Improved Port Knocking with Strong Authentication

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Overview

1) Usefulness of port knocking

2) How port knocking works

3) Problems with existing port knocking systems

4) Our improvements on existing systems

5) Areas for further work

Network Access Authentication

- Any service exposed to a public network can be attacked
- Limiting access by address is not adequate
- Limiting access by user requires authentication

Network Access Authentication

- Authentication is traditionally left up to the application
- But...
  - Some applications have no authentication
  - Flaws in authentication can allow it to be bypassed

Attacks on Network Authentication

```
64 bytes from 209.151.245.6: icmp_seq=1 ttl=61 time=196 ms

--- kremvax.cccp.su ping statistics ---
2 packets transmitted, 2 received, 0% packet loss, time 1000 ms
[root@apollo ~]# nmap -sS -O kremvax.cccp.su

Starting nmap 2.3BETA13 ( http://www.insecure.org/nmap/ ) at 2000-01-21 07:03 PST
Interesting ports on kremvax (209.151.245.6):
(The 1660 ports scanned but not shown below are in state: closed)
PORT      STATE    SERVICE
22/tcp    open     ssh
23/tcp    open     telnet
80/tcp    open     http
Device type: general purpose
Running: Sun Solaris 2.4
Uptime 1865.356 days (since Mon Dec 12 22:30:14 1994)

Nmap finished: 1 IP address (1 host up) scanned in 44.631 seconds
[root@apollo ~]# telnet
telnet> environ define TTYPROMPT foobar
telnet> o kremvax.cccp.su

SunOS 5.4

root c c c c c c c c c c c c c c c c c c c c c c c c c c c c c c c c c c c c c c c c c c c c c c c
 c c c c c c c c c c c c c c c c c\n
Last login: Wed Feb 15 01:27:31 1995
[root@kremvax /]# 
```

Attacks on Network Authentication

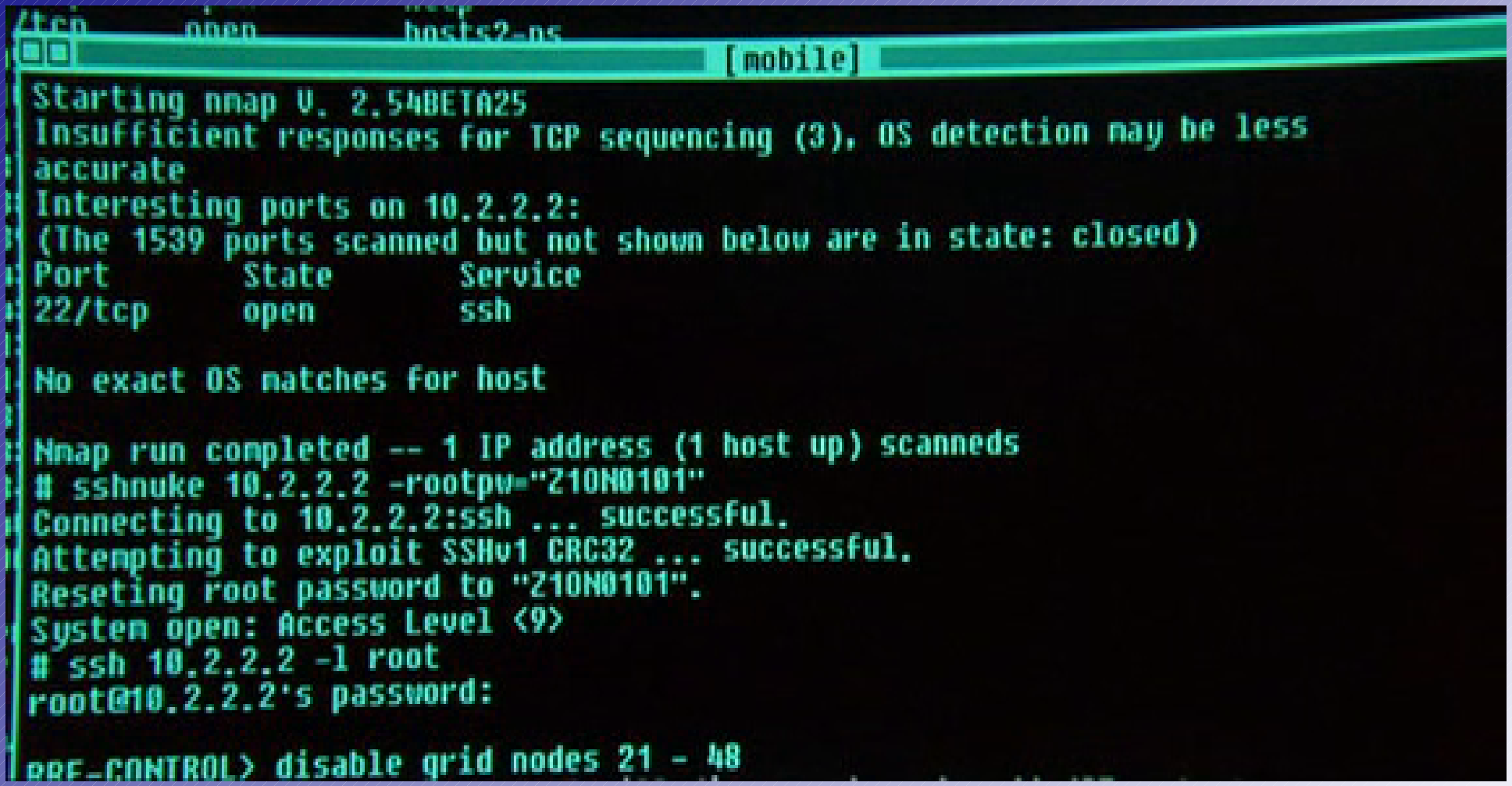

Image from The Matrix Reloaded, copyright 2003, Warner Bros.

Attacks on Network Authentication

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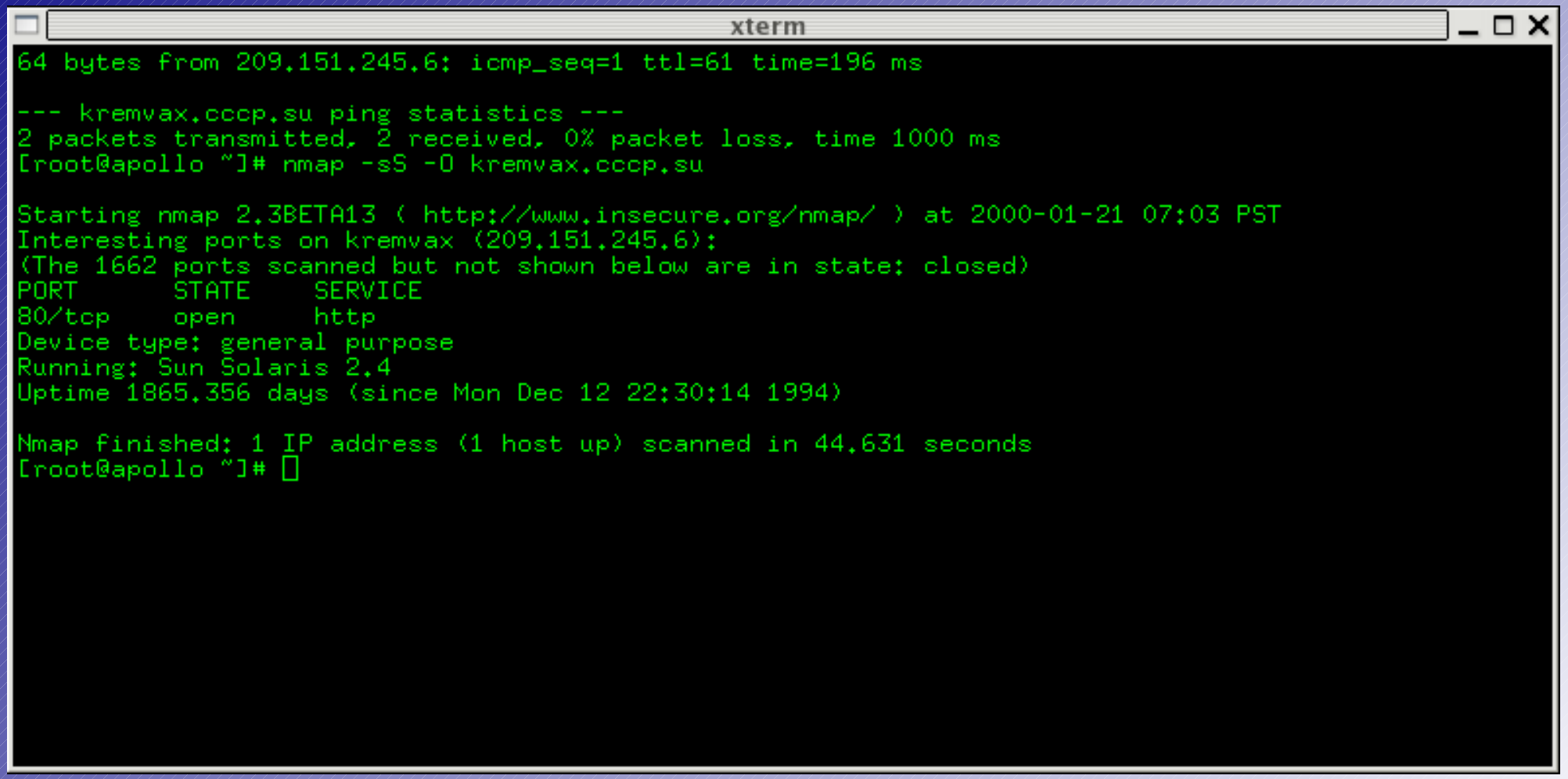
IP-level Authentication for Firewalls

- Defense in depth
- Stop-gap security measure for services with known unpatched vulnerabilities
- Wrapper for services without built-in authentication
- Makes service invisible to port scans

