CS 253: Web Security

Cookies and Sessions

Recall: Cookies

Server sends a cookie with a response

```
Set-Cookie: theme=dark;
```

Header Name

Cookie Name

Cookie Value

Client sends a cookie with a request

```
Cookie: theme=dark;
```

Header Name

Cookie Name

Cookie Value

Sessions

- **Cookies** are used by the server to implement **sessions**
- **Goal:** Server keeps a set of data related to a user's current "browsing session"
- Examples
  - Logins
  - Shopping carts
  - User tracking

Demos: Sessions

Demo: Insecure Session 1

```html
<!doctype html>
<html lang='en'>
  <head>
    <meta charset='utf-8' />
    <title>My Cool Site</title>
  </head>
  <body>
    <h1>Bank login:</h1>
    <form method='POST' action='/login'>
      Username:
      <input name='username' />
      <br />
      Password:
      <input name='password' type='password' />
      <br />
      <input type='submit' value='Login' />
    </form>
  </body>
</html>
```

Demo: Insecure Session 1

```
const express = require('express')
const { createReadStream } = require('fs')
const cookieParser = require('cookie-parser')

const app = express()
app.use(cookieParser())
app.use(express.urlencoded({ extended: false }))

// Routes go here!

app.listen(8000)
```

Demo: Insecure Session 1

```
const USERS = { alice: 'password', bob: '50505' }
const BALANCES = { alice: 500, bob: 100 }

app.get('/', (req, res) => {
  const { username } = req.cookies
  if (username) {
    res.send(`
      <h1>Welcome, ${username}</h1>
      <p>Your balance is $${BALANCES[username]}</p>
    `)
  } else {
    createReadStream('index.html').pipe(res)
  }
})
```

Demo: Insecure Session 1

```
app.post('/login', (req, res) => {
  const { username } = req.body
  const { password } = req.body
  if (password === USERS[username]) {
    res.cookie('username', username)
    res.redirect('/')
  } else {
    res.send('fail!')
  }
})

app.get('/logout', (req, res) => {
  res.clearCookie('username')
  res.redirect('/')
})
```

First HTTP request:

```
POST /login HTTP/1.1
Host: example.com

username=alice&password=password
```

HTTP response:

```
HTTP/1.1 200 OK
Set-Cookie: username=alice
Date: Tue, 24 Sep 2019 20:30:00 GMT

<!DOCTYPE html ...
```

All future HTTP requests:

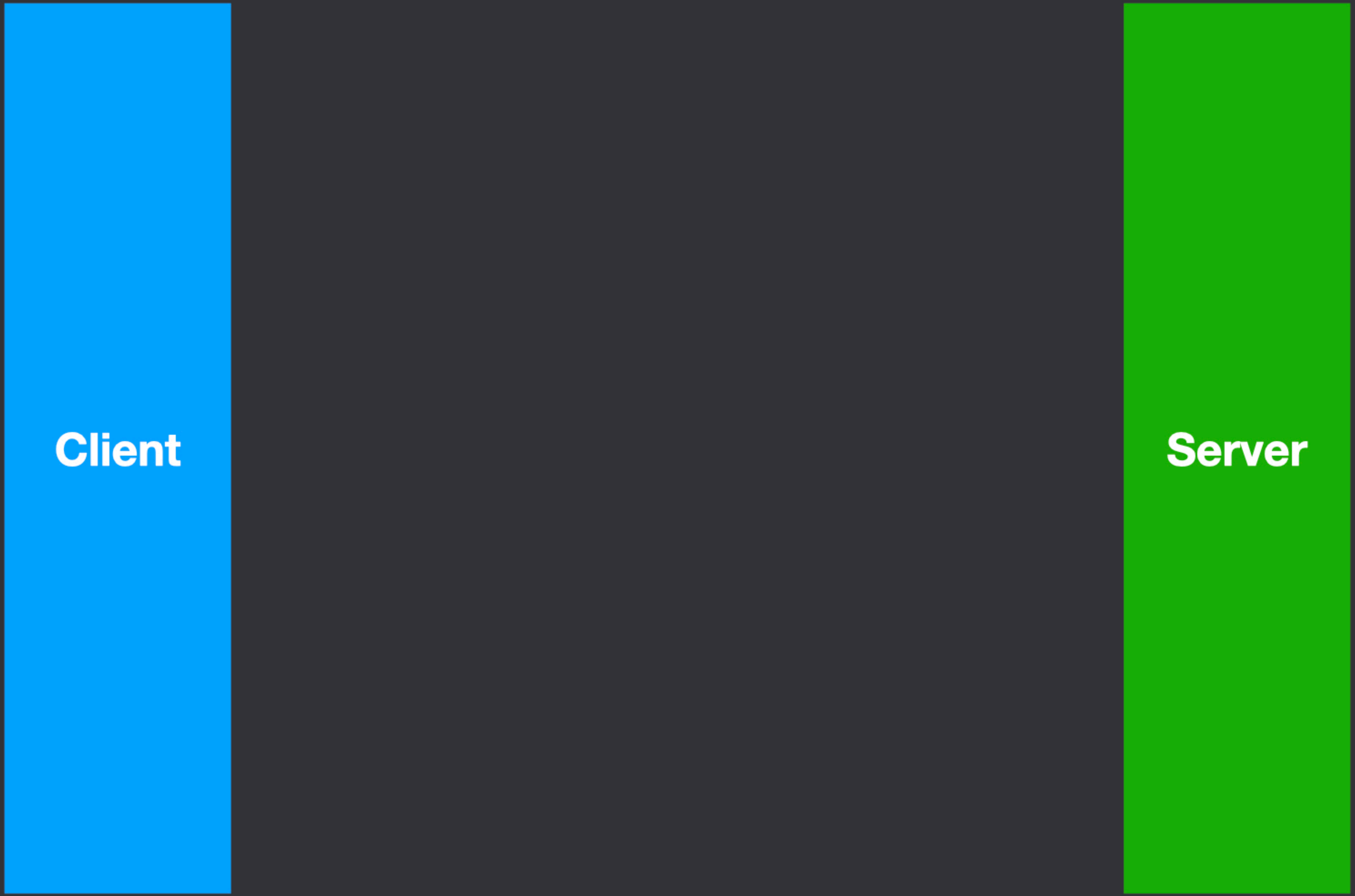
```
GET /page.html HTTP/1.1
Host: example.com
Cookie: username=alice;
```

