

# **Smoke**

An Android Echo Software Application

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## About

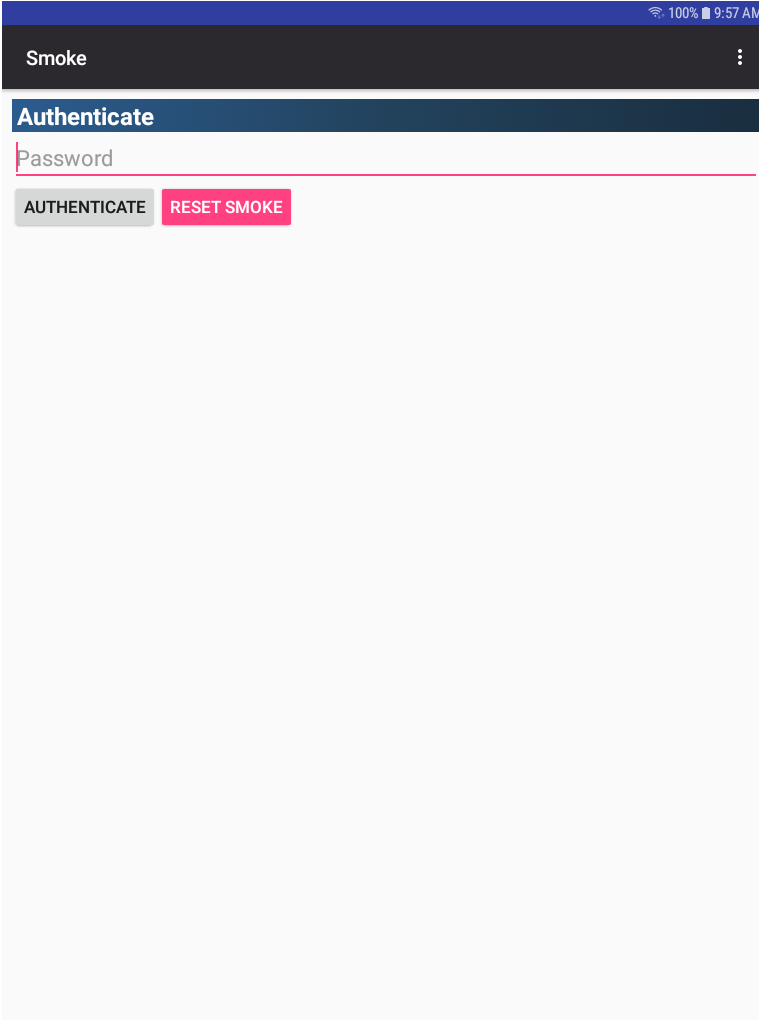
Smoke is an Android communications research project. The software is composed of a single multi-threaded application. A companion application, SmokeStack, provides mobile server services.

Software sources are available at <https://github.com/textbrowser/smoke> and <https://github.com/textbrowser/smokestack>.

## Activity Authenticate

After launching a prepared Smoke installation, the Authenticate activity is displayed. The original password must be provided. If the correct password is provided, essential containers are populated and the kernel is activated. The previously-accessed activity is activated.

Smoke may also be reset within the Authenticate activity.