IP-level Authentication for Firewalls



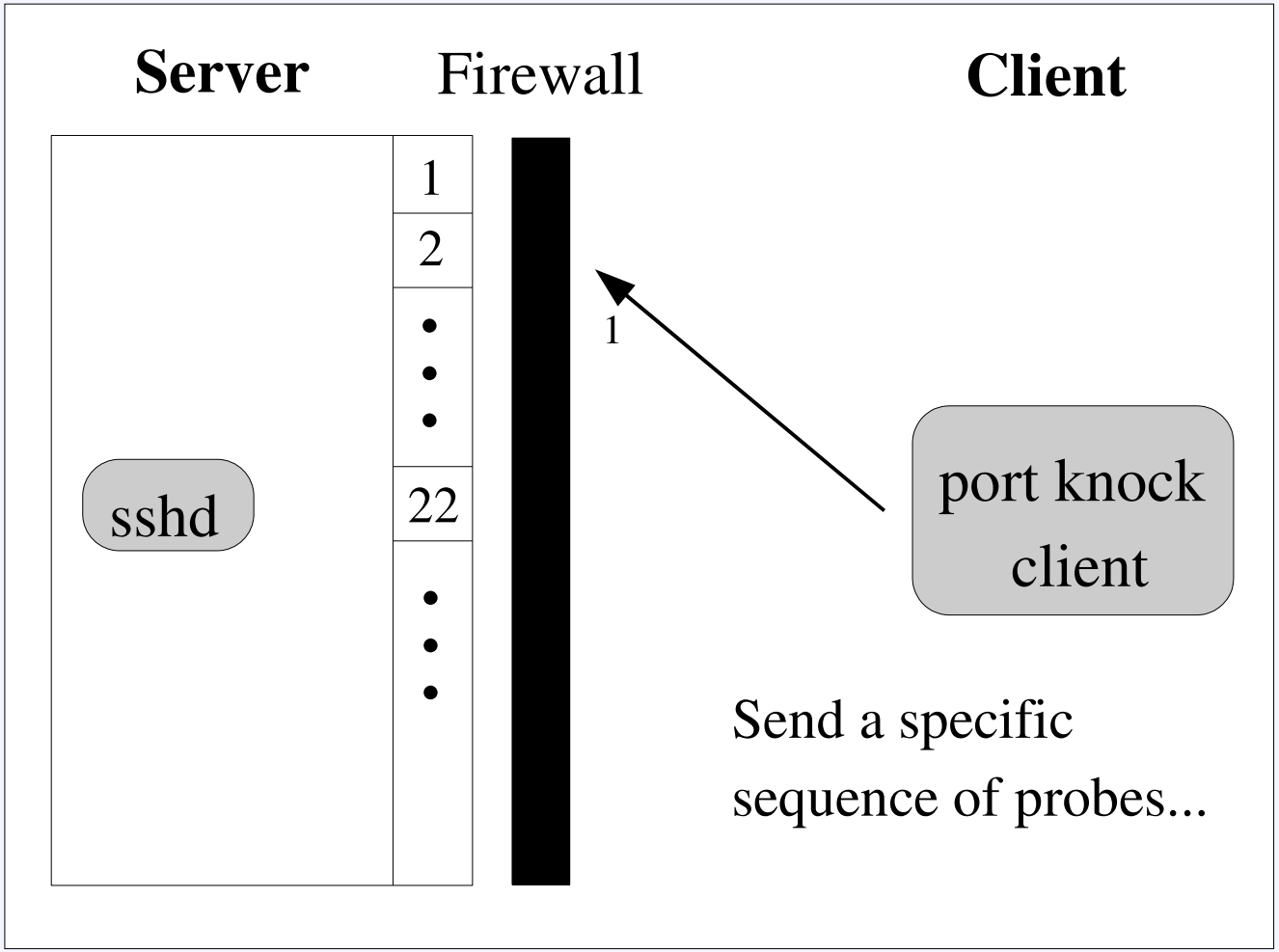
Requirements for Firewall Authentication

- Strong authentication
- Resistance to traffic interception and modification
- Interoperability with existing systems
- Low resource demands
- Simplicity
- Stealth

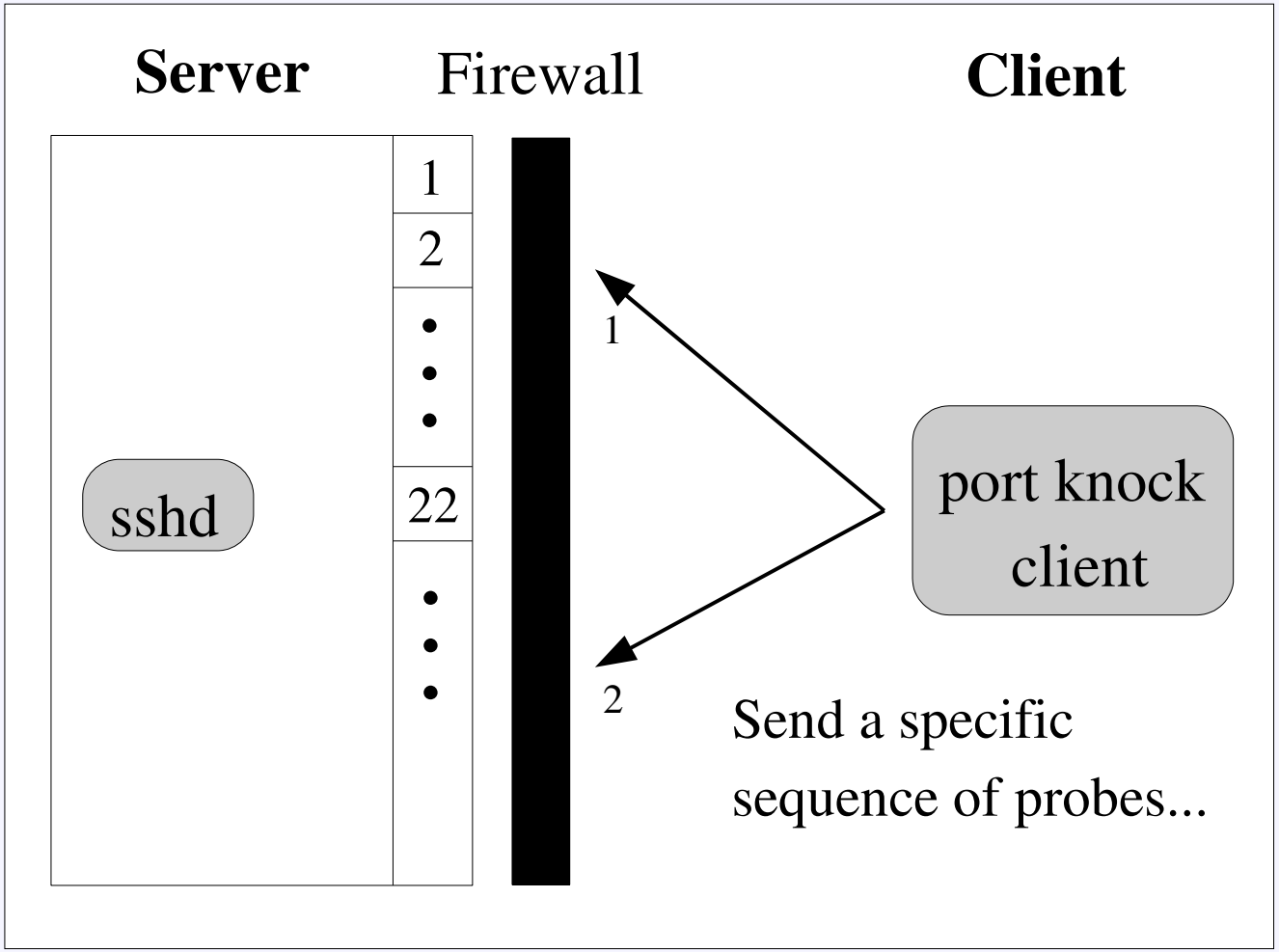
Port Knocking

- Information is encoded as a sequence of TCP or UDP port numbers within a range
- Clients send empty packets to these ports
- Server watches for packets sent to these ports, decodes information, and performs some action