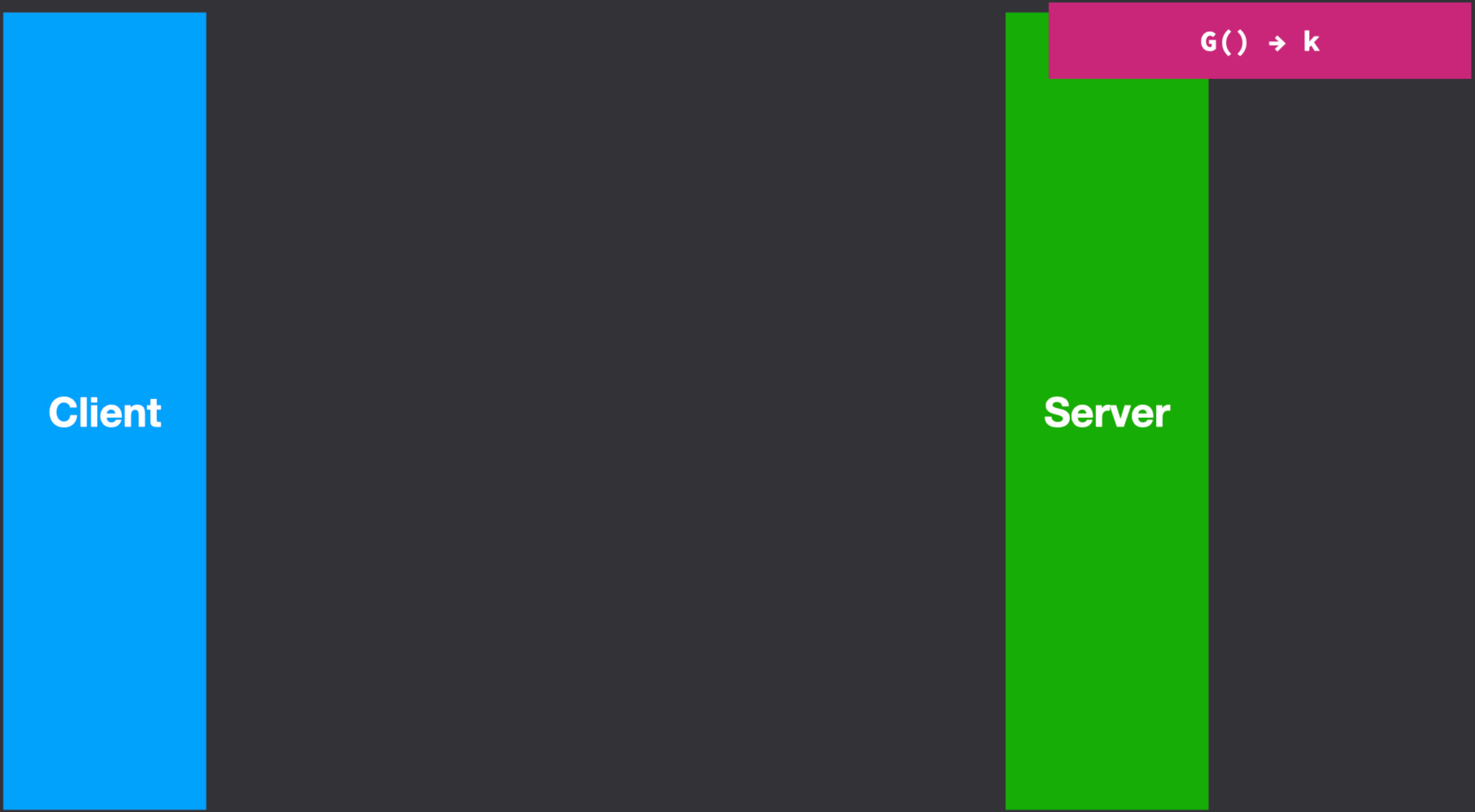
Ambient authority

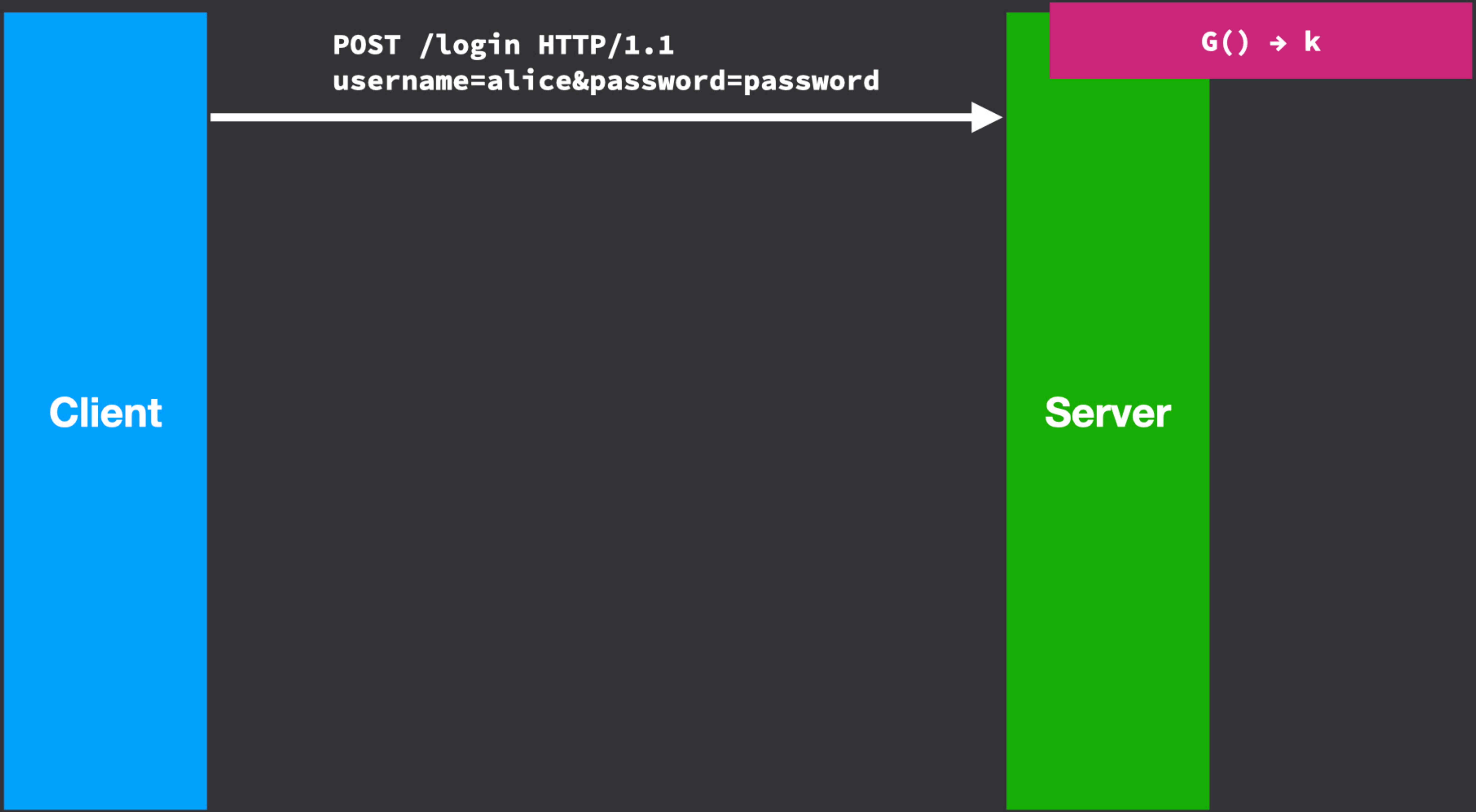
- **Access control** - Regulate who can view resources or take actions
- **Ambient authority** - Access control based on a **global and persistent property** of the requester
    - The alternative is explicit authorization **valid only for a specific action**
- There are four types of ambient authority on the web
    - **Cookies** - most common, most versatile method
    - **IP checking** - used at Stanford for library resources
    - **Built-in HTTP authentication** - rarely used
    - **Client certificates** - rarely used

