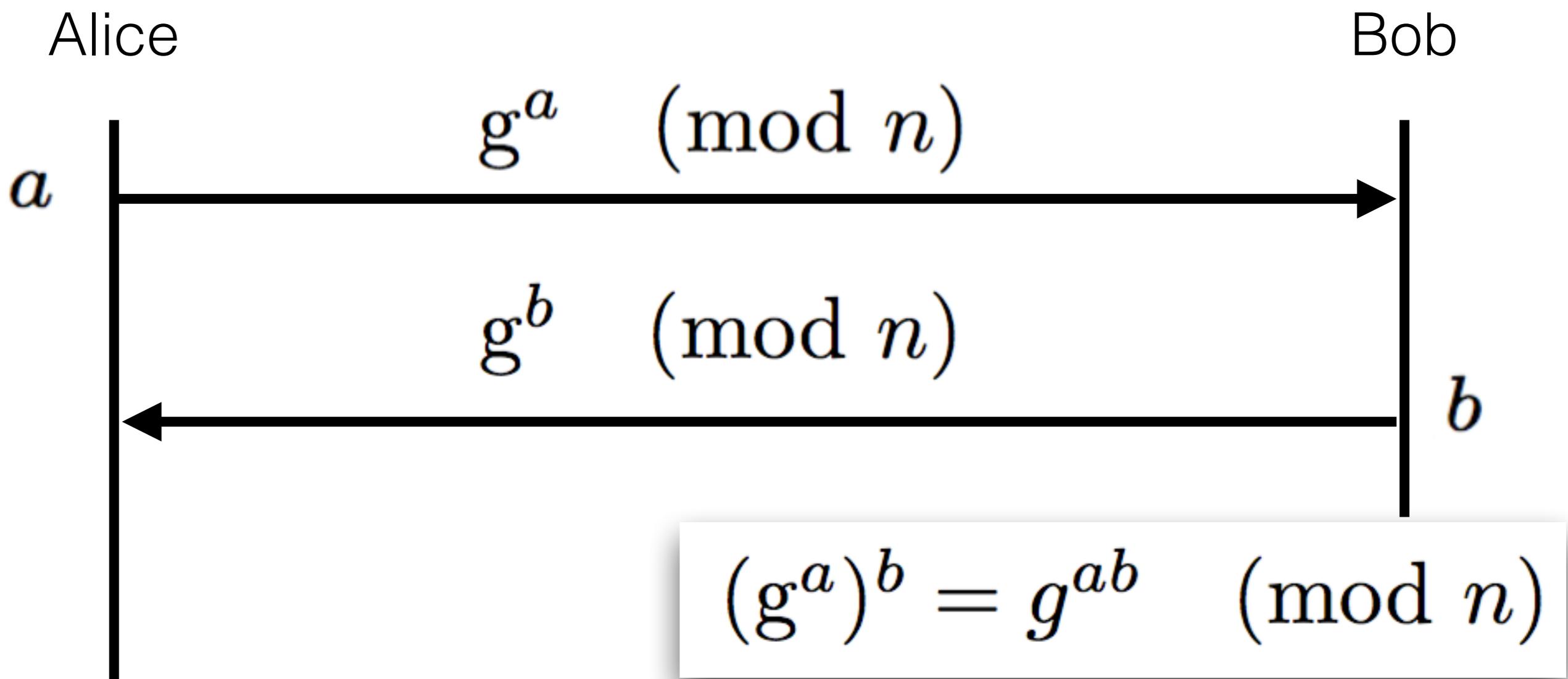
Diffie-Hellman



Diffie-Hellman



Diffie-Hellman



Agenda

1. Group Theory
2. Attacks on DH
3. Construct a backdoor
4. Construct a NOBUS backdoor

Group Theory

$g, g^2, g^3, g^4, \dots \pmod{n}$

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$g, g^2, g^3, g^4, \dots \pmod{n}$

Alice's $g^a \pmod{n}$

Group Theory

$$g, g^2, g^3, g^4, \dots \pmod{n}$$

$$\dots, g^{\varphi(n)} = 1$$

Group Theory

$$g, g^2, g^3, g^4, \dots \pmod{n}$$

$$\dots, g^{\varphi(n)} = 1, g^{\varphi(n)+1} = g$$

Group Theory

$$g, g^2, g^3, g^4, \dots \pmod{n}$$

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$$\dots, g^{\varphi(n)} = 1, g^{\varphi(n)+1} = g, g^2, \dots \pmod{n}$$

$$\varphi(n) = \begin{cases} n - 1 & \text{if } n \text{ prime} \\ \end{cases}$$

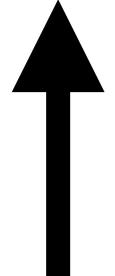
Group Theory

$$g, g^2, g^3, g^4, \dots \pmod{n}$$

$$\dots, g^{\varphi(n)} = 1, g^{\varphi(n)+1} = g, g^2, \dots \pmod{n}$$

$$\varphi(n) = \begin{cases} n - 1 & \text{if } n \text{ prime} \\ (p - 1)(q - 1) & \text{if } n = pq \end{cases}$$