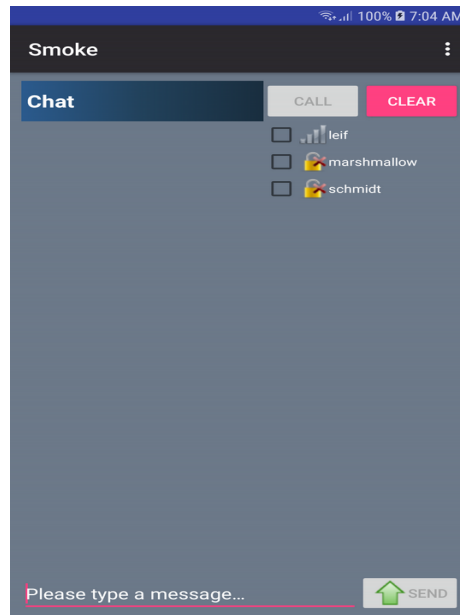


The screenshot shows a mobile application interface for the 'Smoke' application. At the top, a dark blue header bar contains the word 'Smoke' on the left and a vertical ellipsis menu icon on the right. Below this header, a dark blue bar displays the title 'Authenticate'. Underneath the title is a text input field labeled 'Password' with a red underline. At the bottom of the interface, there are two buttons: a grey button labeled 'AUTHENTICATE' and a red button labeled 'RESET SMOKE'. The status bar at the very top of the screen shows a Wi-Fi icon, 100% battery, and the time 9:57 AM.

## Activity Chat

The Chat activity is one of two messaging activities. From this activity, one may message one or more defined participants. If Smoke is connected to at least one network peer, a green network icon is displayed. Otherwise, a red network icon is displayed.

Before a messaging session may begin between two participants, the parties must exchange private key material. Exchanging private key material may be achieved via the Call and Custom Session mechanisms.



A context menu may be activated by pressing and holding on the right-hand Participants widget. Menu items are described below.

### Custom Session

Private key material may be generated per the selected participant. The generated material is not transferred on the network.

### Optional Signatures

Messaging and status messages are digitally signed. Signatures may be disabled per participant. Please note that if one party requires signatures and signatures are not provided by the other party, messages will be ignored by the receiving party.

### Purge Session

Discard private key material for the specified participant.

### Refresh Participants Table

Refresh the Participants widget.

### Retrieve Messages

Retrieve messages from SmokeStack instances. An Ozone and an active network must be present for this option to be enabled.

### Show Details

Disable or enable various Participants details.

### Show Icons

Disable or enable participant presence icons.

## Activity Fire

The Fire activity is one of two messaging activities. From this activity, one may communicate with one or more groups of anonymous participants. If Smoke is connected to at least one network peer, a green network icon is displayed. Otherwise, a red network icon is displayed. Fire is compatible with Spot-On's Buzz. 256-bit AES-CBC along with SHA-384 HMAC address the encryption and authentication requirements.

Smoke

Details

Name

Fire

Fire Channels

Spot-On\_Develope..

Spot-On\_Developer\_C  
hannel\_Key

smokey

## Activity Settings

The Settings activity contains various configurable items. Smoke may also be reset from this activity. This page will describe miscellaneous portions.

### About

Describes software information, including the Android version of the device. Log clearing may also be performed in this section. The Prefer Active CPU option, if enabled, ensures that the CPU remains active if the screen is turned off.

### Ozone

One Ozone address may be defined in this section. Please refer to the Ozone page for more details.

### Password

Generate new local authentication and encryption keys as well as public and private key pairs. If confirmed, all existing data will be purged.

### Public Data

Contains the SipHash Chat ID. A SipHash Identity is synonymous to an e-mail address. Basic public-key data is also displayed in this section.



## Android

Smoke has been successfully tested on Android versions 4.4, 5.0, 5.1, 6.0, 7.0, and 7.1. Android versions 4.4, 5.0, and 5.1 are not officially supported.

According to <https://developer.android.com/about/dashboards/index.html>, Smoke supports 92.7% of all Android versions.

## **Congestion Control**

Smoke implements a software-based congestion control mechanism. The SipHash algorithm is used for computing digests. Computed digests are stored in an SQLite database table. Routinely, expired entries are removed.

## Corrupted Database Values

Encrypted database values pose an interesting design problem. How should an application depict a faulty database value to the user if the application is unable to properly decrypt an encrypted value? Some software packages ignore the potential problem altogether. Others, delete or hide the corrupted entries; logging the failures in squandered logs. Smoke offers an exceptionally-transparent solution. Damaged database entries are depicted in various containers. These depictions offer insight into potential system failures.