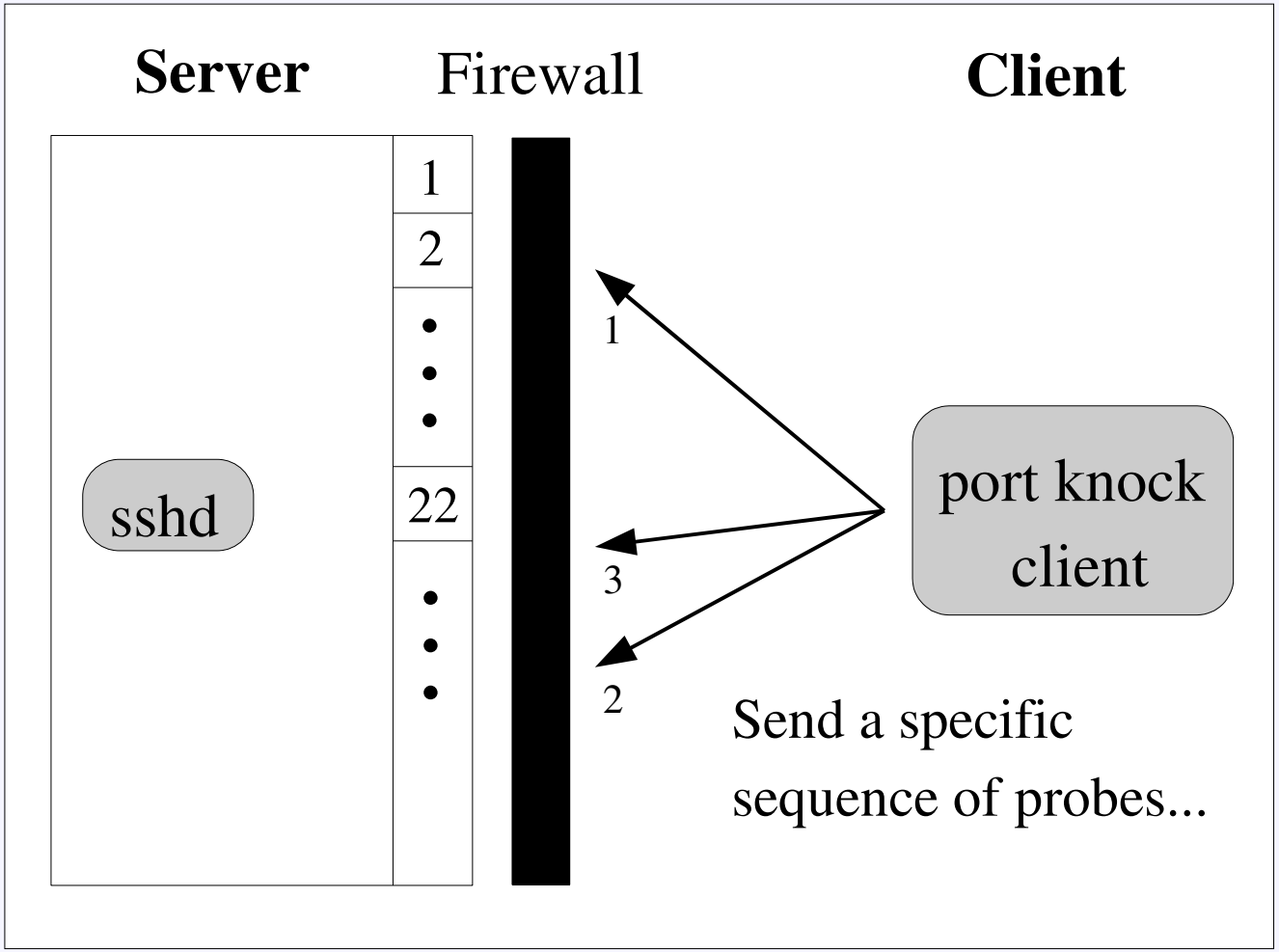
Port Knocking



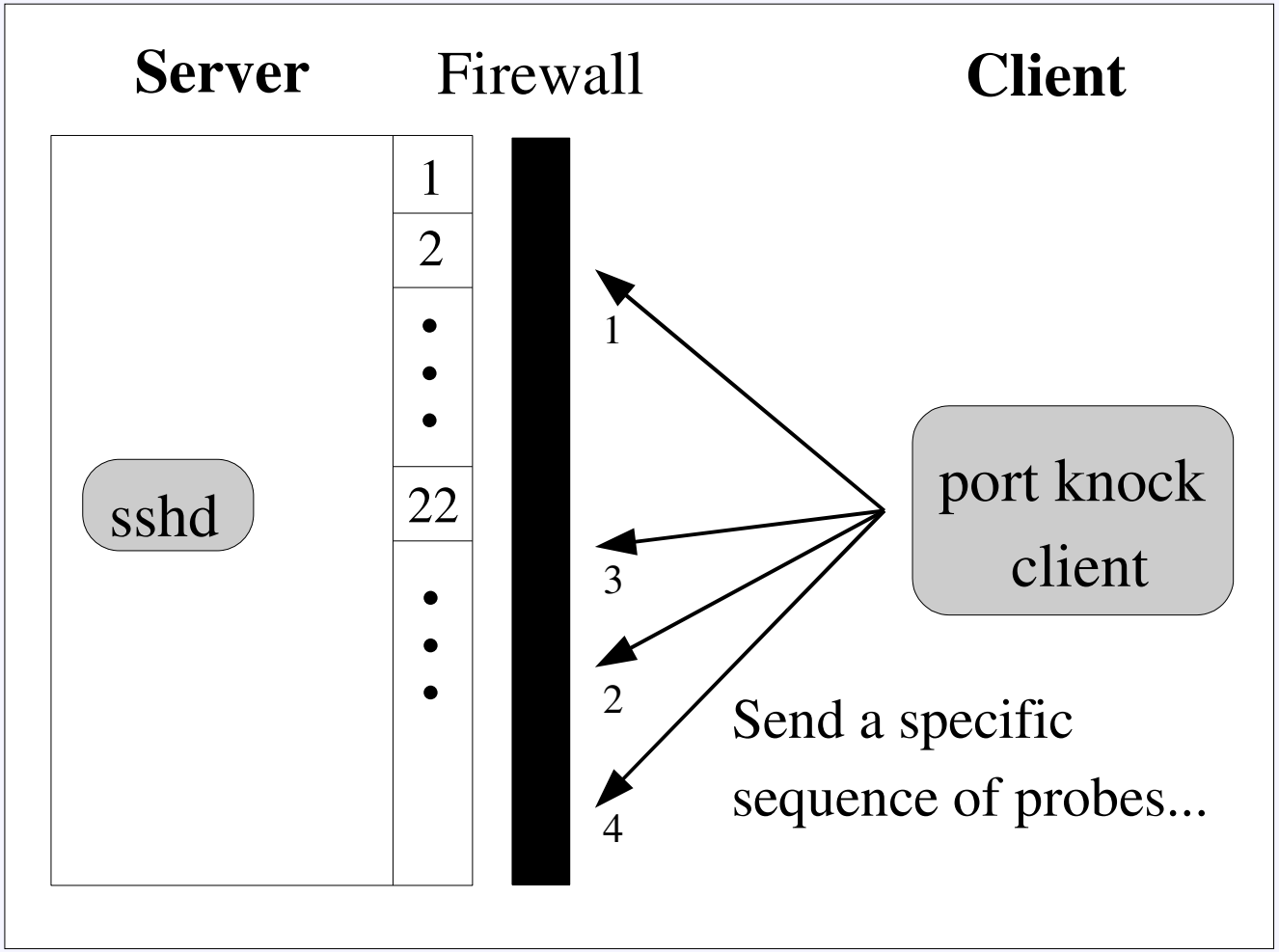
Port Knocking



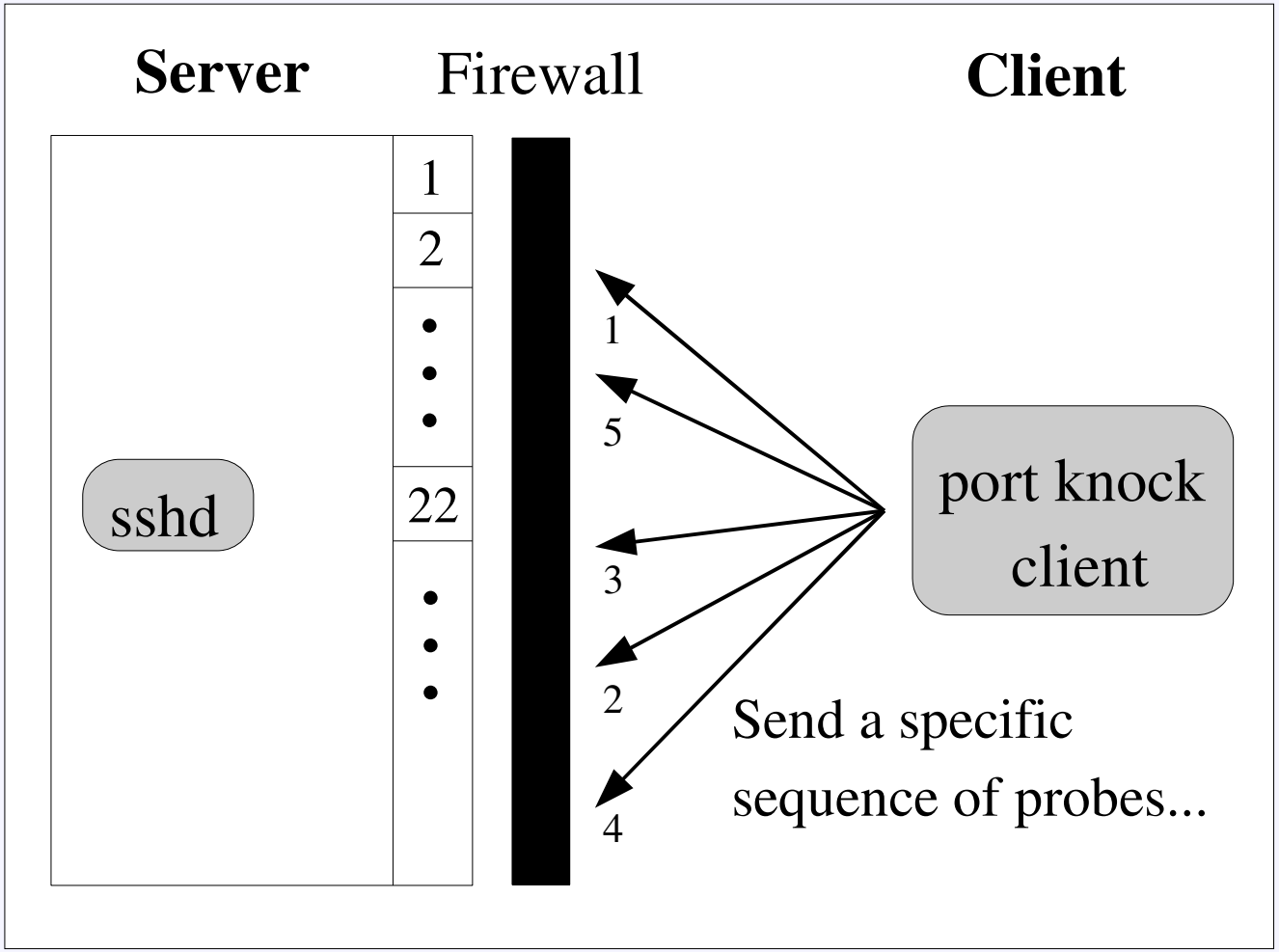
Port Knocking



Port Knocking



Port Knocking



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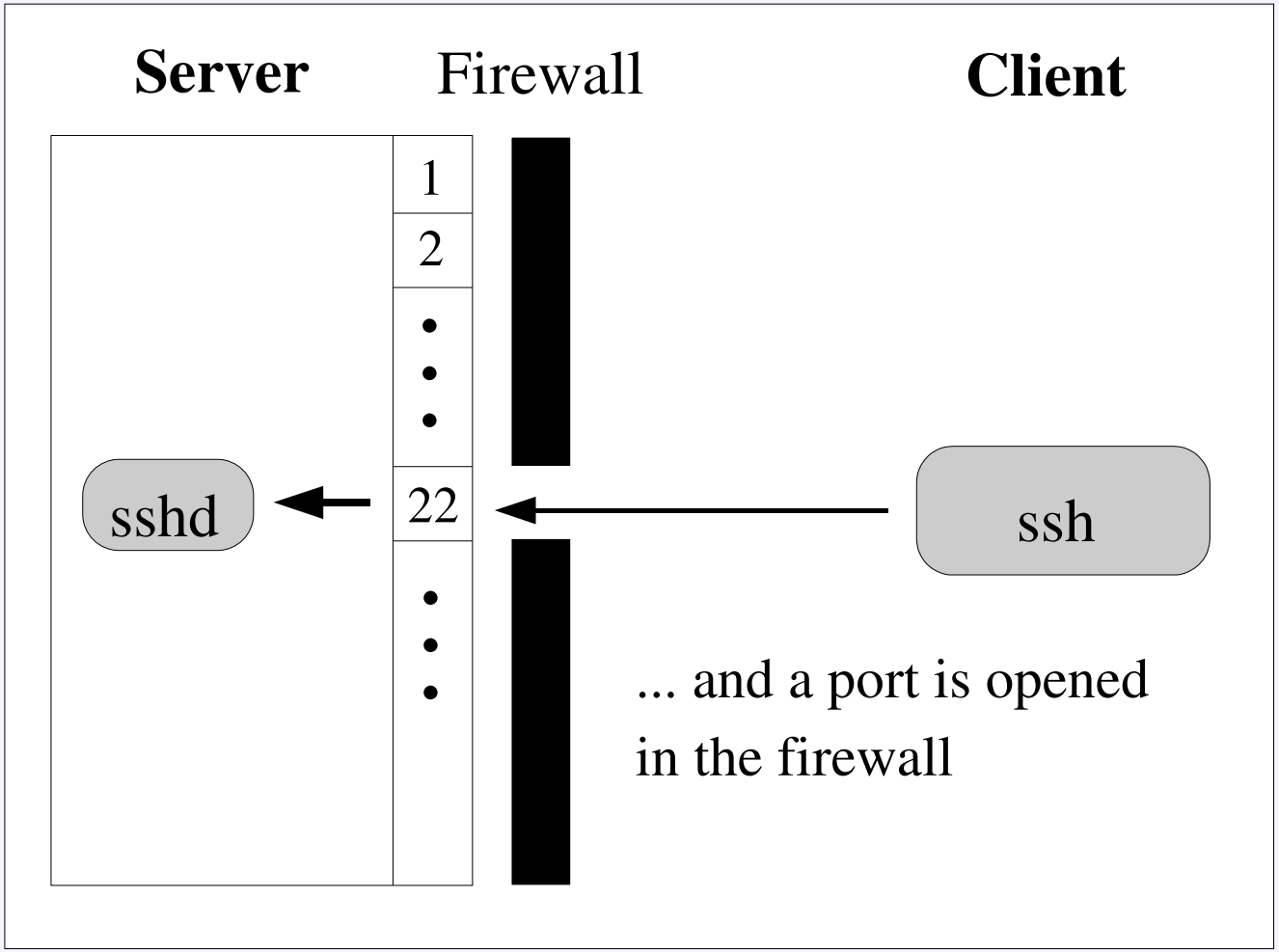
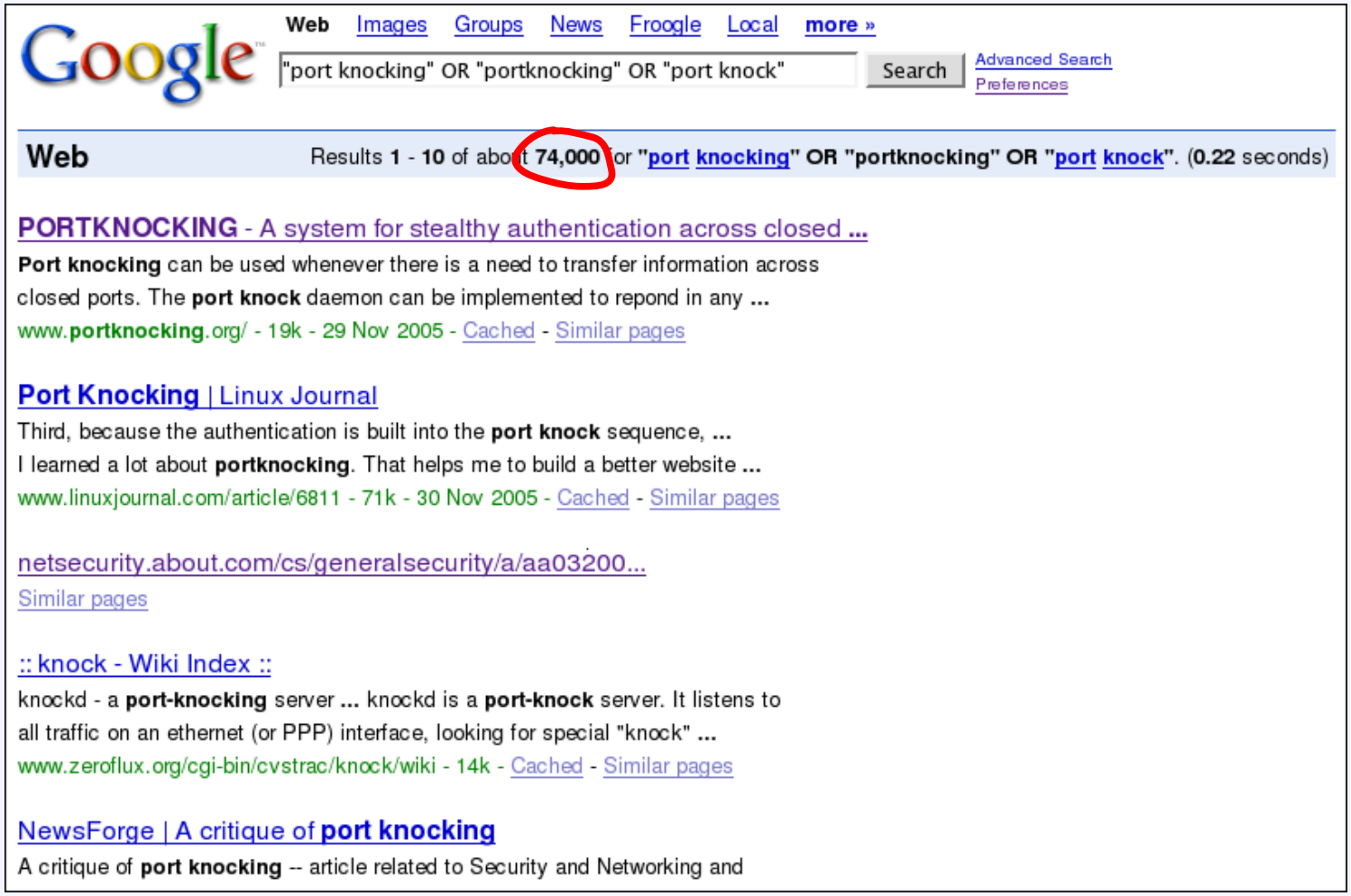


Other Work on Port Knocking



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"port knocking" OR "portknocking" OR "port knock" Search Advanced Search Preferences

Web Results **1** - **10** of about **74,000** for "**port knocking**" **OR** "**portknocking**" **OR** "**port knock**". (**0.22** seconds)

PORTKNOCKING - A system for stealthy authentication across closed **...**

Port knocking can be used whenever there is a need to transfer information across closed ports. The **port knock** daemon can be implemented to repond in any **...**

www.**portknocking**.org/ - 19k - 29 Nov 2005 - Cached - Similar pages

Port Knocking | Linux Journal

Third, because the authentication is built into the **port knock** sequence, **...** I learned a lot about **portknocking**. That helps me to build a better website **...**