Group Theory

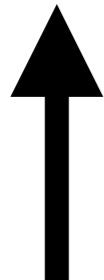
$$g, g^2, g^3, g^4, g^5, g^6, g^7, \dots, g^{\varphi(n)}$$


Group Theory

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Group Theory

, g^2 , , g^4 , , g^6 , , . . . ,



Group Theory

$$\varphi(p) = p - 1 = p_1 \times \cdots \times p_k$$

Known attacks against DH

$$g^a \pmod{n}$$

Known attacks against DH

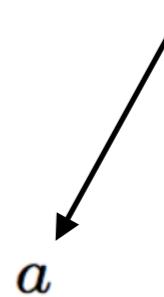
$$g^a \pmod{n}$$



a

Known attacks against DH

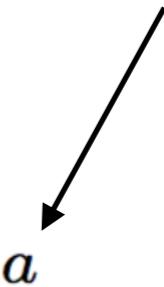
- Trial Multiplication

$$g^a \pmod{n}$$


A black arrow points downwards from the mathematical expression $g^a \pmod{n}$ towards the variable a .

Known attacks against DH

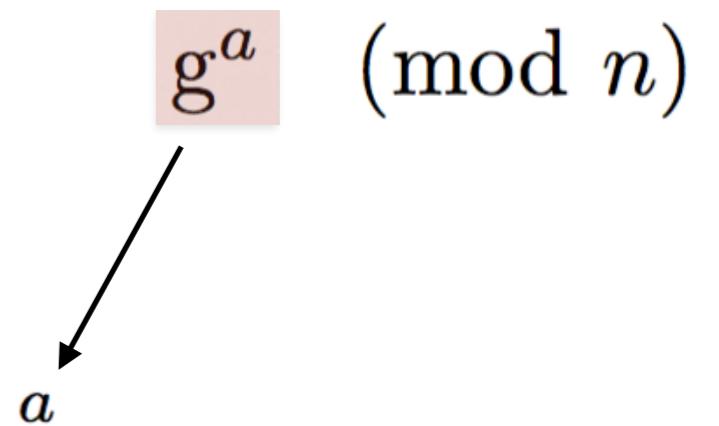
- Trial Multiplication
- SNFS, GNFS

$$g^a \pmod{n}$$


A black arrow points from the variable a down towards the base of the exponent in the mathematical expression $g^a \pmod{n}$.

Known attacks against DH

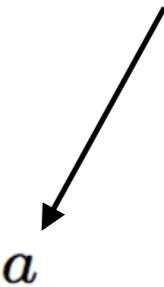
- Trial Multiplication
- SNFS, GNFS
- Shank's BSGS, **Pollard Rho** & Kangaroo, ...

$$g^a \pmod{n}$$


A diagram illustrating the components of a discrete logarithm problem. A pink rectangular box contains the mathematical expression $g^a \pmod{n}$. An arrow originates from the variable a and points downwards towards the base g of the exponentiation.

Known attacks against DH

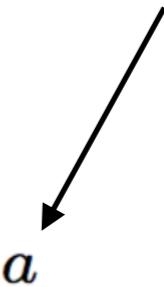
- Trial Multiplication
- SNFS, GNFS
- Shank's BSGS, **Pollard Rho** & Kangaroo, ...
- Small subgroup attacks (active)

$$g^a \pmod{n}$$


A black arrow points from the variable 'a' down towards the modulus 'n' in the congruence symbol.

Known attacks against DH

- Trial Multiplication
- SNFS, GNFS
- Shank's BSGS, **Pollard Rho** & Kangaroo, ...
- Small subgroup attacks (active)
- **Pohlig-Hellman** (passive)