## Database Containers

Most of the database fields contain authentically-encrypted values. Some fields contain keyed digests, including keyed digests of binary (false / true) values. Values are stored as  $E(\text{Data}, K_e) \parallel \text{HMAC}(E(\text{Data}, K_e), K_a)$  and  $\text{HMAC}(\text{Data}, K_a)$ . 256-bit AES-CBC is used for encrypting data. SHA-512 HMAC is used for data authentication.

## Developers

Android Studio is required for development. Please download the application from <https://developer.android.com/studio/index.html>. Building Smoke may be performed via Studio or a terminal. Please refer to the included Makefile and Makefile.linux for guidance.

## Discovery via Cryptography

Cryptographic discovery is a mechanism which allows servers to lighten the computational and data responsibilities of mobile devices.

Shortly after a Smoke instance connects to a SmokeStack service, the Smoke instance shares some non-private material. The material allows a SmokeStack server to transfer messages to their correct destinations. SmokeStack instances routinely distribute gathered, non-expired material to other SmokeStack services, thus creating a network of cooperative SmokeStack faculties.

Cryptographic Discovery assumes a trustworthy network.

To mitigate replay attacks, Smoke offers SmokeStack instances random identity streams during message-retrieval requests. The identity streams self-expire.

## Distribution

Smoke is distributed in debug (smoke-debug.apk) and release (smoke.apk) forms. The release bundle is signed and includes the source.

## Exchanging Private Credentials

The Calling feature allows two parties to exchange private key material. Please note that messages which have been recorded in a SmokeStack instance via one set of credentials will not be available if the credentials have changed. The process of exchanging private credentials is as follows:

1. A participant issues a Call via a selected participant. A new 2048-bit RSA public-key pair is generated. A signature fastening the two participants is computed. The bundle is then transferred to the recipient.
2. A participant receives the bundle, verifies the included signature, generates private authentication and encryption keys, and bundles the private key material via the included public RSA key. The participant transfers the signed private key material bundle to the initial participant.
3. The initiating participant receives the private key material, verifies the included signature, and unpackages the private key material via the ephemeral private key.



## Fire

Fire introduces communication networks between Smoke and Spot-On. Key generation is described below.

```
authentication_key = pbkdf2(sha512(Digest || "sha384"), // Salt
                             Digest,
                             10000,
                             768)                      // Bits (96 Bytes)
authentication_key, destination_key := authentication_key[0 ... 31], authentication_key[32 ... ]
encryption_key := pbkdf2(Salt,
                          Channel || "aes256" || "sha384",
                          10000,      // Iteration Count
                          2304)       // Bits (288 Bytes)
encryption_key := encryption_key[0 ... 31]
```

## Inflate

Smoke expands text-messaging data to 8192 bytes. If the provided data exceeds 8192 bytes, Smoke expands the provided data by  $1024 + \text{mod}(\text{data length}, 2)$  bytes. Inflation does not apply to Fire as Fire must remain compatible with Spot-On.

## McEliece CCA2

As of version Drooling Dragon, Smoke supports McEliece-Fujisaki via BouncyCastle. Parameters are SHA-256,  $m = 11$ ,  $t = 50$ . Some discussions:

- Authentication process may require several minutes to complete.
- Communications between McEliece and RSA are fully functional.
- During the key-sharing process, McEliece signatures are not provided and therefore are not verified.
- Expect degraded performance.
- Initialization processes may require several minutes to complete.

## Message Structures

This page will detail the various message structures.

### CALL-HALF-AND-HALF-A

[PK] (1) McEliece 352 Bytes, RSA Key Size / 8 Bytes

```
{
    AES-256 Key (1)
    SHA-512 Key (2)
}
```

[AES-256] (2)

```
{
    0x00 (1) 1 Byte
    A Timestamp (2) 8 Bytes
    RSA 2048-Bit Public Key (3) 294 Bytes
    Sender's Identity (4) 8 Bytes
    Sender's Public Encryption Key SHA-512 Digest (5) 64 Bytes
    [PK Signature] (6) Variable Bytes
    {
        [PK] (1 ... 2) || [AES-256] (1 ... 5) ||
        Recipient's Public Encryption Key SHA-512 Digest (1)
    }
}
```

[SHA-512 HMAC] (3) 64 Bytes

```
{
    [PK] || [AES-256] (1)
}
```

/\*

\*\* The destination is created via the recipient's SipHash identity.