www.linuxjournal.com/article/6811 - 71k - 30 Nov 2005 - Cached - Similar pages

netsecurity.about.com/cs/generalsecurity/a/aa03200...

Similar pages

:: knock - Wiki Index ::

knockd - a **port-knocking** server **...** knockd is a **port-knock** server. It listens to all traffic on an ethernet (or PPP) interface, looking for special "knock" **...**

www.zeroflux.org/cgi-bin/cvstrac/knock/wiki - 14k - Cached - Similar pages

NewsForge | A critique of **port knocking**

A critique of **port knocking** -- article related to Security and Networking and

Problems with Existing Systems

- Plain-text authentication
- Broken cryptography
- Network Address Translators
- Sensitive to packet delivery order
- No association between authentication and connection

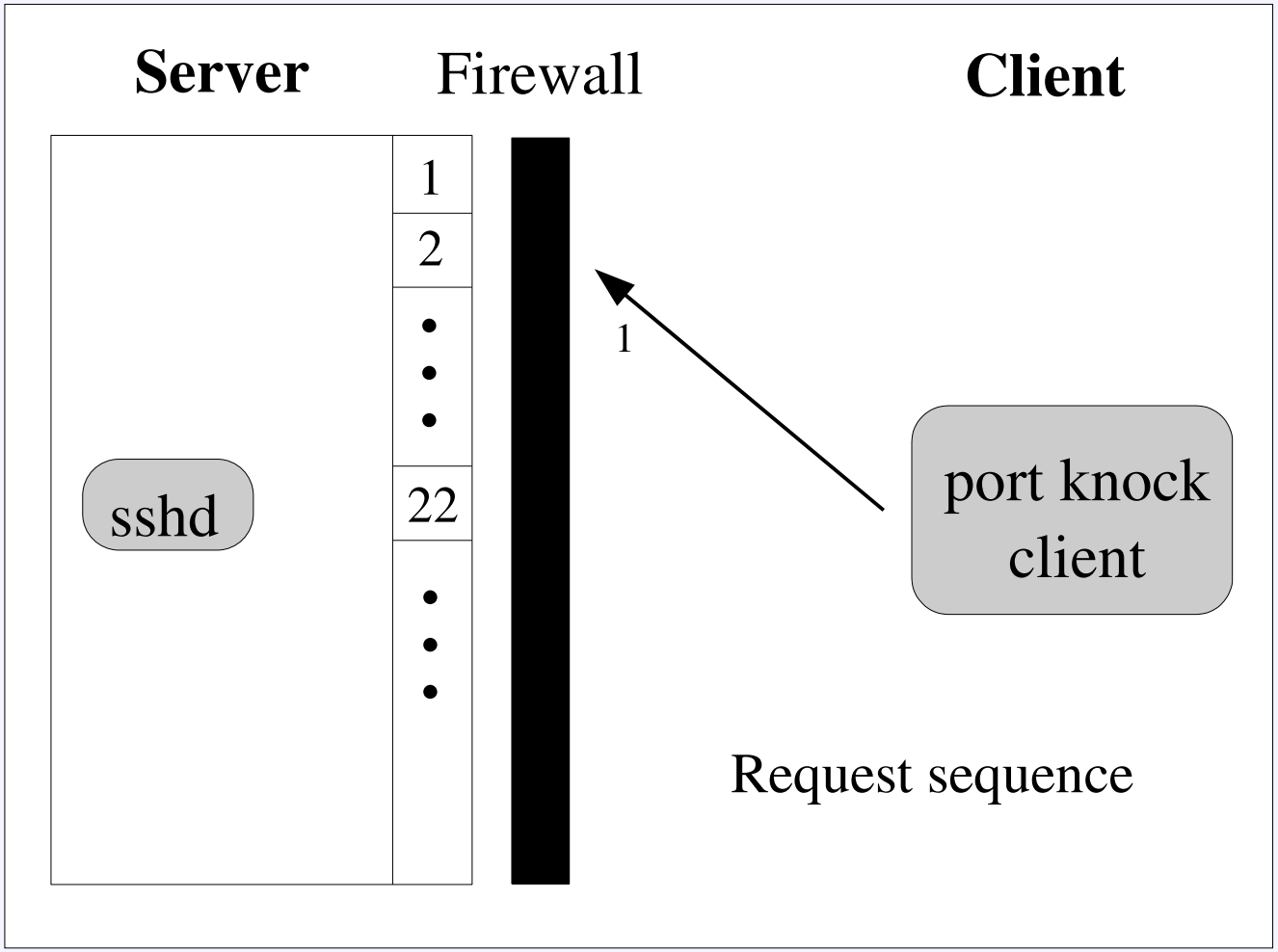
Enhancements to Port Knocking

- Challenge-response authentication that works even if the client is NATed
- Efficient encoding techniques that allow packets to be re-ordered on delivery

NAT-Aware Unilateral Authentication

- Variant on ISO two-pass unilateral authentication
- Uses server as an identity oracle for client
- The same idea also works for mutual authentication