$$g^a \pmod{n}$$


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Small Subgroups Attack

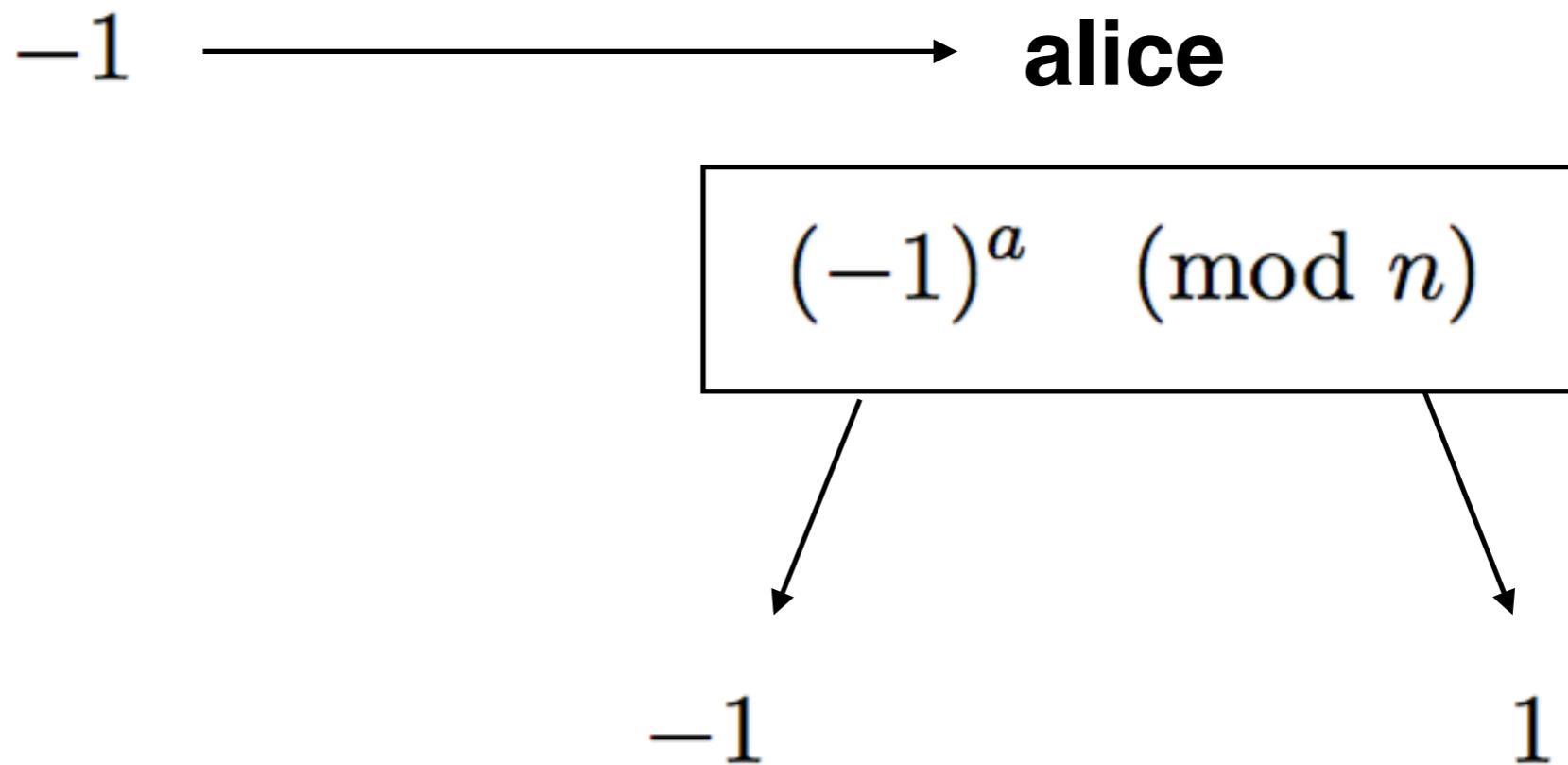
-1 → **alice**

Small Subgroups Attack

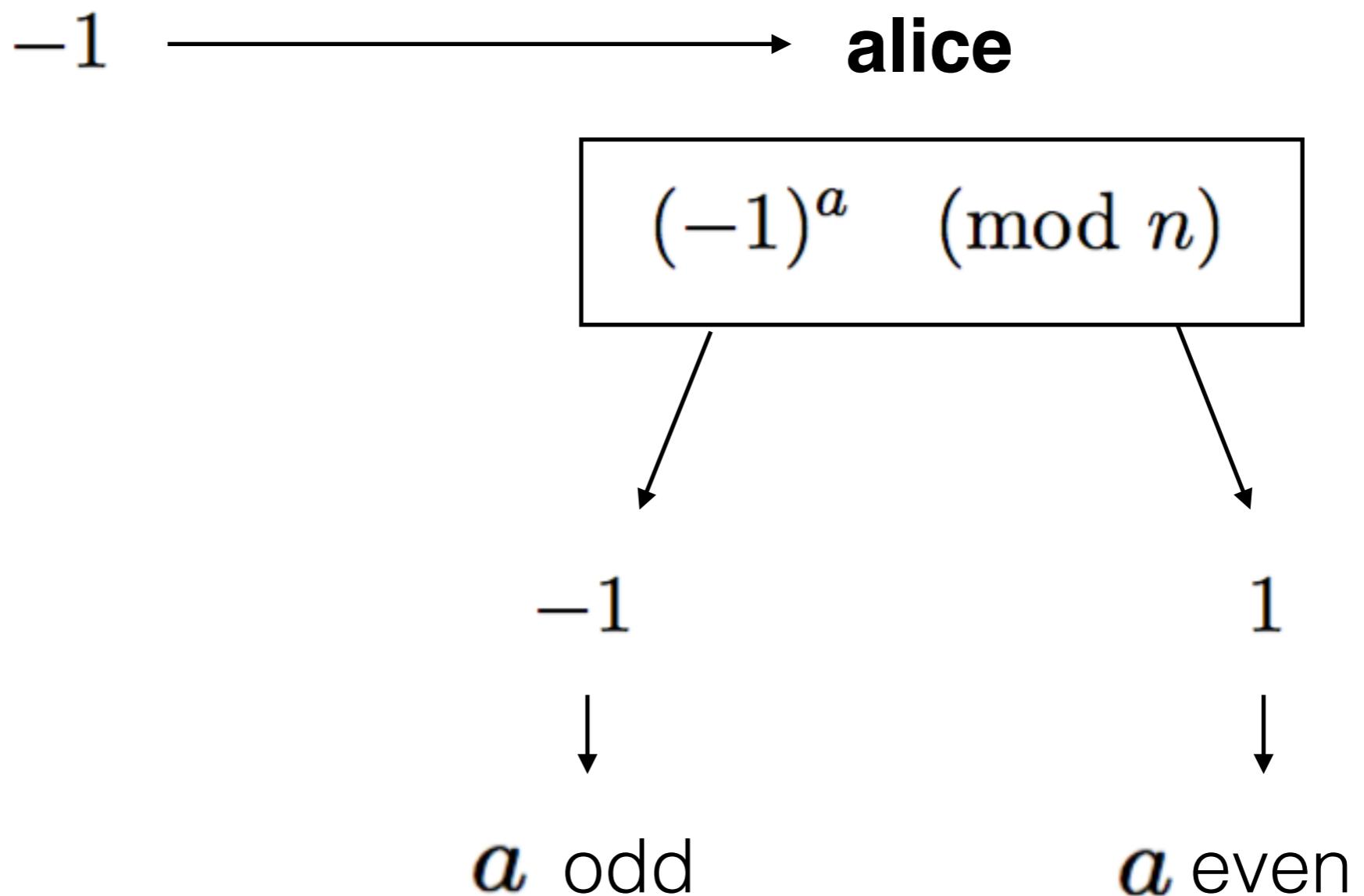
-1 → **alice**

$$(-1)^a \pmod{n}$$