Quick primer: Signature schemes

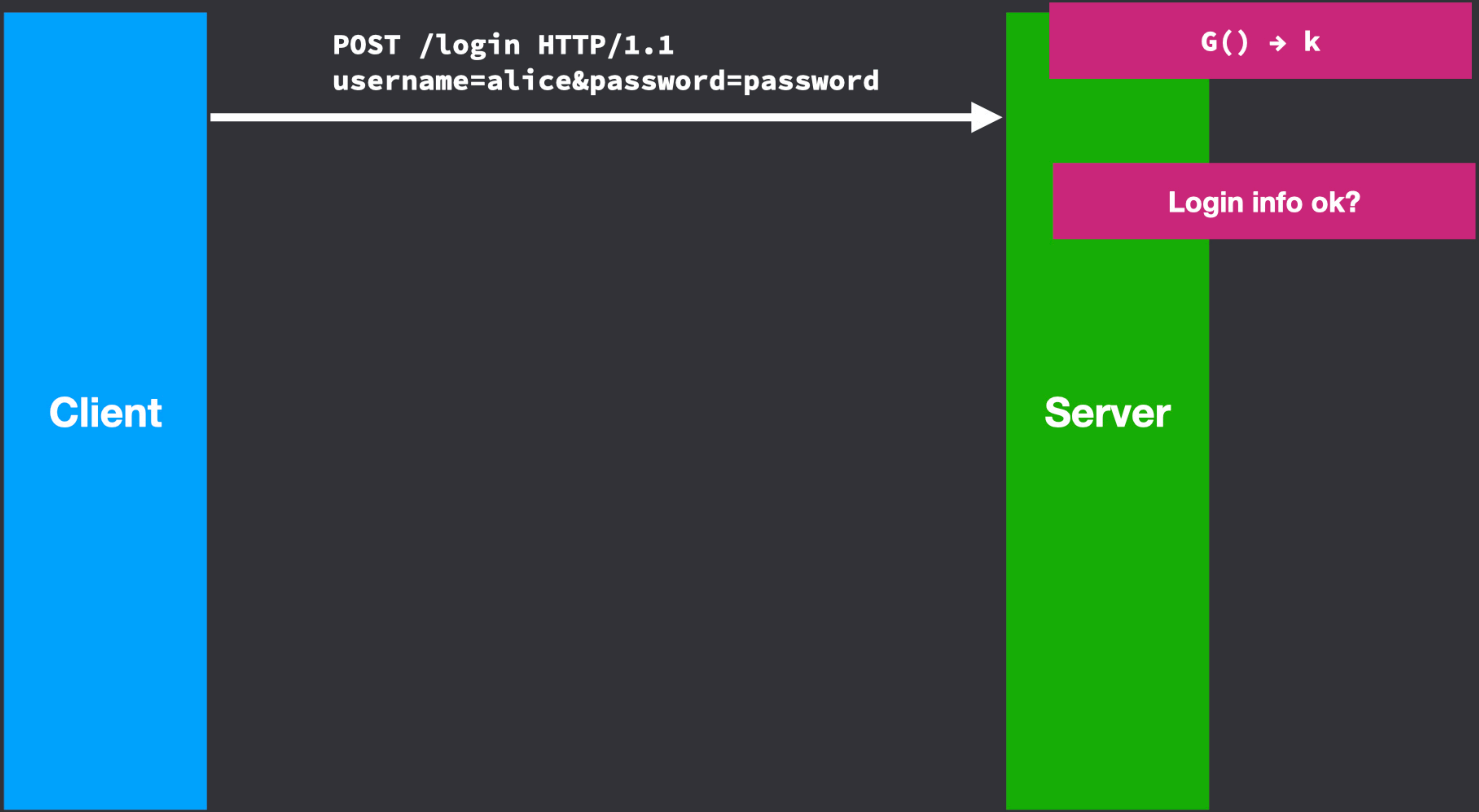
- Triple of algorithms **`(G, S, V)`**
  - **`G`**() → **`k`** - generator returns key
  - **`S`**(**`k`**, **`x`**) → **`t`** - signing returns a tag **`t`** for input **`x`**
  - **`V`**(**`k`**, **`x`**, **`t`**) → **`accept`**|**`reject`** - checks validity of tag **`t`** for given input **`x`**
- Correctness property
  - **`V`**(**`k`**, **`x`**, **`S`**(**`k`**, **`x`**)) = **`accept`** should always be true
- Security property
  - **`V`**(**`k`**, **`x`**, **`t`**) = **`accept`** should almost never be true when **`x`** and **`t`** are chosen by the attacker