\*/

[Destination SHA-512 HMAC] (4) 64 Bytes

```
{
    [PK] || [AES-256] || [SHA-512] (1)
```

```
}
```

## CALL-HALF-AND-HALF-B

```
[PK] (1)                                McEliece 352 Bytes, RSA Key Size / 8 Bytes
```

```
{
```

```
    AES-256 Key (1)
```

```
    SHA-512 Key (2)
```

```
}
```

```
[AES-256] (2)
```

```
{
```

```
    0x01 (1)                                1 Byte
```

```
    A Timestamp (2)                        8 Bytes
```

```
    RSA 2048-Bit Public Key (3)            256 Bytes
```

```
    {
```

```
        AES-256 Key (1)
```

```
        SHA-512 Key (2)
```

```
    }
```

```
    Sender's Identity (4)                  8 Bytes
```

```
    Sender's Public Encryption Key SHA-512 Digest (5) 64 Bytes
```

```
    [PK Signature] (6)                    Variable Bytes
```

```
    {
```

```
        [PK] (1 ... 2) || [AES-256] (1 ... 5) ||
```

```
        Recipient's Public Encryption Key SHA-512 Digest (1)
```

```
    }
```

```
}
```

```
[SHA-512 HMAC] (3)                        64 Bytes
```

```
{
```

```
    [PK] || [AES-256] (1)
```

```
}
```

```
/*
```

```
** The destination is created via the recipient's SipHash identity.
```

```
*/
```

[Destination SHA-512 HMAC] (4)      64 Bytes

```
{
    [PK] || [AES-256] || [SHA-512] (1)
}
```

## CHAT

[PK] (1)      McEliece 320 Bytes, RSA Key Size / 8 Bytes

```
{
    Sender's Public Encryption Key SHA-512 Digest (1)      64 Bytes
}
```

[AES-256] (2)

```
{
    0x00 (1)      1 Byte
    A Timestamp (2)      8 Bytes (Base-64)
    Message (3)      Variable Bytes (Base-64)
    Sequence (4)      8 Bytes (Base-64)
    [PK Signature] (5)      Variable Bytes (Base-64)
    {
        [PK] (1) || [AES-256] (1 ... 4) ||
        Recipient's Public Encryption Key SHA-512 Digest (1)
    }
}
```

[SHA-512 HMAC] (3)      64 Bytes

```
{
    [PK] || [AES-256] (1)
}
```

/\*

\*\* The destination is created via the recipient's identity.

\*/

[Destination SHA-512 HMAC] (4)      64 Bytes

```
{
    [PK] || [AES-256] || [SHA-512 HMAC] (1)
```

}

## CHAT-RETRIEVAL

[AES-256] (1)

{

0x00 (1)	1 Byte
A Timestamp (2)	8 Bytes
An Identity (3)	64 Bytes
Sender's Public Encryption Key SHA-512 Digest (4)	64 Bytes
[PK Signature] (5)	Variable Bytes
{	
[AES-256] (1 ... 4) (1)	
}	

}

[SHA-512 HMAC] (2)                      64 Bytes

{

    [AES-256] (1)

}

## CHAT-STATUS

[PK] (1)                                  McEliece 320 Bytes, RSA Key Size / 8 Bytes

{

    Sender's Public Encryption Key SHA-512 Digest (1)      64 Bytes

}

[AES-256] (2)

{

0x01 (1)	1 Byte
A Timestamp (2)	8 Bytes
Status (3)	1 Byte (Ignored)
[PK Signature] (4)	Variable Bytes
{	