Port Knocking with Strong Authentication



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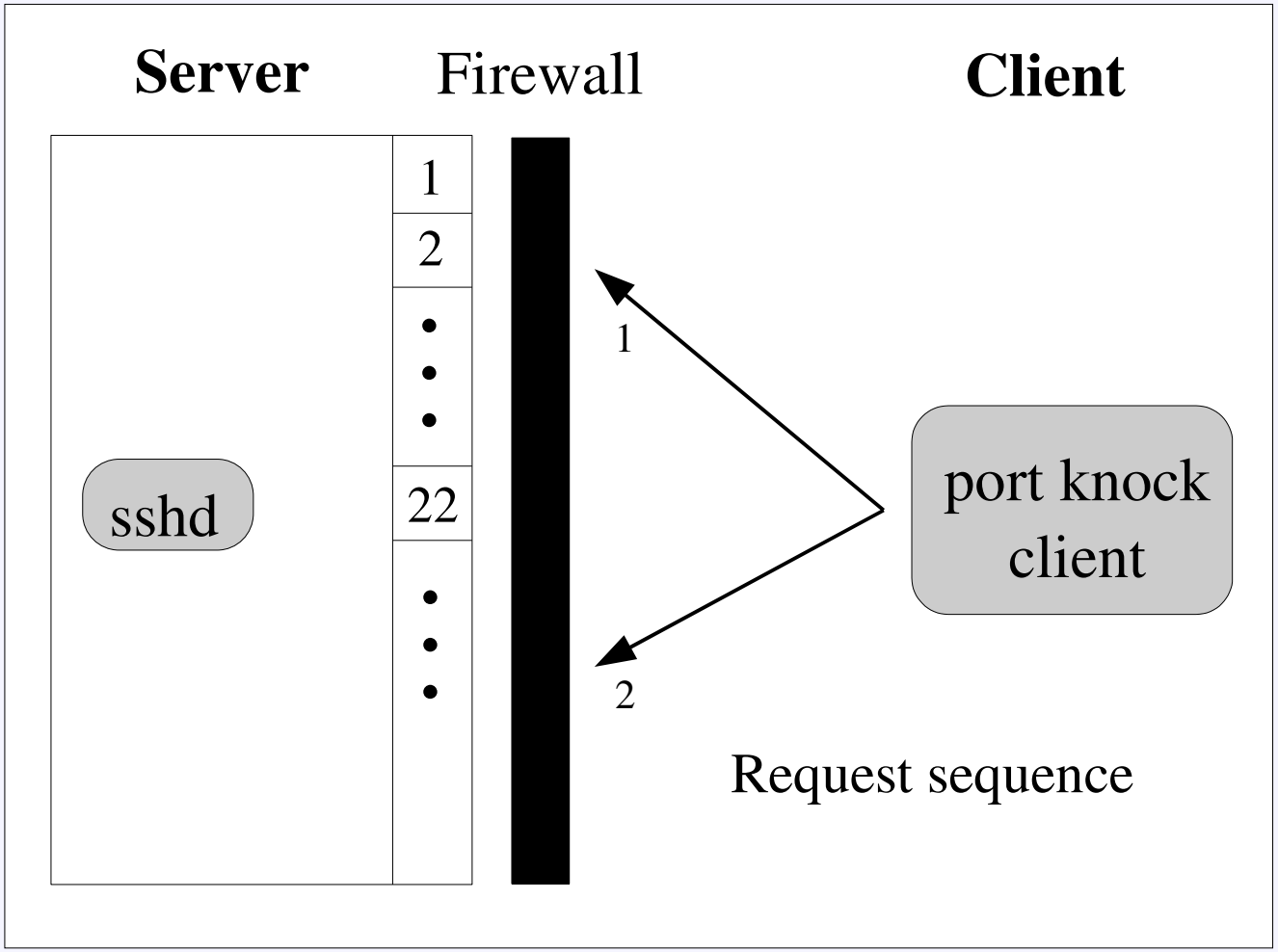

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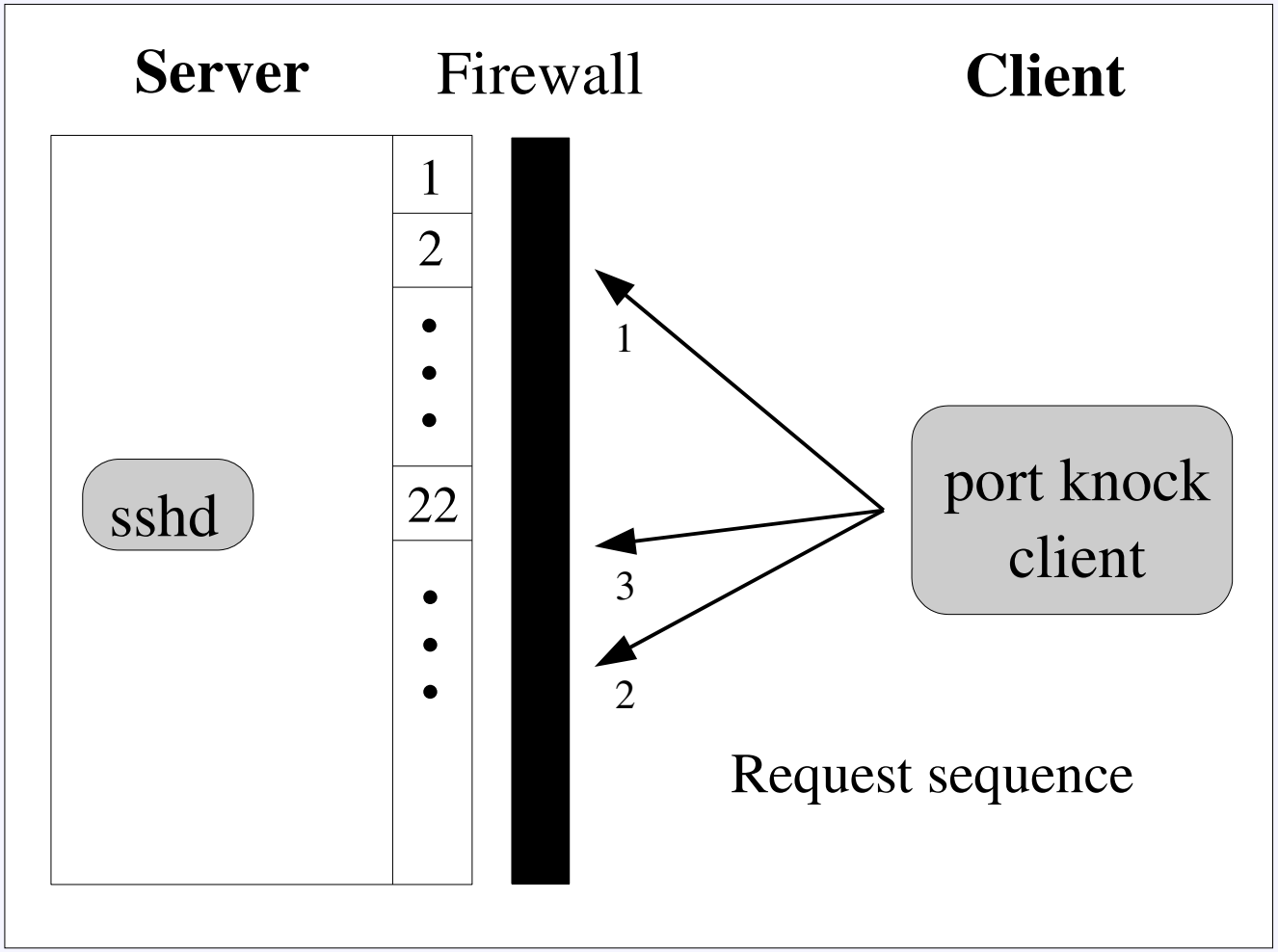

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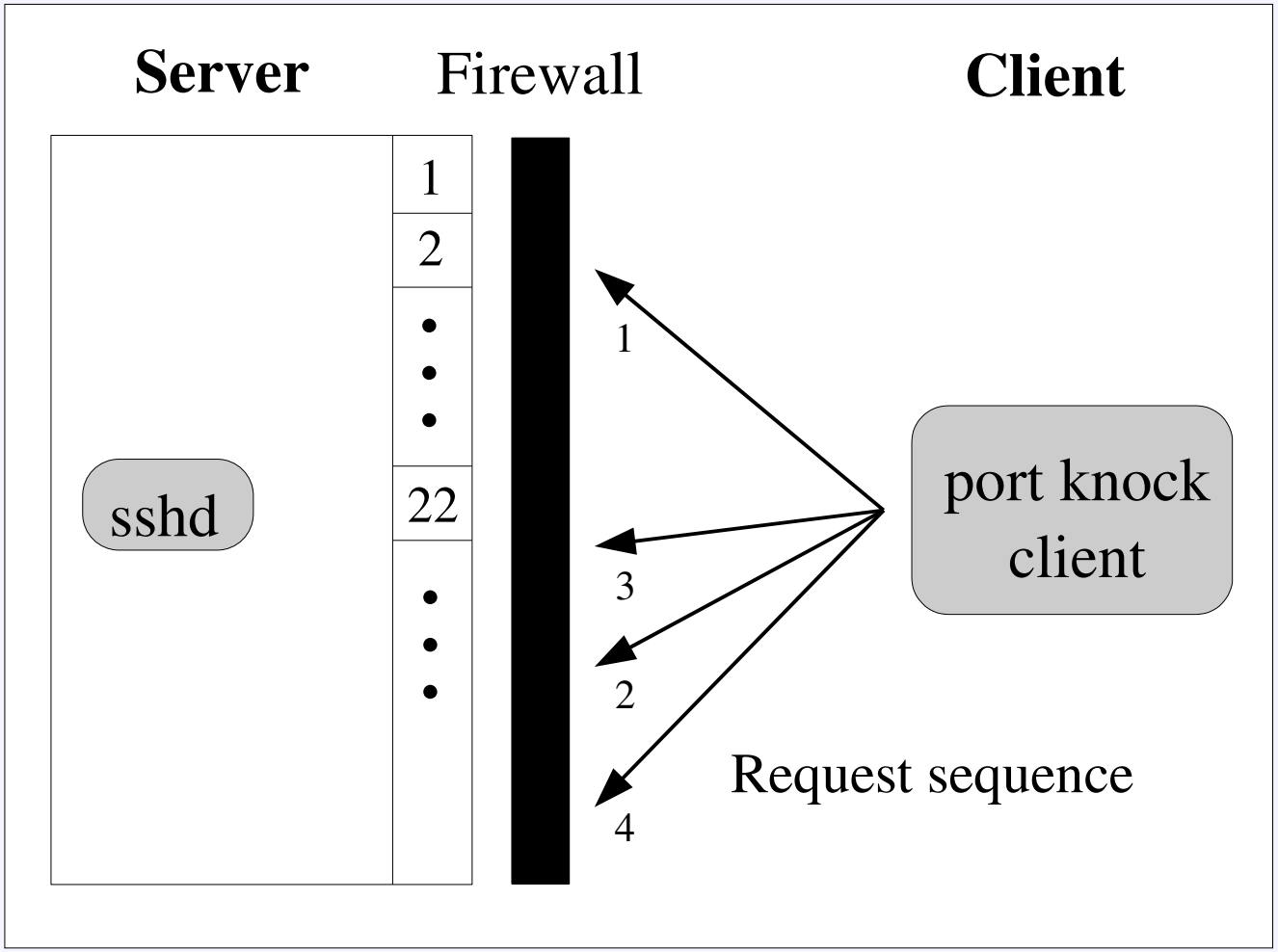