Client
Server

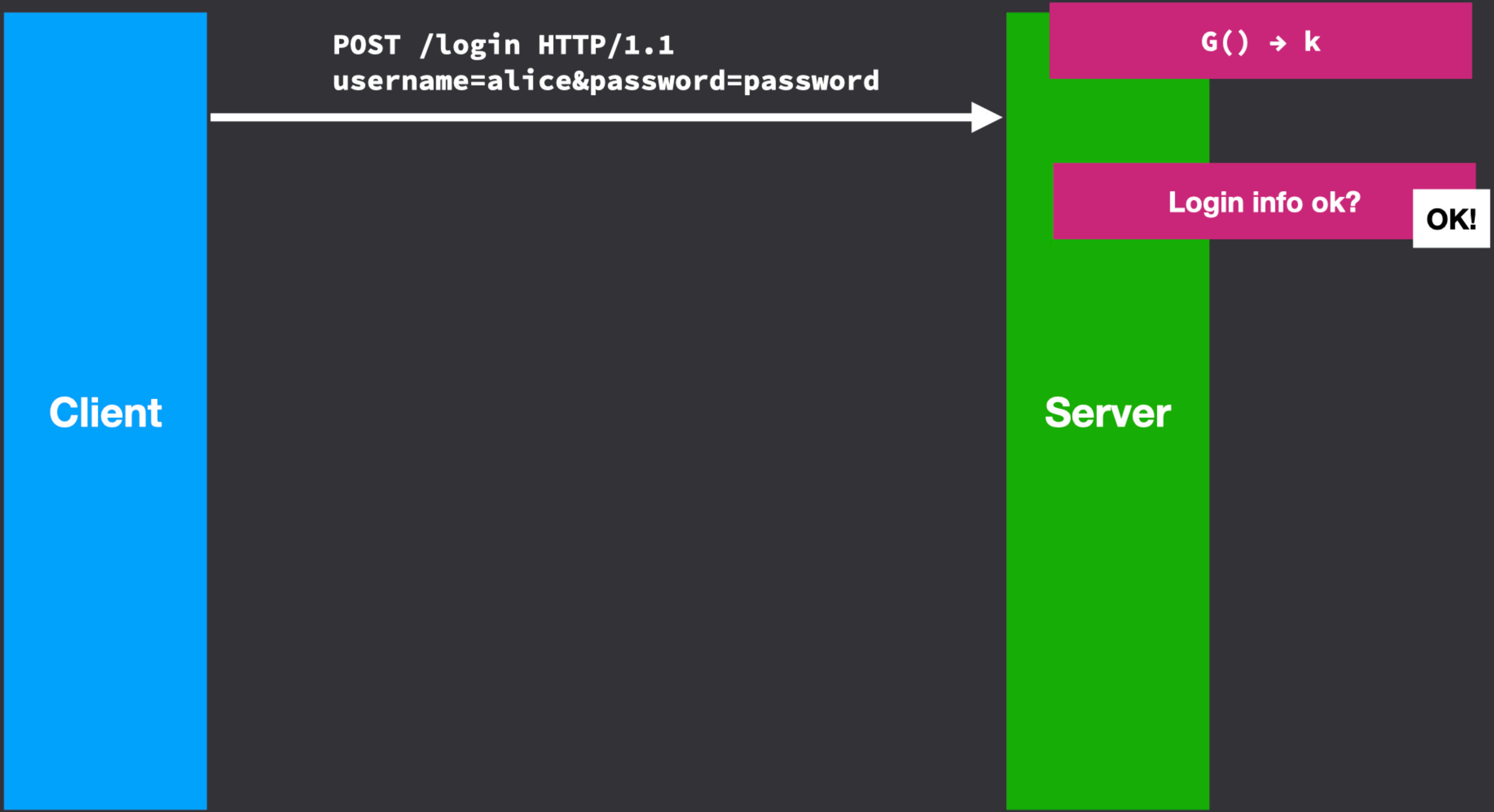

G() → k
Client
Server



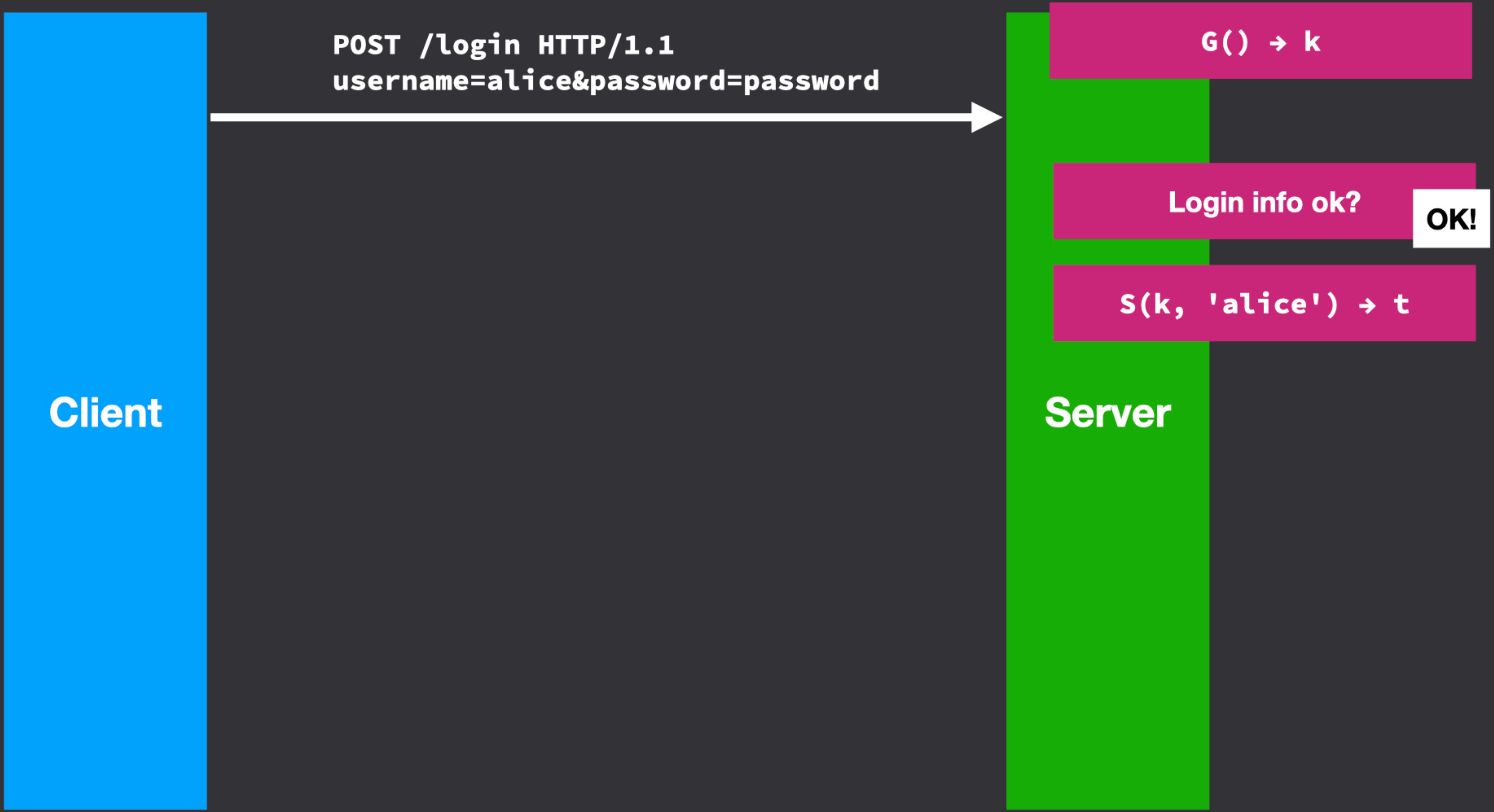
```
POST /login HTTP/1.1
username=alice&password=password
```



```
POST /login HTTP/1.1