    [PK] (1) || [AES-256] (1 ... 3) ||

    Recipient's Public Encryption Key SHA-512 Digest (1)

```
    }  
}
```

```
[SHA-512 HMAC] (3)          64 Bytes  
{  
    [PK] || [AES-256] (1)  
}
```

```
/*  
** The destination is created via the recipient's identity.  
*/
```

```
[Destination SHA-512 HMAC] (4)    64 Bytes  
{  
    [PK] || [AES-256] || [SHA-512 HMAC] (1)  
}
```

## EPKS

```
[AES-256] (1)  
{  
    A Timestamp (1)          8 Bytes (Base-64)  
    Key Type (2)             1 Byte (Base-64)  
    Public Key (3)           Variable Bytes (Base-64)  
    Public Key Signature (4)  Variable Bytes (Base-64)  
    Signature Public Key (5)  Variable Bytes (Base-64)  
    Signature Public Key Signature (6) Variable Bytes (Base-64)  
}
```

```
[SHA-512 HMAC] (2)          64 Bytes  
{  
    [AES-256] (1)  
}
```

```
/*  
** The destination is created via the recipient's SipHash identity.  
*/
```



```
[Destination SHA-512 HMAC] (3)          64 Bytes
{
    [AES-256] || [SHA-512 HMAC] (1)
}
```

## FIRE-CHAT

```
[AES-256] (1)
{
    0040b (1)          Base-64
    \n
    Name (2)           Base-64
    \n
    ID (3)             Base-64
    \n
    Message (4)        Base-64
    \n
    UTC Date (5)       Base-64
}
```

```
[SHA-384 HMAC] (2)          Base-64
{
    [AES-256] (1)
}
```

```
[Destination SHA-512 HMAC] (3)      Base-64
{
    [AES-256] || [SHA-384 HMAC] (1)
}
```

## FIRE-STATUS

```
[AES-256] (1)
{
    0040a (1)          Base-64
    \n
```

```

    Name (2)          Base-64
    \n
    ID (3)            Base-64
    \n
    UTC Date (4)      Base-64
}

```

```

[SHA-384 HMAC] (2)          Base-64
{
    [AES-256] (1)
}

```

```

[Destination SHA-512 HMAC] (3)      Base-64
{
    [AES-256] || [SHA-384 HMAC] (1)
}

```

## PKP-REQUEST

```

[AES-256] (1)
{
    0x01 (1)          1 Byte
    A Timestamp (2)    8 Bytes
    Destination SipHash Identity (3)  23 Bytes
    Requested SipHash Identity (4)    23 Bytes
}

```

```

[SHA-512 HMAC] (2)          64 Bytes
{
    [AES-256] (1)
}

```

# Neighbors

New neighbors may be defined via the Settings activity. This page will describe the various nuances of network peers.

Smoke offers infinitely-many IPv4 and IPv6 TCP and UDP client definitions. Each network peer includes dedicated and independent parsing-data, read-socket, and write-socket threads. TCP neighbors support HTTP and SOCKS proxies. Please note that host translations are not performed via the defined proxies.

A pull-down menu accompanies each defined neighbor.

## Connect

Instruct Smoke to place the specified neighbor in a connect status. Connection attempts are performed every 2.5 seconds. TCP sockets are required to connect within 10 seconds. After connections are established, SSL/TLS handshakes must be completed within 10 seconds.

## Delete

Display a confirmation prompt. If confirmed, the specified neighbor is scheduled for deletion.

## Disconnect

Instruct Smoke to place the specified neighbor in a disconnect status.

## Purge Queue

Purge the outbound queue of the specified neighbor.

## Reset SSL/TLS Credentials

Reset the locally-stored SSL/TLS credentials of TCP neighbors.

A connected neighbor attempts to read 1 MiB of data from its socket every 100 milliseconds. The read request blocks for at most 2.5 seconds. If data is successfully read, it is appended to an internal buffer. The internal buffer may accumulate at most 8 MiB of data, with the potential of overflow. Parsing of data occurs every 100 milliseconds. Because the parsing and read threads are independent, it's possible that the internal buffer may temporarily overflow.