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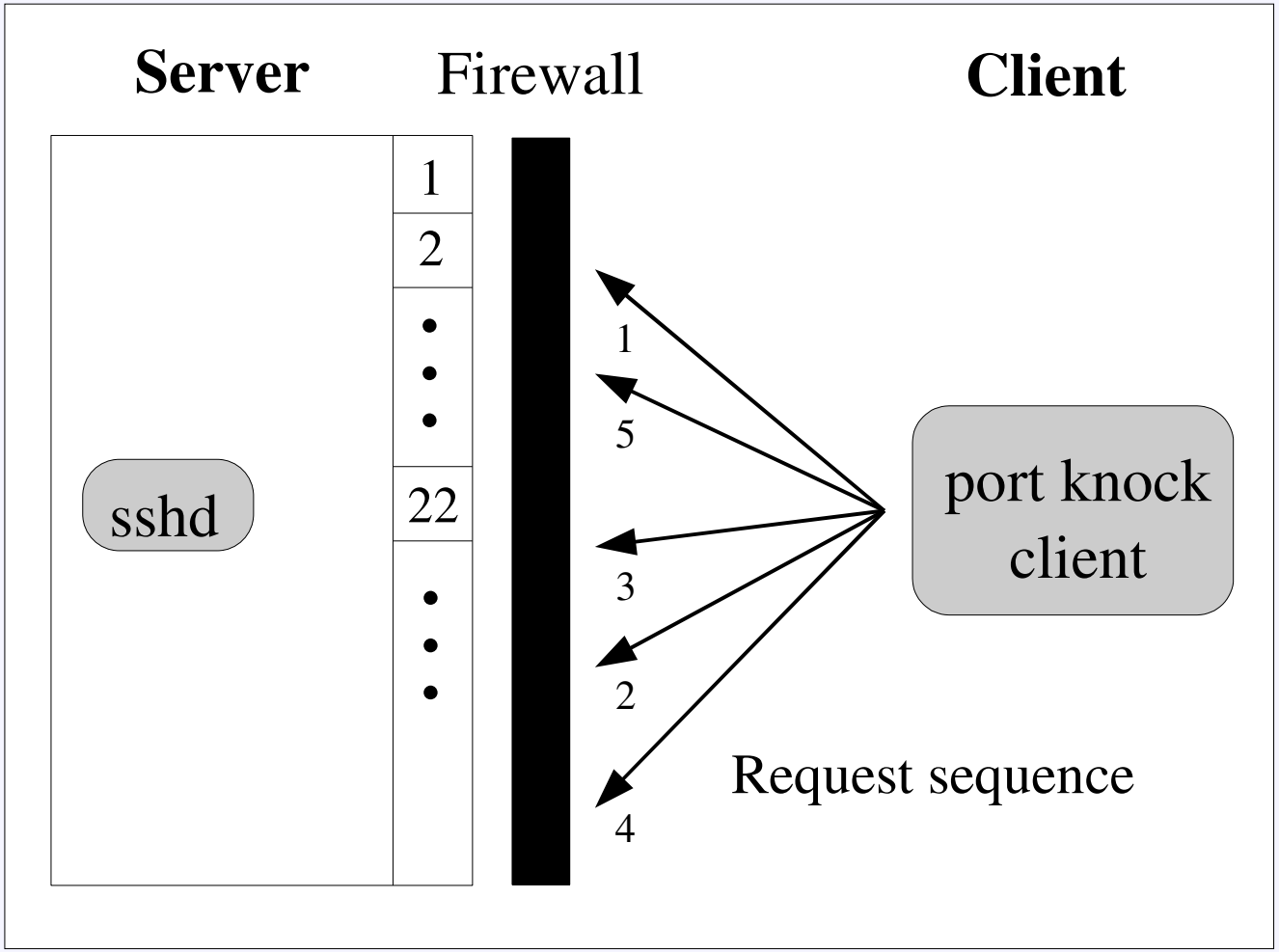

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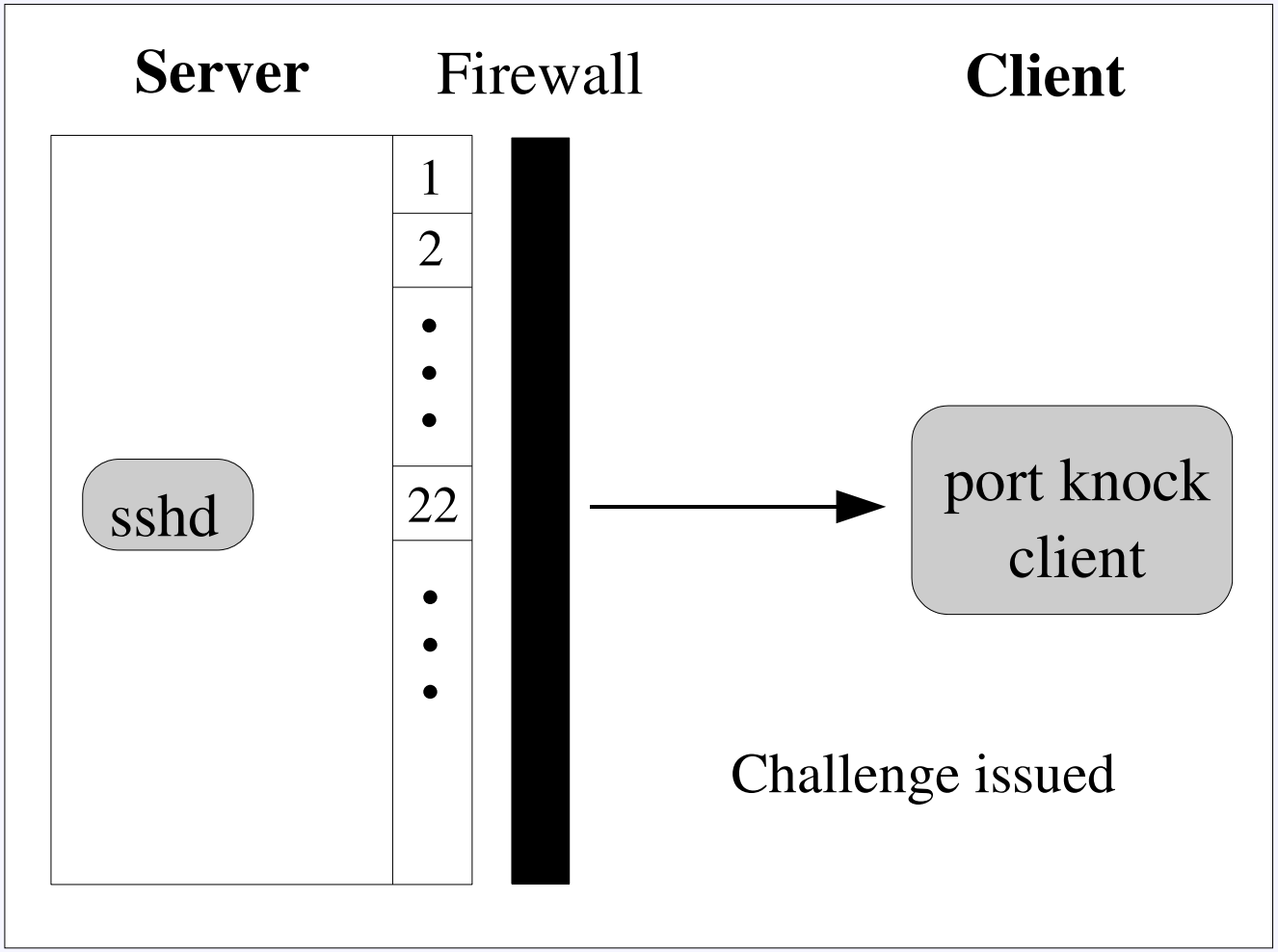

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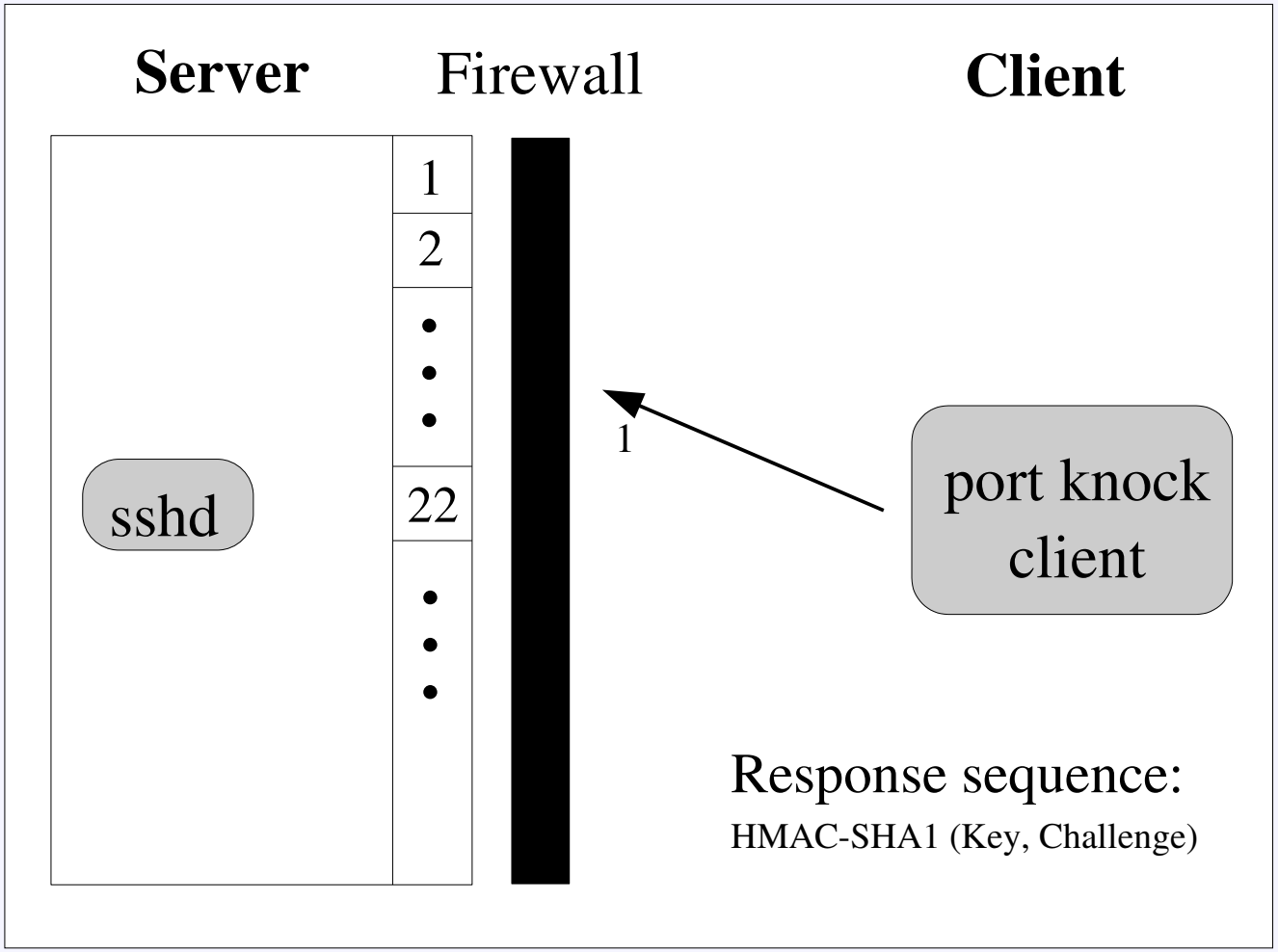