username=alice&password=password
```



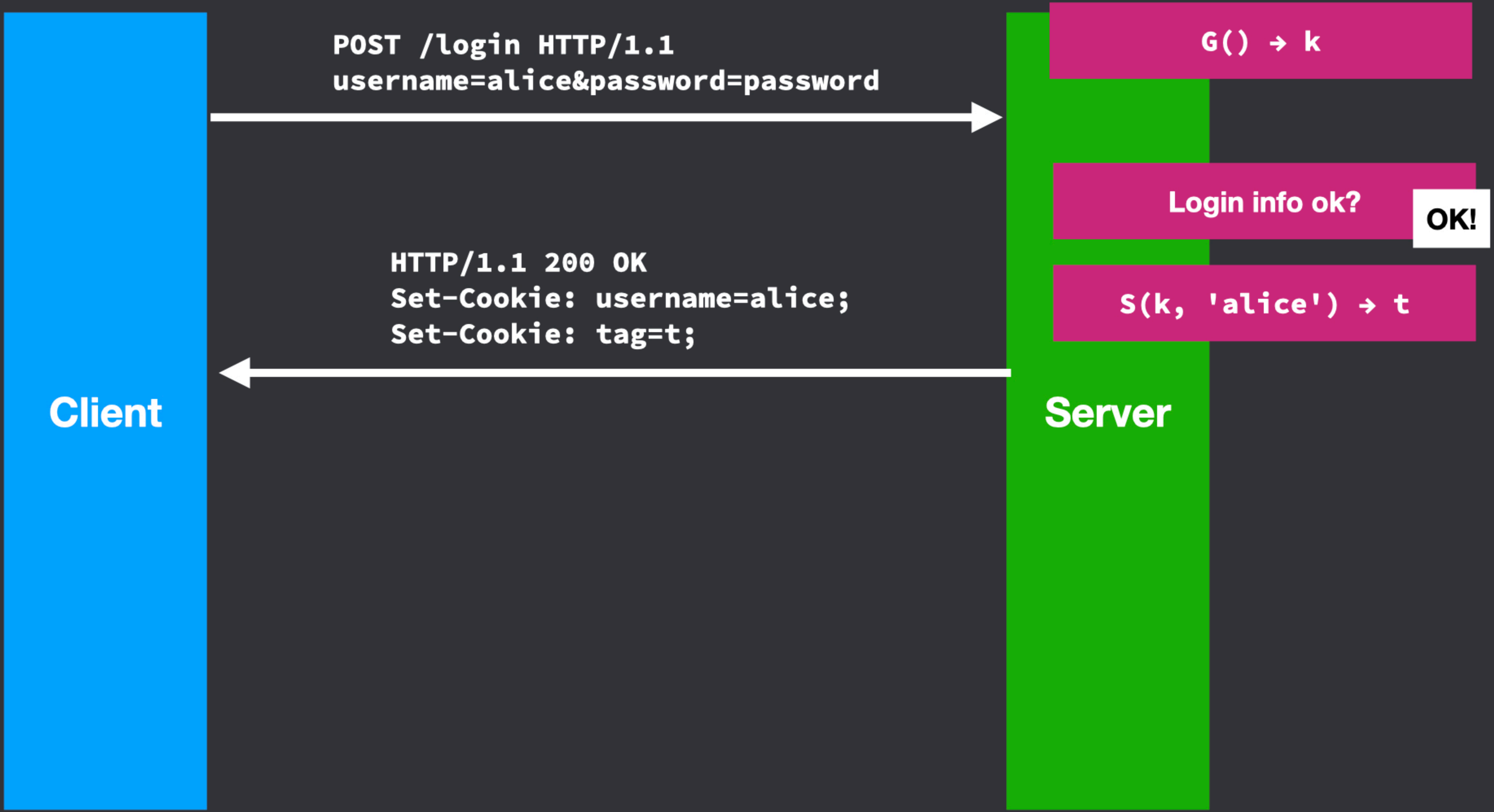
```
POST /login HTTP/1.1
username=alice&password=password
```



```
POST /login HTTP/1.1
username=alice&password=password
```