Each neighbor object includes two internal queues, Echo and real-time queues. Echo queues allow Smoke to echo internal data from local neighbor to local neighbor. This mechanism must be enabled via the Echo option. Each Echo queue may contain at most 256 messages. Please note that the Echo mechanism may burden a device. A neighbor will echo data if it discovers that the data is not intended for it. Calling, Chat statuses, Fire messages, Fire statuses, and SmokeStack message-retrieval requests utilize real-time queues. Real-time queues are not bound.

Various per-neighbor statistics are included in the Settings activity. Also included are per-neighbor descriptive errors.

## New Installation

After launching a new installation of Smoke, some initial settings are required.

### Encryption

Public-key algorithm. McEliece-Fujisaki and 3072-bit RSA are supported.

### Iteration Count

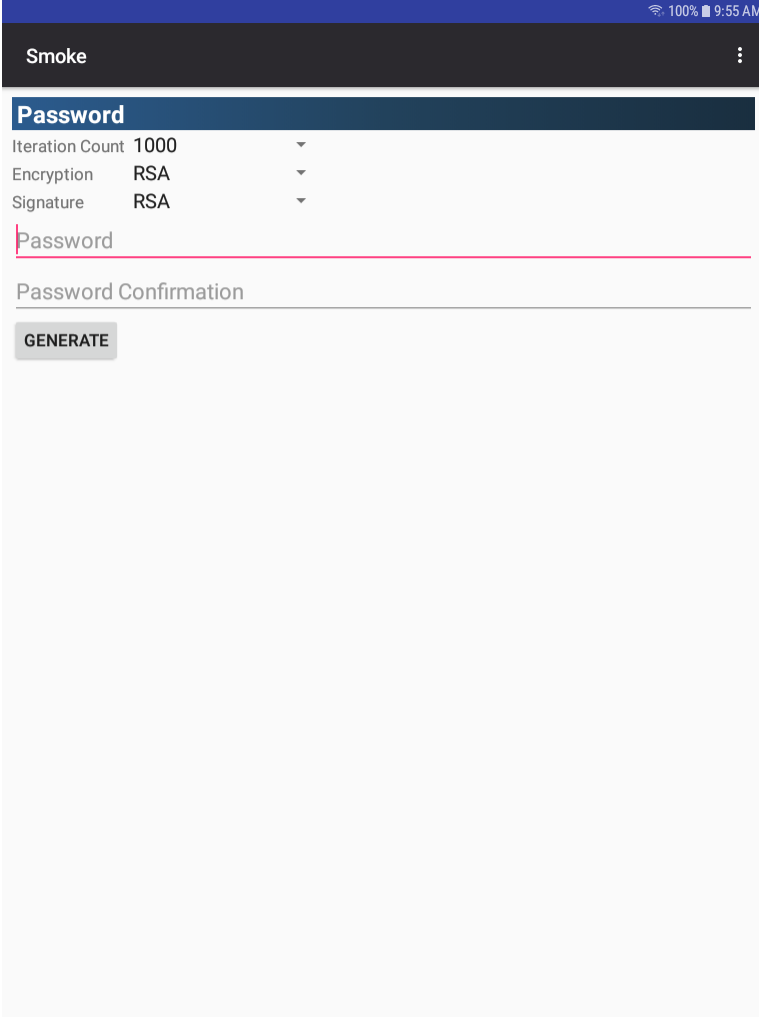
Local authentication and encryption keys are generated via PBKDF2. The function requires an iteration count. If the selected value exceeds 7500, a confirmation prompt is displayed.

### Password

At least one character is required.

### Signature

Public-key digital signatures. 384-bit ECDSA and 3072-bit RSA are supported.