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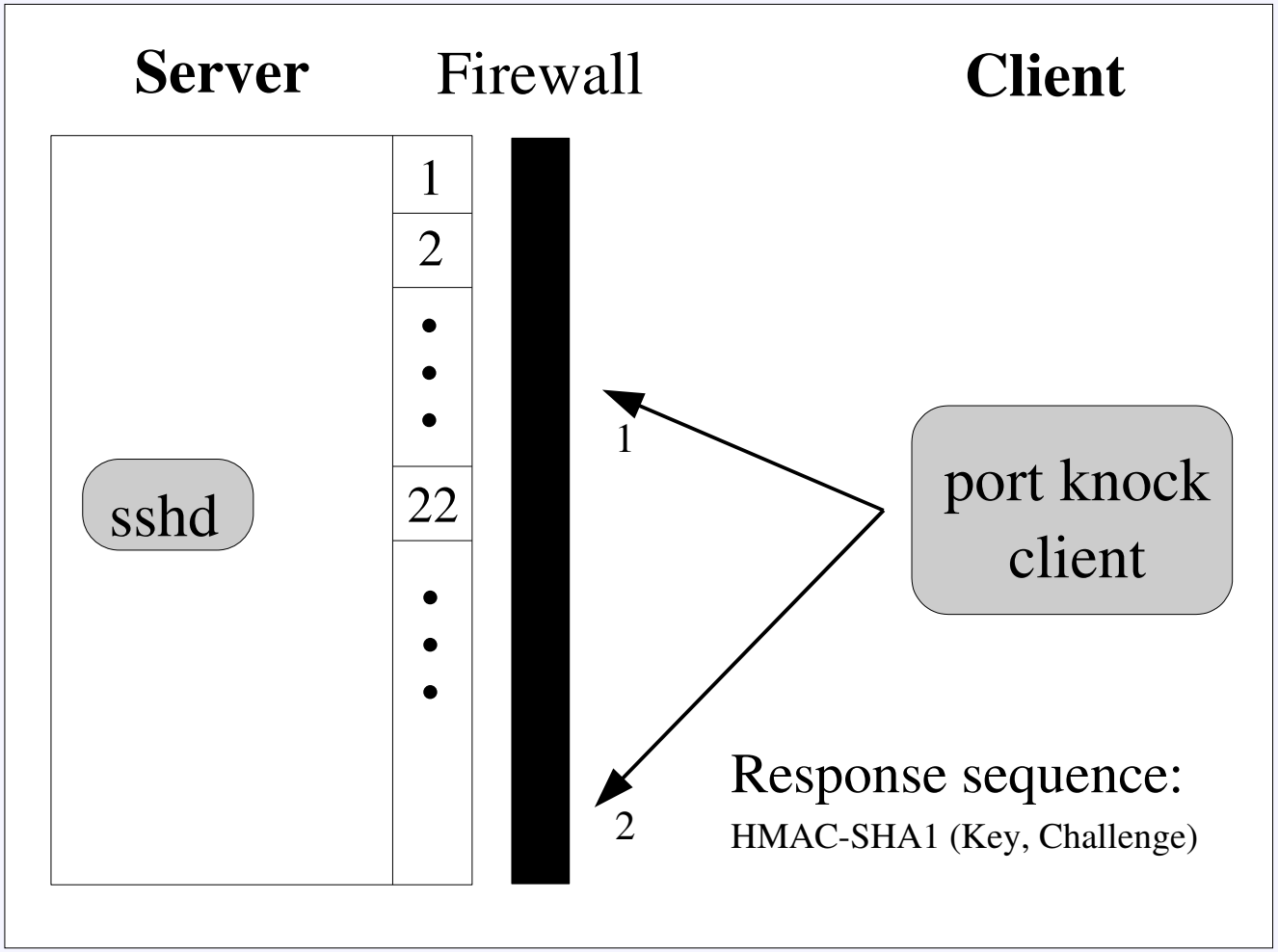

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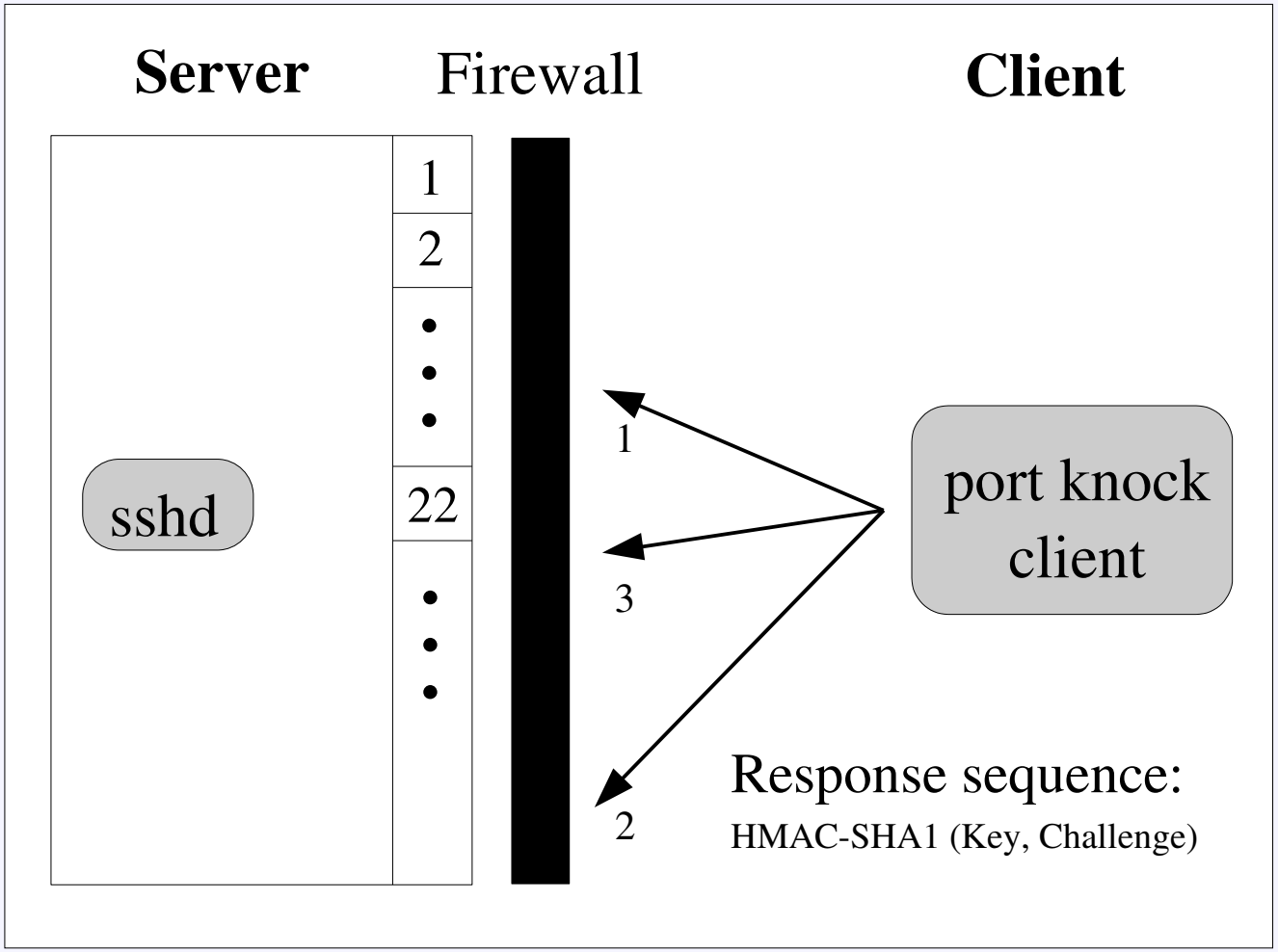

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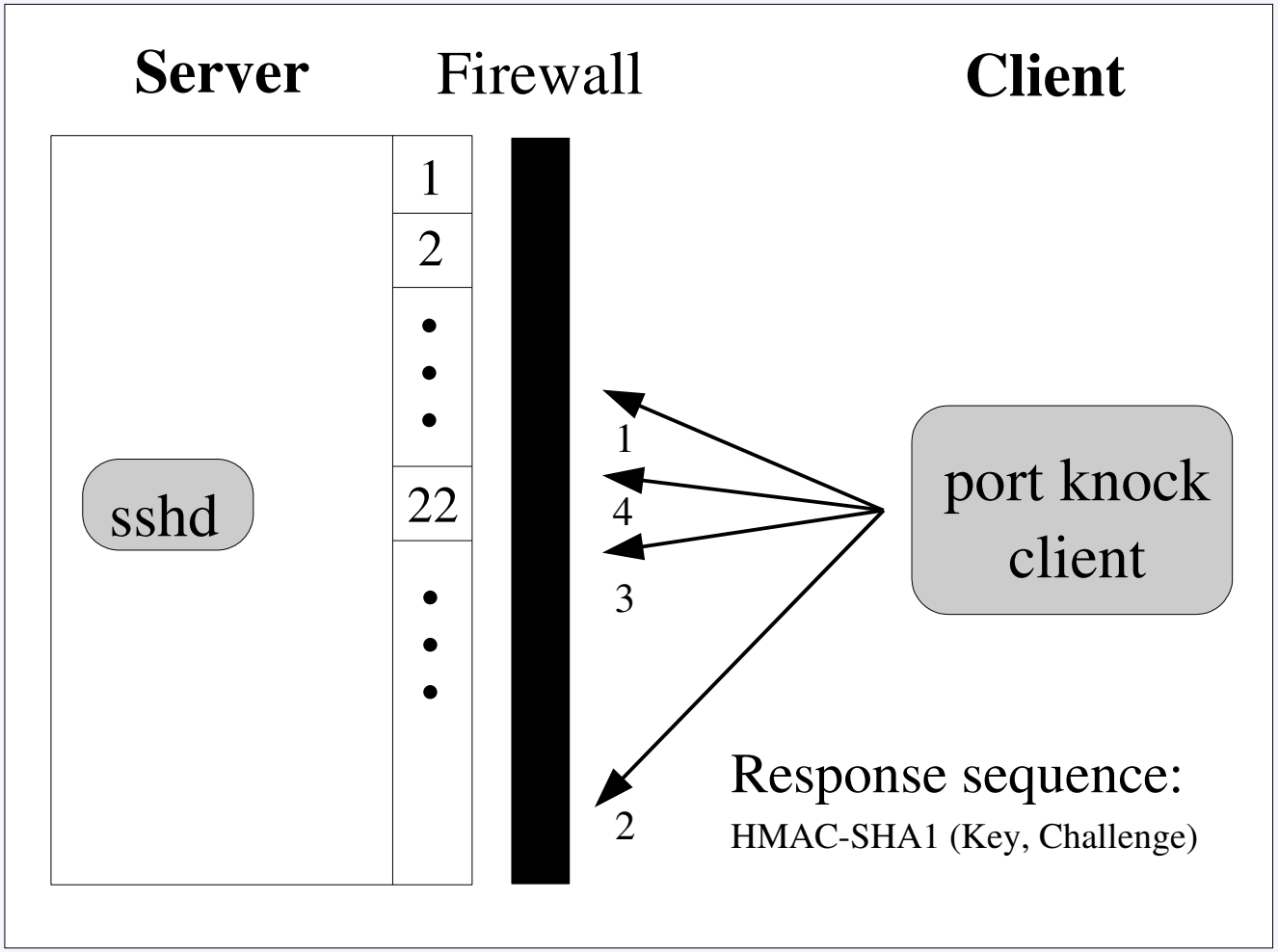