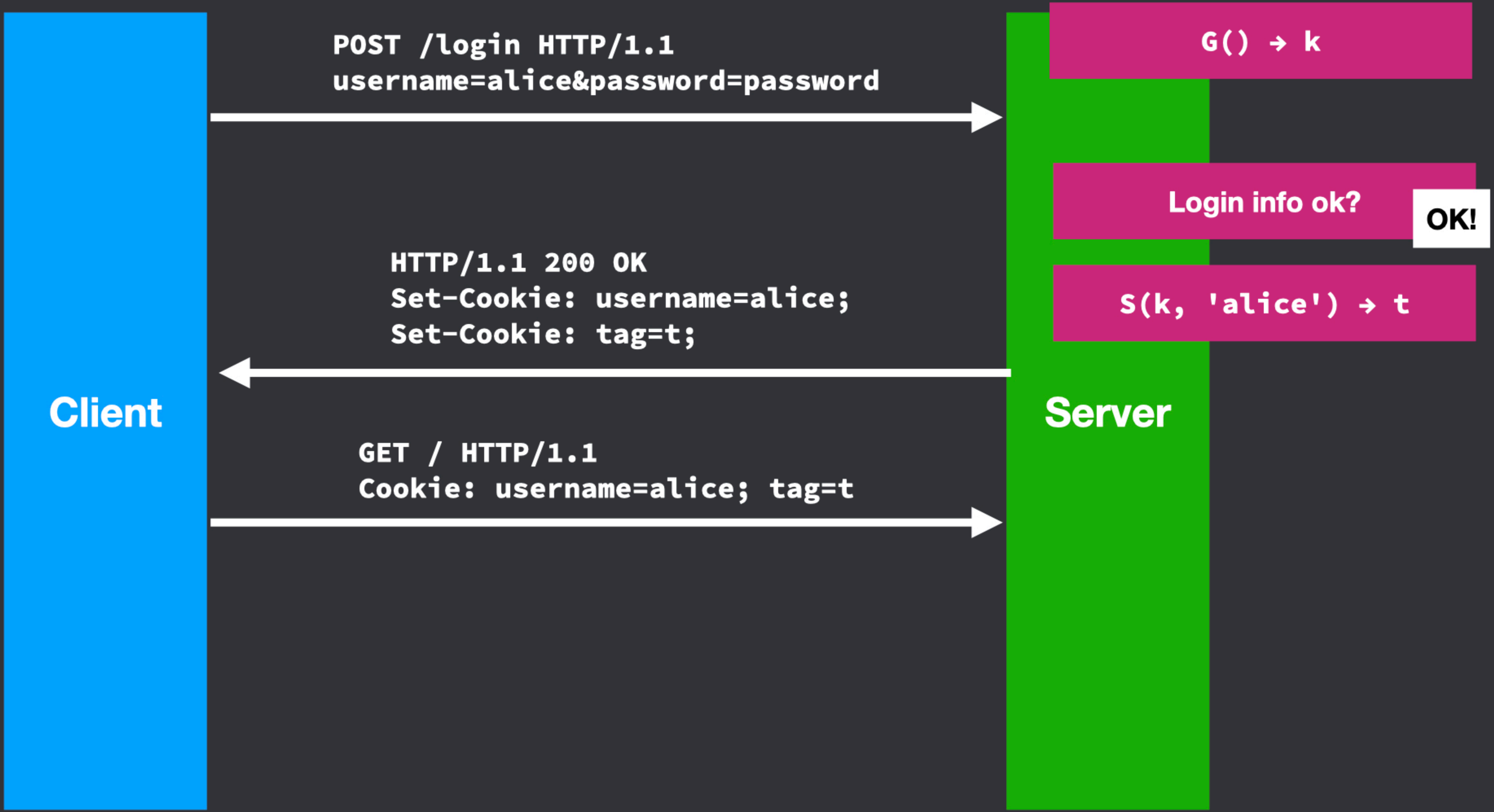
```
G() → k
```

```
S(k, 'alice') → t
```



```
POST /login HTTP/1.1
username=alice&password=password
```