Small Subgroups Attack



Small Subgroups Attack



Pohlig-Hellman

$$g^a \pmod{n}$$

Pohlig-Hellman

$$(g^a)^k \pmod{n}$$



$$a \pmod{l}$$

Prime groups

$$\varphi(p) = p - 1 = p_1 \times \cdots \times p_k$$
$$y = g^x \pmod{p}$$

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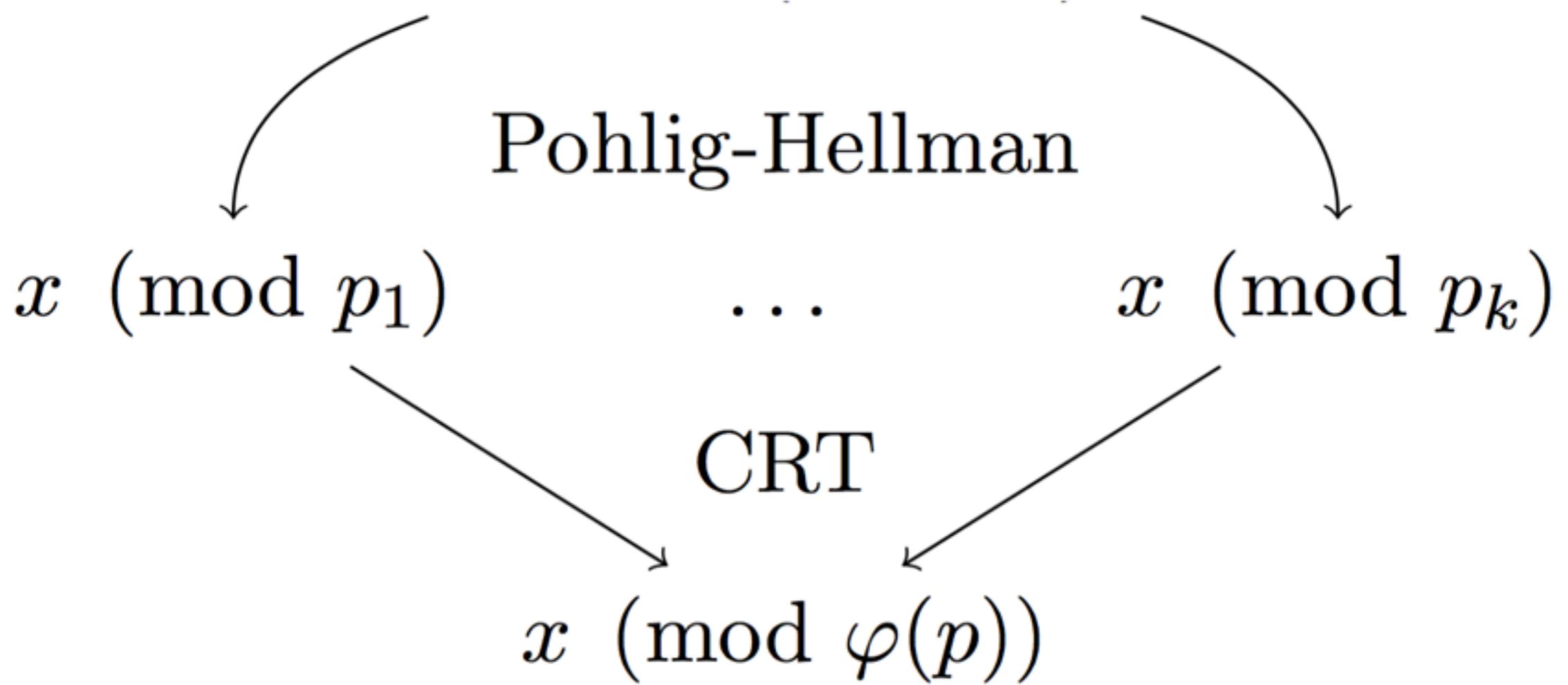
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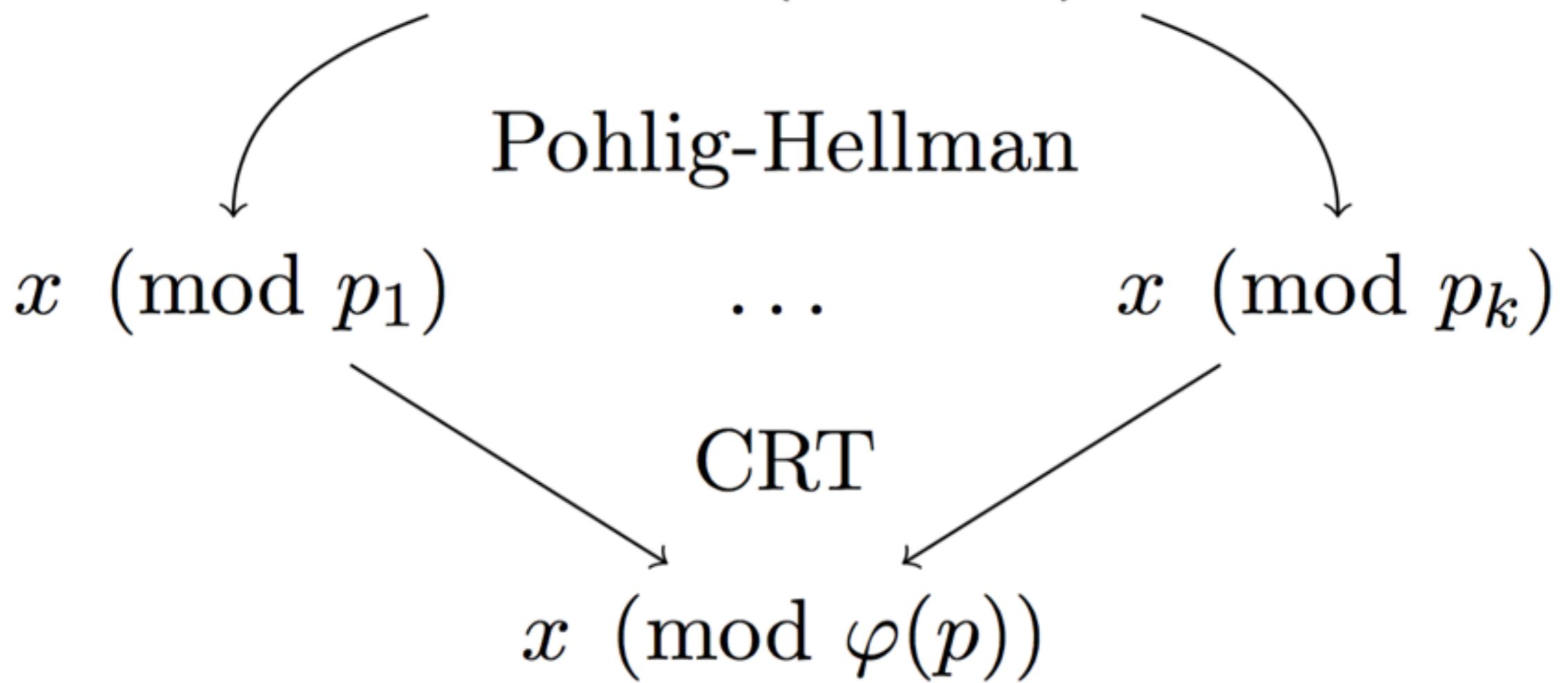
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CM-HSO