The screenshot shows the 'Smoke' application interface for a new installation. At the top, there's a status bar with 'Smoke' and a menu icon. Below it, a 'Password' section is highlighted. The settings are as follows:

Password	
Iteration Count	1000
Encryption	RSA
Signature	RSA

Below the settings, there are two input fields: 'Password' and 'Password Confirmation'. The 'Password' field has a red border, indicating it's required. At the bottom, there is a 'GENERATE' button.

## Outbound Queues

Smoke offers near-real-time communications. As network services may be unreliable, certain outbound messages are enqueued in an SQLite database table. Each network peer is assigned a separate queue. Messages are dequeued in a timely manner and placed onto the network. Calling messages, retrieval of offline messages, and status messages are considered expendable and are therefore written to network sockets regardless of network availability.

Please note that peers which are in disconnected status-control states are ignored during the enqueue processes.

## Ozone Address

An Ozone address may be assigned the Settings activity.

An Ozone address is a pseudo-private string which identifies a virtual entity. Smoke and SmokeStack utilize Ozones as a means of retrieving and storing offline messages and public-key pairs. Smoke supports one Ozone while SmokeStack supports infinitely many. Ozone addresses must be exchanged separately. Retrieved messages are only meaningful within the context of a session. It is possible for multiple Smoke parties to house distinct Ozones if common SmokeStack instances are aware of the distinct Ozone addresses.

Please note that public Ozone addresses will introduce denial of service vulnerabilities.

## Participants

Participant SipHash Identities may be defined within the Participants section of the Settings activity. After defining a participant, local public-key pairs may be shared manually. An automatic process distributes key pairs to participants which have not been paired. A context menu may also be activated by pressing and holding on the Participants widget. The contents of the menu are described below.

### Delete (SipHash Identity)

Delete the selected participant. A confirmation dialog is displayed.

### Request Keys via Ozone (SipHash Identity)

Submit a public-key request to SmokeStack instances via the selected SipHash Identity. An Ozone address must be defined for this option to be enabled.

### Share Keys (SipHash Identity)

The selected participant's public-key pair is distributed using the specified SipHash Identity. If a public-key pair does not exist for the specified participant, the option is disabled.

## **Private Public-Key Server**

In addition to housing messages, SmokeStack also serves as a private public-key server. A SmokeStack administrator is responsible for coordinating the storage of public-key pairs of participants. Participants may request public-key pairs of specific participants via Ozone addresses.



## SipHash Identities

Exchanging public-key pairs is often an involved process. Smoke implements the pseudo-random function SipHash so as to simplify the process. The SipHash function generates outputs of 8 bytes (16 characters hexadecimal). These short strings are easily memorized and/or distributed via other communications applications. SipHash identities are generated as follows:

```
id := siphash(public-encryption-key || public-signature-key,  
              pbkdf2(sha512(public-encryption-key || public-signature-key), // Salt  
                    public-encryption-key || public-signature-key,  
                    4096, // Iteration Count  
                    128)) // Bits (16 Bytes)
```

Non-confidential authentication and encryption key streams from SipHash identities are generated as follows:

```
keystream1 := pbkdf2(sha512(id), // Salt  
                    id,  
                    4096,          // Iteration Count  
                    160)          // Bits (20 Bytes)  
keystream2 := pbkdf2(sha512(id), // Salt  
                    keystream1,  
                    1,            // Iteration Count  
                    768)          // Bits (96 Bytes)
```

### Public Data

Chat Encryption Key

Algorithm: RSA

Fingerprint: 27:1ef6:31:d7:67:4b:b3:82:00:4b:59:3c:d9:16:41:93:47:a5:a3:c5:17:1e:5f:

70:56:06:cc:a8:de:f2:1d:ea:b4:ca:d7:99:34:a0:a6:8f:27:2e:df:9a:78:7c:43:a1:a1:bc:63:3f:51:e2:9a:83:1f:73:66:22:63:01:f6

Format: X.509

Size: 3072

Chat Signature Key

Algorithm: RSA

Fingerprint: a3:42:81:f1:34:d1:dd:c8:2f:2c:1d:a3:c4:95:31:17:79:73:d7:b2:6c:df:9c:91:8e:1c:07:6f:42:af:16:31:4a:9c:

69:7d:d8:b6:de:5f:ab:8a:b1:58:38:ae:96:ec:37:fd:ef:fc:21:3d:a4:c2:db:36:a3:80:92:fb:ee:5e

Format: X.509

Size: 3072

**SipHash Chat ID**

**@39B8-3DE5-A567-9C6F**

RESET SMOKE

The transport keys which are generated from SipHash identities may be used for exchanging public-key data via the Echo Public-Key Share (EPKS) protocol.

It is impossible to avoid SipHash collisions as there are infinitely-many inputs and a limited number of outputs.

## TCP, UDP Protocols

Smoke supports both the TCP and UDP network protocols. Multicast and unicast UDP varieties are provided. Multiple clients may be defined via the Settings activity. A limit on the number of clients is not imposed. When defining neighbors, one may define SmokeStack and/or Spot-On neighbors. SmokeStack, the companion application of Smoke, offers mobile server services as well as message and public-key storage.

Example UDP multicast address: 239.255.43.21.

The screenshot shows the Smoke application interface on an Android device. The top status bar indicates 100% battery and 2:43 PM. The app title "Smoke" is at the top. Below it is the "About" section, which includes version information (2018.03.03 Defective Delta (Debug)), Android version (7.1.1), and status of WakeLock and WiFiLock (both locked). There is a checkbox for "Prefer Active CPU" which is checked, and a "CLEAR LOG" button. The main section is "Neighbor Servers", which has a "Control" tab selected. It shows a list of servers with details for "Control: Connect", "Status: Connected", "rosemary-ipv4.tilaa.cloud:4710:TCP", and "192.168.178.25:48056". It also displays proxy statistics: "Temp. Queued: 0 / 256", "In: 436.73 KiB", "Out: 3.69 KiB", "Outbound Queued: 0", and "Uptime: 0:29 Min.". There are checkboxes for "Automatic Refresh" (checked) and "Details" (unchecked), and an "Echo" checkbox (unchecked). A "REFRESH" button is present. Below the server list, there are input fields for "IP Address" (containing "4710"), "Scope ID", "Proxy IP Address", and "Proxy Port" (set to "HTTP"). There are "ADD" and "RESET FIELDS" buttons. At the bottom, there is a section labeled "Ozone".

Smoke

**About**

Version 2018.03.03 Defective Delta (Debug)  
Android 7.1.1  
WakeLock Locked: True  
WiFiLock Locked: True  
☒ Prefer Active CPU  
CLEAR LOG

**Neighbor Servers**

Control Remote

Action ▾ Control: Connect  
Status: Connected  
rosemary-ipv4.tilaa.cloud:4710:TCP  
192.168.178.25:48056  
Proxy:  
Temp. Queued: 0 / 256  
In: 436.73 KiB  
Out: 3.69 KiB  
Outbound Queued: 0  
Uptime: 0:29 Min.

☒ Automatic Refresh ☐ Details  
☐ Echo  
REFRESH

IP Address

4710 Scope ID

☒ IPv4 ☐ IPv6 TCP ▾

Proxy IP Address

Proxy Port HTTP ▾

ADD RESET FIELDS

**Ozone**

## Thread Utilization

Smoke is an extremely-threaded application. For example, the Kernel object utilizes 7 threads while a single Neighbor object spawns 3 threads. Various threads are also defined in the activities.

## UDP Datagrams

Outbound UDP messages are partitioned into 576-byte datagrams. For example, a 15000-byte message will be partitioned into 27 datagrams.

## Verifying Public-Key Ownership

Before initiating an exchange of public-key pairs, Smoke generates digital signatures using the private keys of the encryption and signature public keys. The signatures are included in the EPKS bundle. A receiving Smoke instance verifies the signatures and accepts the public-key pairs if the signatures are valid. McEliece signatures are not included and are therefore not verified.