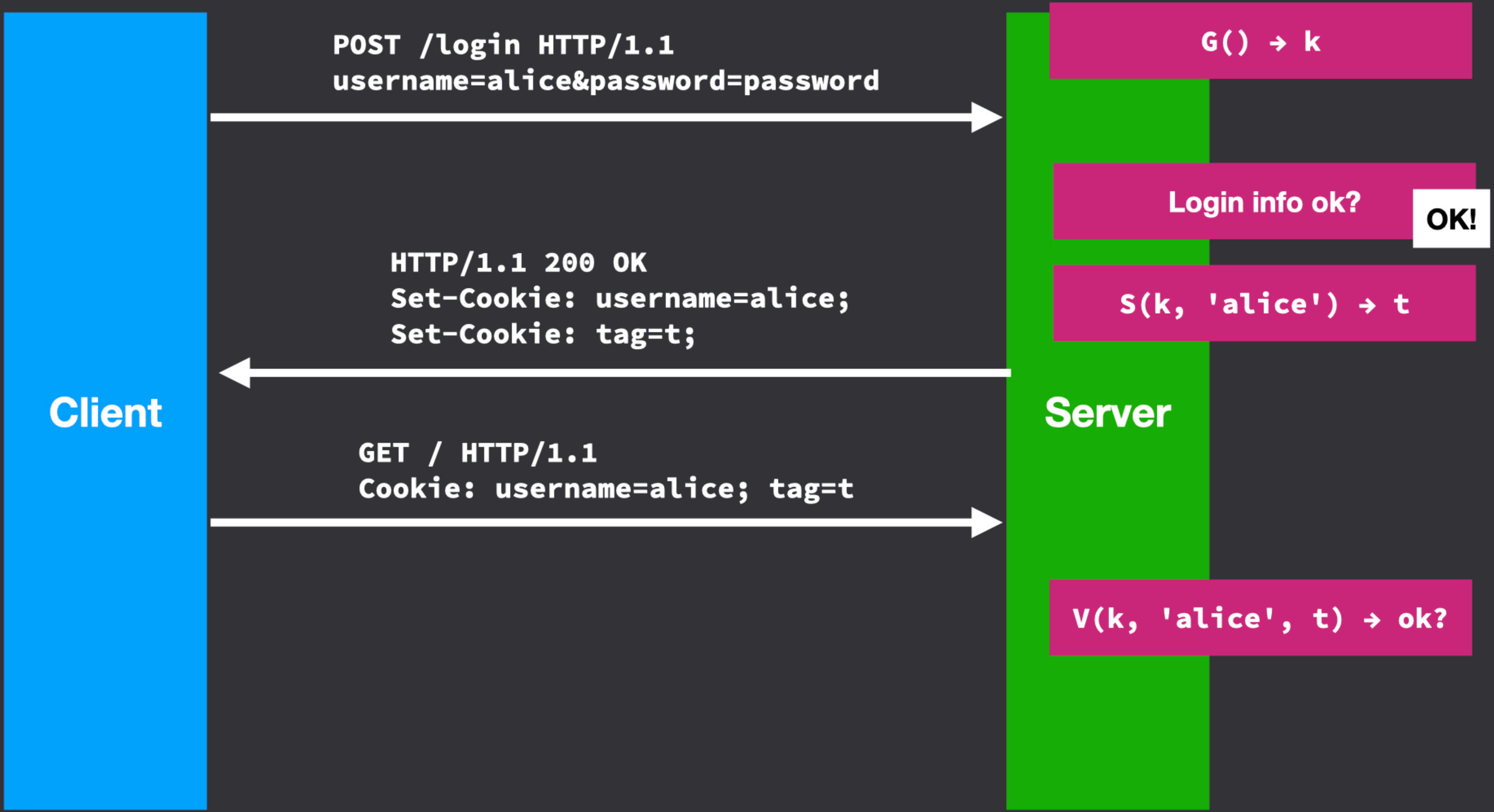
```
HTTP/1.1 200 OK
Set-Cookie: username=alice;
Set-Cookie: tag=t;
```



```
POST /login HTTP/1.1
username=alice&password=password
```

```
HTTP/1.1 200 OK
Set-Cookie: username=alice;
Set-Cookie: tag=t;
```

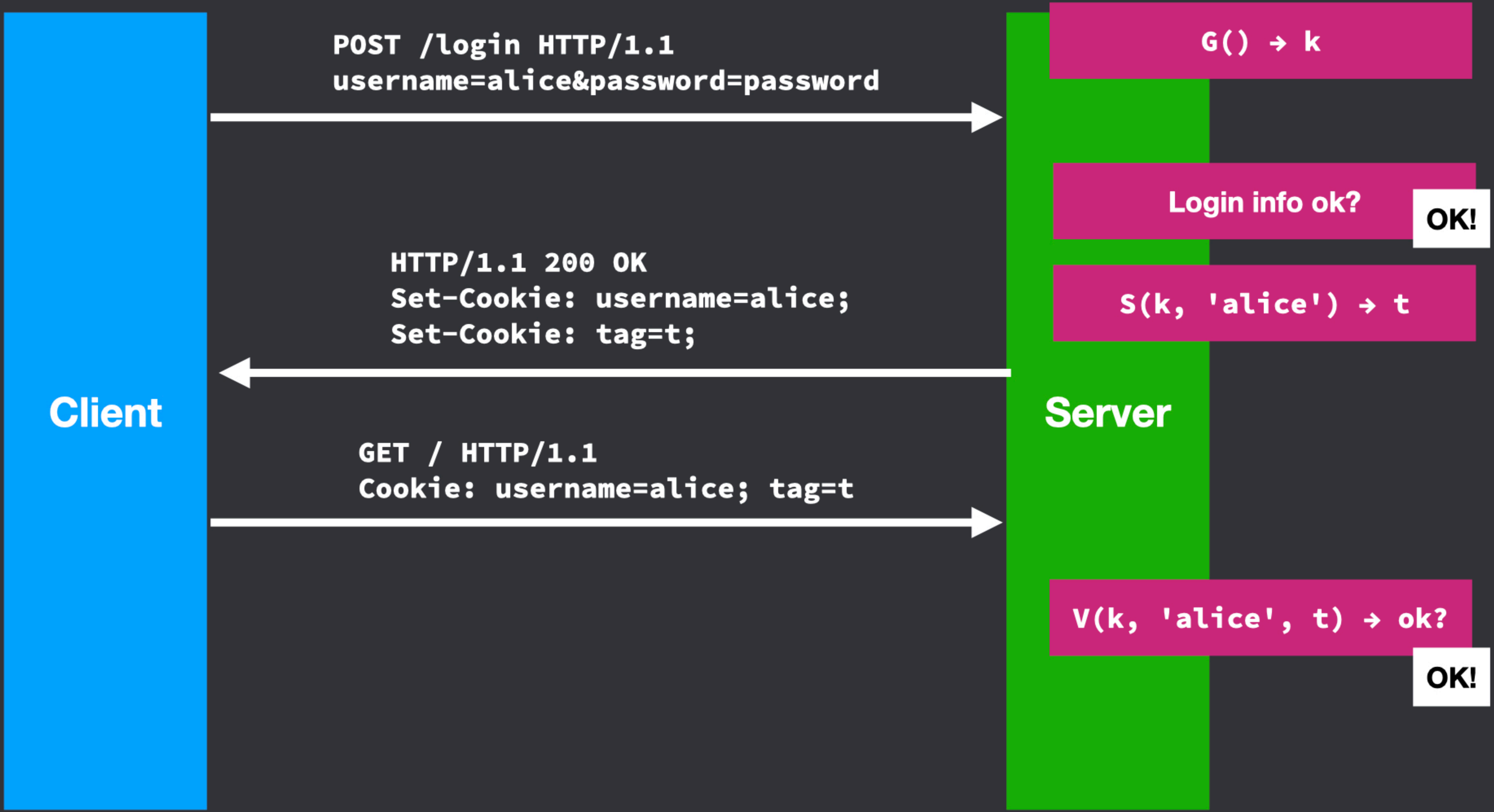
```
GET / HTTP/1.1
Cookie: username=alice; tag=t
```



```
POST /login HTTP/1.1
username=alice&password=password
```

```
HTTP/1.1 200 OK
Set-Cookie: username=alice;
Set-Cookie: tag=t;
```