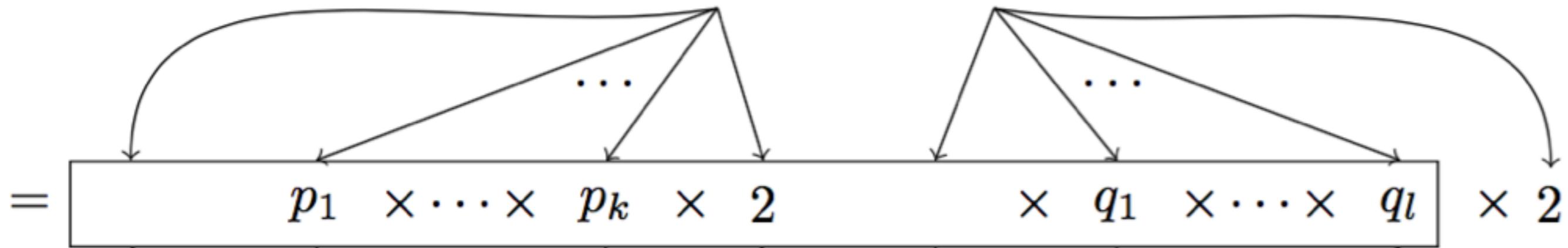
Composite Modulus with a Hidden Smooth Order