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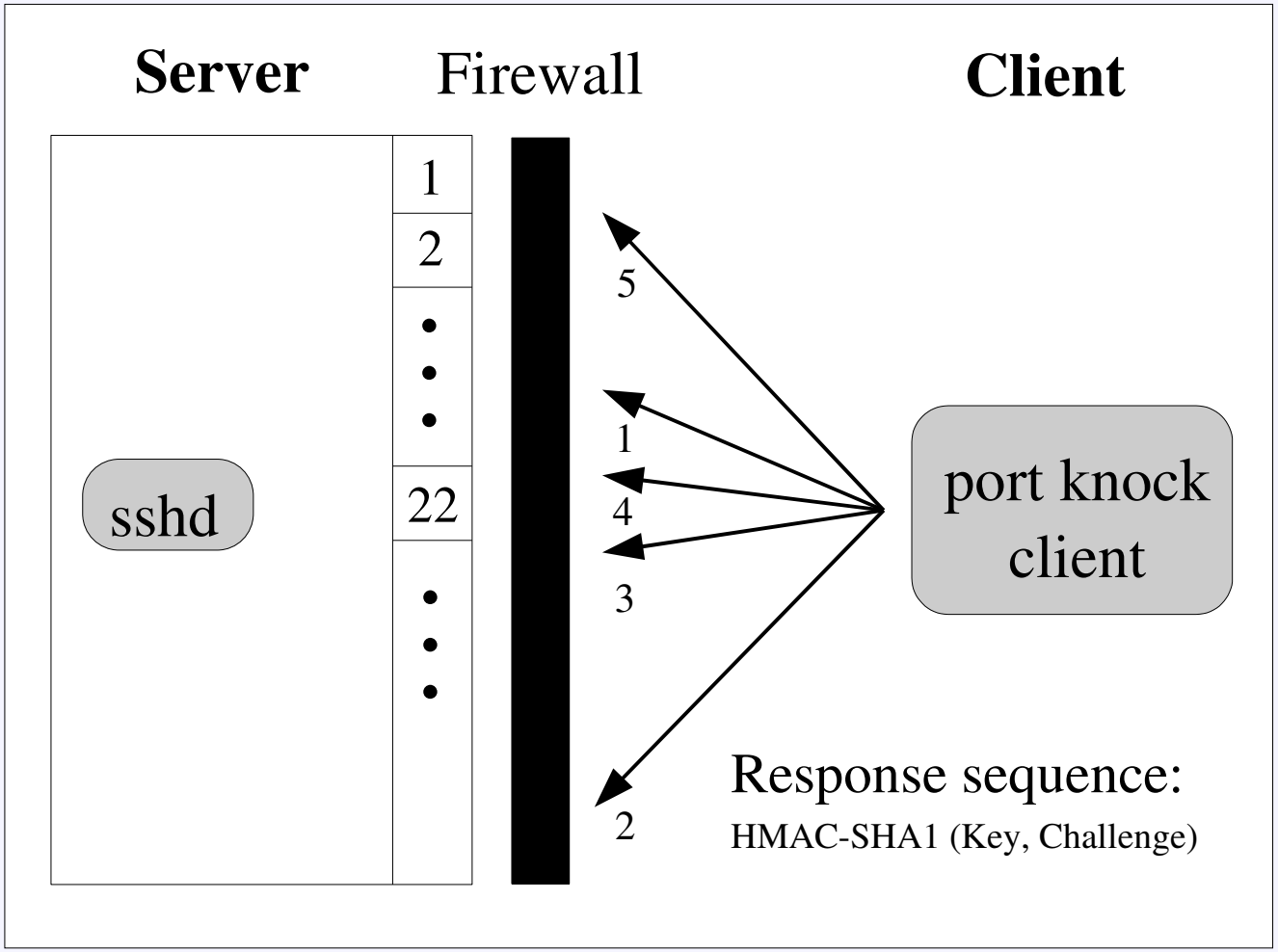

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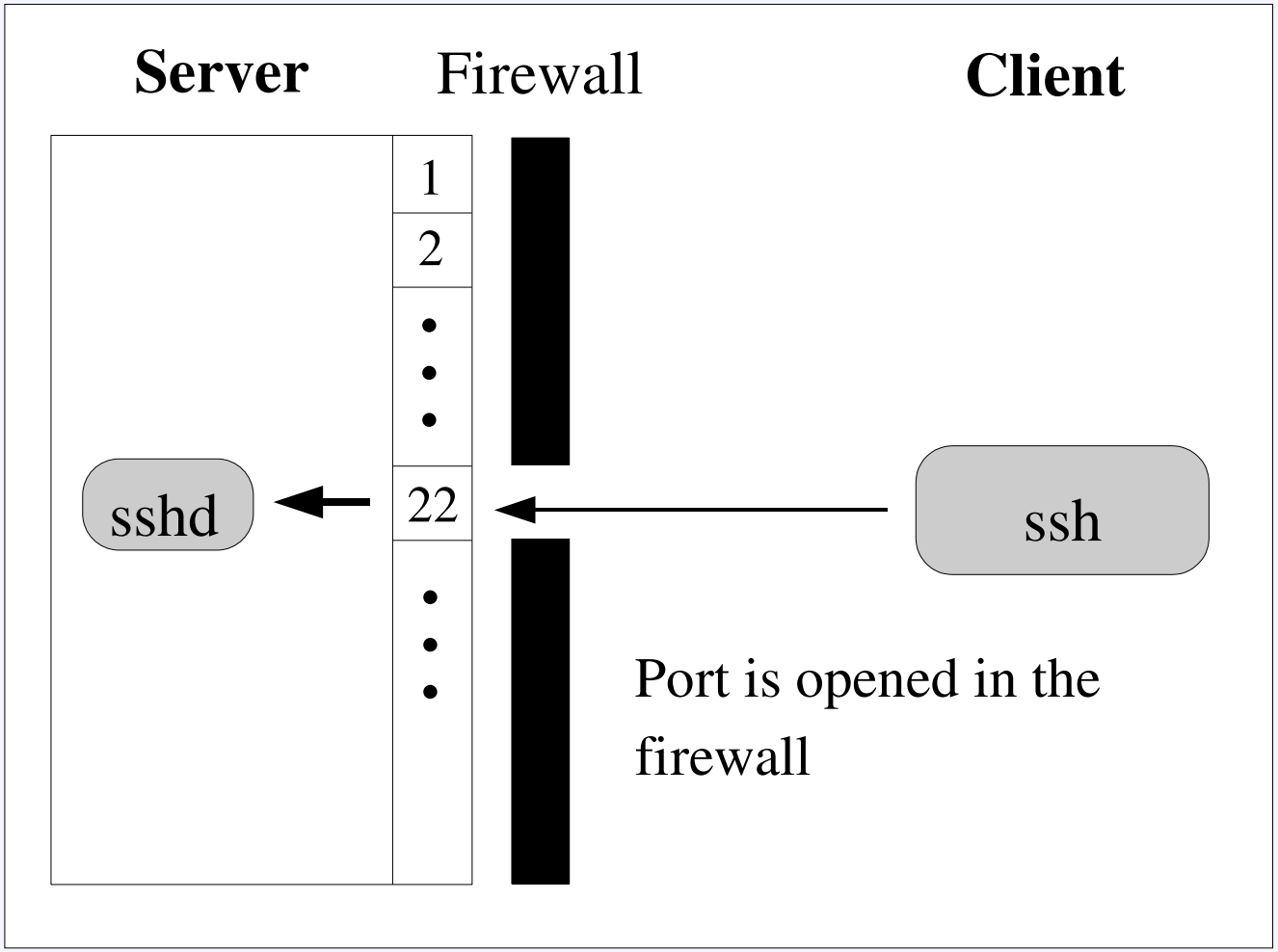

Packet Re-ordering

- Examined four methods
- Delay between sending
  - Slow
  - doesn't allow packet loss detection
- Separate data and sequence number fields
  - Long sequences require either large port ranges or long execution times

Packet Re-ordering

- Encode data as a monotonically increasing sequence
  - Example: 1st packet to [0, 255], 2nd to [256, 511], 3rd to [512, 767], etc.
  - Same run time as above, but requires fewer ports
  - Easier to use with disjoint port ranges
  - Optimal point: authentication in 0.278 seconds over 5120 ports on a slow network

Packet Re-ordering

```
Data:    73,  121,   92,  246,  149
```

Packet Re-ordering

```
Data:   73,  121,   92,  246,  149
```

Encode: send[i] = data[i] + 256*i + 1024

```
Send: 1097, 1401, 1628, 2038, 2197
```

Packet Re-ordering

```
Data:    73,  121,   92,  246,  149
```

Encode: send[i] = data[i] + 256*i + 1024

```
Send: 1097, 1401, 1628, 2038, 2197

Recv: 2197, 1079, 1628, 1401, 2038
```

Packet Re-ordering

```
Data:    73,  121,   92,  246,  149
```

Encode: send[i] = data[i] + 256*i + 1024

```
Send: 1097, 1401, 1628, 2038, 2197

Recv: 2197, 1079, 1628, 1401, 2038
```

Decode: sort(recv)

data[i] = recv[i] – 256*i - 1024

```
Data:    73,  121,   92,  246,  149
```

Packet Re-ordering

- Send packets with sequence numbers congruent mod *n* to the same range; others to different, unique ranges
  - Equivalent to previous method, except that the port range resets every *n* packets
  - Example: 1st packet to [0, 255], 2nd to [256, 511], ..., 21st to [0, 255], ...
  - Chance of failure
  - Only useful for long sequences (n > ~20)

Weaknesses of Our Design

- No authentication-connection association
- If client is NATed, the server opens the port to the entire NATed network
- Knock sequences may be blocked by egress filters
- Failure on packet loss

Summary

- Port knocking is a practical way to add a light-weight authentication wrapper around existing services
- Current port knocking implementations have a variety of problems
- We have found solutions to several of these problems

Questions?

Improved Port Knocking with Strong Authentication

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