$$\varphi(n) = (p - 1) \times (q - 1)$$

CM-HSO

Composite Modulus with a Hidden Smooth Order

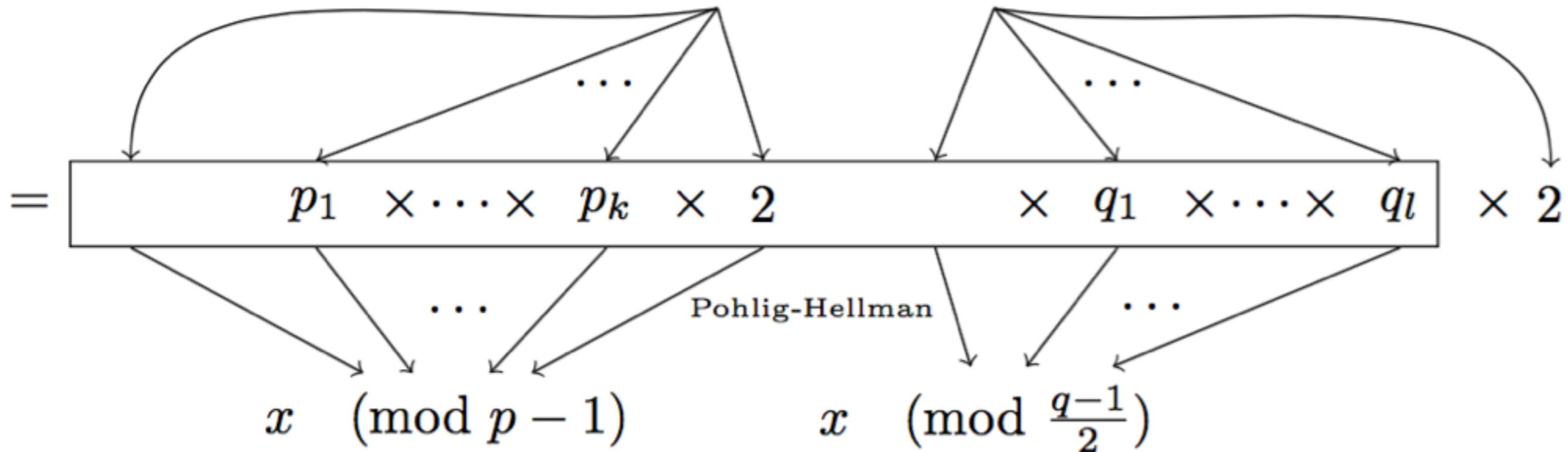
$$\varphi(n) = (p-1) \times (q-1)$$



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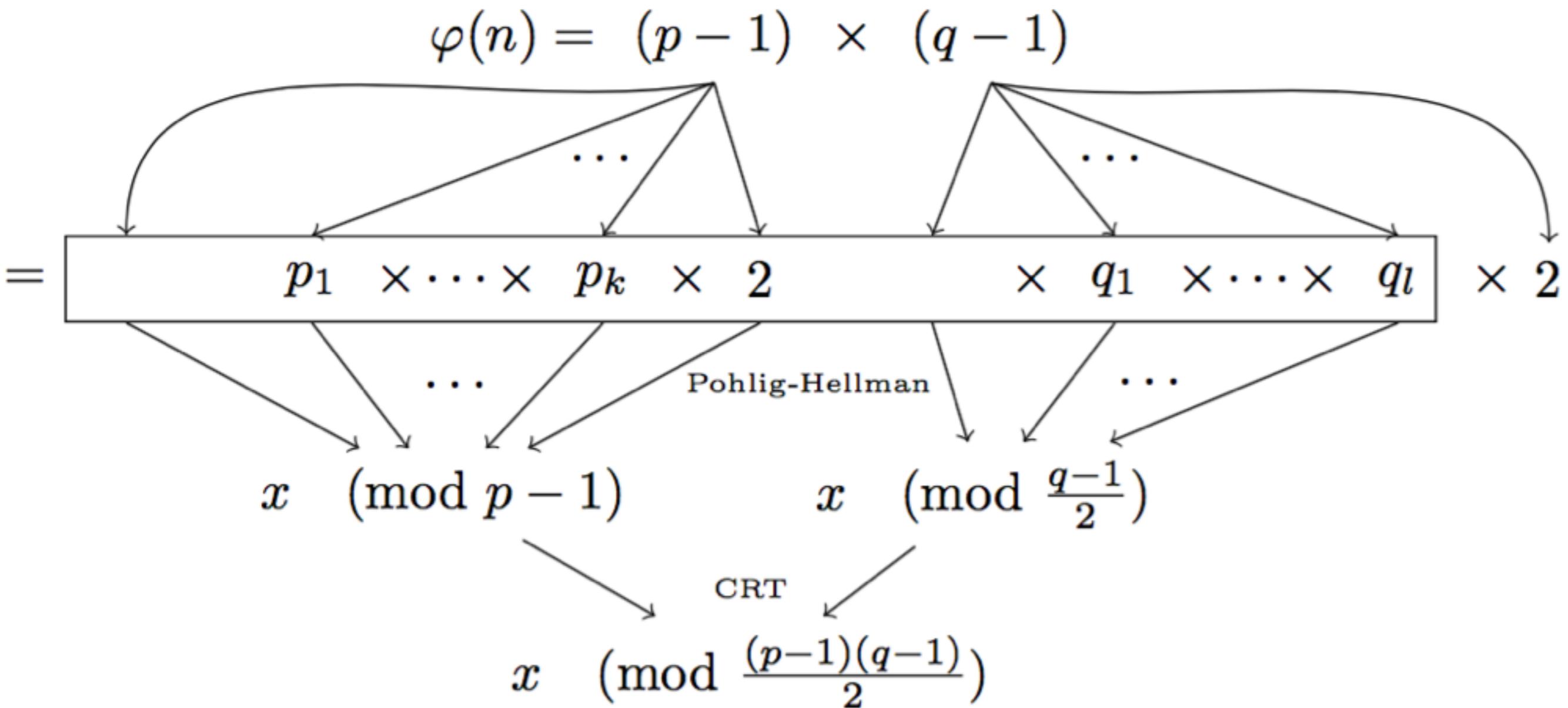
Composite Modulus with a Hidden Smooth Order

$$\varphi(n) = (p-1) \times (q-1)$$



CM-HSO

Composite Modulus with a Hidden Smooth Order





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{

```
    static unsigned char dh1024_p[] = {
0x4b,0x60,0xd1,0x11,0xa2,0x1c,0xa8,0x31,0x43,0xe8,0x5c,0x0b,
0xbf,0xf8,0xbb,0xcf,0x9e,0xfb,0xbc,0xe9,0x61,0x32,0x2c,0xfe,
0xf9,0x3d,0x68,0x08,0x9a,0xa2,0x25,0xa9,0x78,0x13,0xb7,0x9f,
0xc3,0xa4,0x33,0xb0,0x50,0x6c,0x4e,0xea,0xcd,0xbf,0x98,0x3e,
0x25,0x56,0x23,0x79,0x49,0xbe,0x1b,0x12,0xd0,0xdd,0xfe,0x05,
0xfb,0x93,0xdc,0xca,0x4f,0xed,0xbc,0xf0,0x35,0x01,0x55,0x0d,
0x70,0xc6,0xb8,0xe8,0xbe,0x6a,0xba,0xc3,0x72,0xa8,0x30,0x12,
0x10,0xab,0xfa,0xab,0x0c,0xdc,0xa8,0x98,0xf7,0x1d,0x85,0xde,
0xb9,0xec,0x16,0x45,0x05,0x51,0x05,0x89,0xa1,0xe4,0xaf,0x1f,
0x70,0x76,0x25,0xde,0xac,0x24,0x99,0x7d,0x09,0x4c,0xe3,0xb0,
0xc4,0x18,0x13,0xc1
};

    static unsigned char dh1024_g[] = {
0x02,
};

    DH *dh;
```

-UU-:**—F1 xio-openssl.c 57% L924 Git-3ee5ac5 (C/l Abbrev) --

[0] <r_generatorZ 2:emacs*> "dhcp-101.chi.matasano" 11:45 03-May-1666

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{

```
static unsigned char dh1024_p[] = {
```

```
0xCC, 0x17, 0xF2, 0xDC, 0x96, 0xDF, 0x59, 0xA4, 0x46, 0xC5, 0x3E, 0x0E,  
0xB8, 0x26, 0x55, 0x0C, 0xE3, 0x88, 0xC1, 0xCE, 0xA7, 0xBC, 0xB3, 0xBF,  
0x16, 0x94, 0xD8, 0xA9, 0x45, 0xA2, 0xCE, 0xA9, 0x5B, 0x22, 0x25, 0x5F,  
0x92, 0x59, 0x94, 0x1C, 0x22, 0xBF, 0xCB, 0xC8, 0xC8, 0x57, 0xCB, 0xBF,  
0xBC, 0x0E, 0xE8, 0x40, 0xF9, 0x87, 0x03, 0xBF, 0x60, 0x9B, 0x08, 0xC6,  
0x8E, 0x99, 0xC6, 0x05, 0xFC, 0x00, 0xD6, 0x6D, 0x90, 0xA8, 0xF5, 0xF8,  
0xD3, 0x8D, 0x43, 0xC8, 0x8F, 0x7A, 0xBD, 0xBB, 0x28, 0xAC, 0x04, 0x69,  
0x4A, 0x0B, 0x86, 0x73, 0x37, 0xF0, 0x6D, 0x4F, 0x04, 0xF6, 0xF5, 0xAF,  
0xBF, 0xAB, 0x8E, 0xCE, 0x75, 0x53, 0x4D, 0x7F, 0x7D, 0x17, 0x78, 0x0E,  
0x12, 0x46, 0x4A, 0xAF, 0x95, 0x99, 0xEF, 0xBC, 0xA6, 0xC5, 0x41, 0x77,  
0x43, 0x7A, 0xB9, 0xEC, 0x8E, 0x07, 0x3C, 0x6D,
```

};

```
static unsigned char dh1024_g[] = {
```

```
0x02,
```

};

```
DH *dh;
```

-UU-----F1 xio-openssl.c 57% L923 Git-3ee5ac5 (C/l Abbrev) --

[0] <r_generatorZ 2:emacs*> "dhcp-101.chi.matasano" 11:43 03-May-1660

```
vagrant@proxy:/vagrant/shared$ go build proxy.go attack.go && sudo ./proxy -l 192.168.0.66:6666 -r 192.168.0.50:4433
```

```
vagrant@server:~$ sudo socat openssl-listen:4433,verify=0,cert=server.pem,key=server.key,cipher=DHE-RSA-AES128-SHA256,reuseaddr -
```

```
vagrant@client:~/shared$ socat - openssl:192.168.0.66:6666,verify=0,reuseaddr
```

```
[0] 0...deBasedCrypto- 1.../github_socat 2:vagrant*
```

```
"dhcp-101.chi.matasano" 12:12 27-Jun-16
```

[https://github.com/mimoo/**Diffie-Hellman_Backdoor**](https://github.com/mimoo/Diffie-Hellman_Backdoor)

Detect and Protect

- Check for prime modulus

Detect and Protect

- Check for prime modulus
- Better: check for **safe prime** modulus

Detect and Protect

- Check for prime modulus
- Better: check for **safe prime** modulus
- Google Chrome deprecating DHE (-> ECDHE)

END

how many VPN/libraries/closed-source products are
backdoored?

END

how many VPN/libraries/closed-source products are
backdoored?

what about **ECDHE**?



twitter.com/lyon01_david