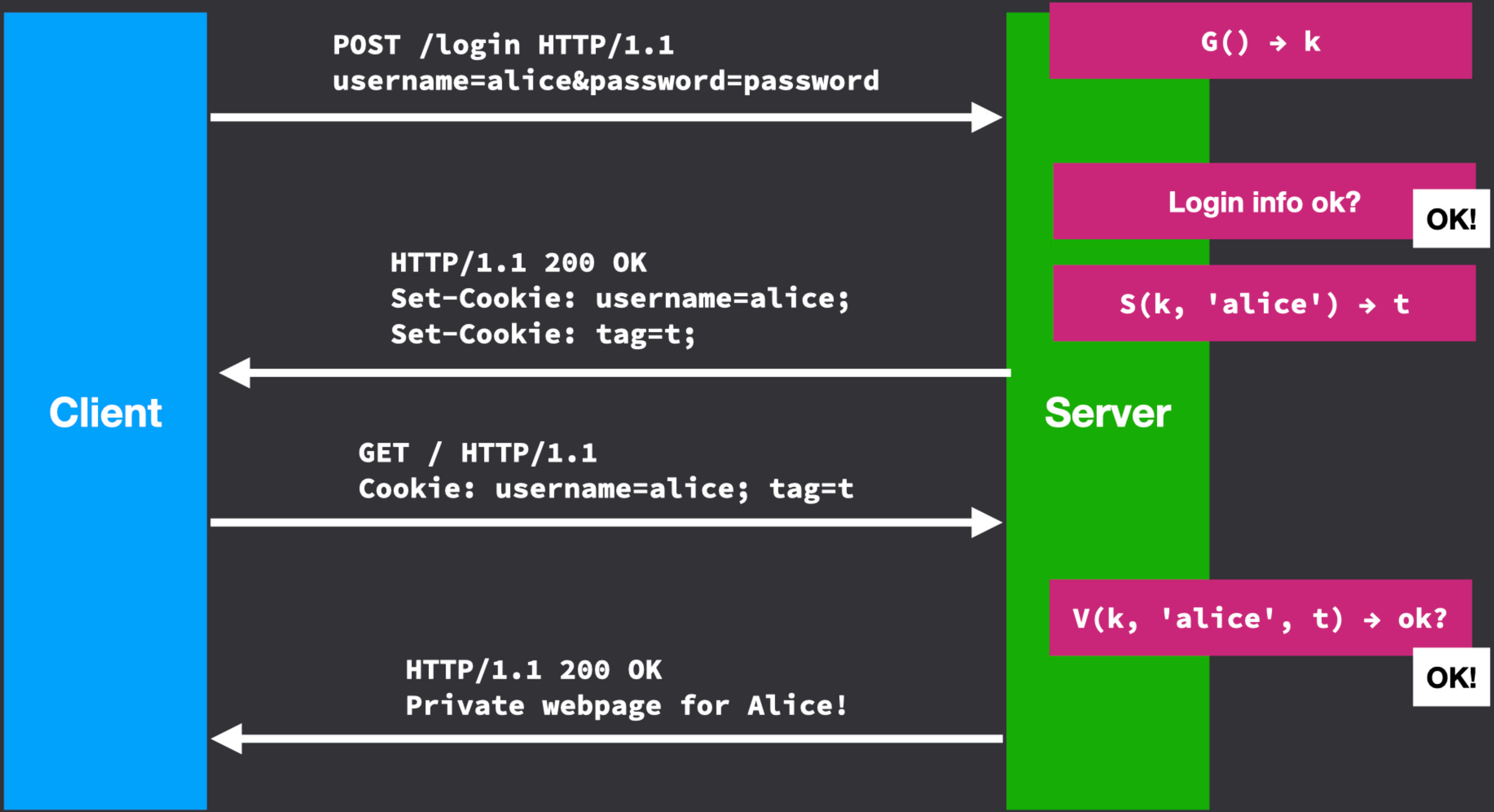
```
GET / HTTP/1.1
Cookie: username=alice; tag=t
```



```
POST /login HTTP/1.1
username=alice&password=password
```

```
HTTP/1.1 200 OK
Set-Cookie: username=alice;
Set-Cookie: tag=t;
```

```
GET / HTTP/1.1
Cookie: username=alice; tag=t
```

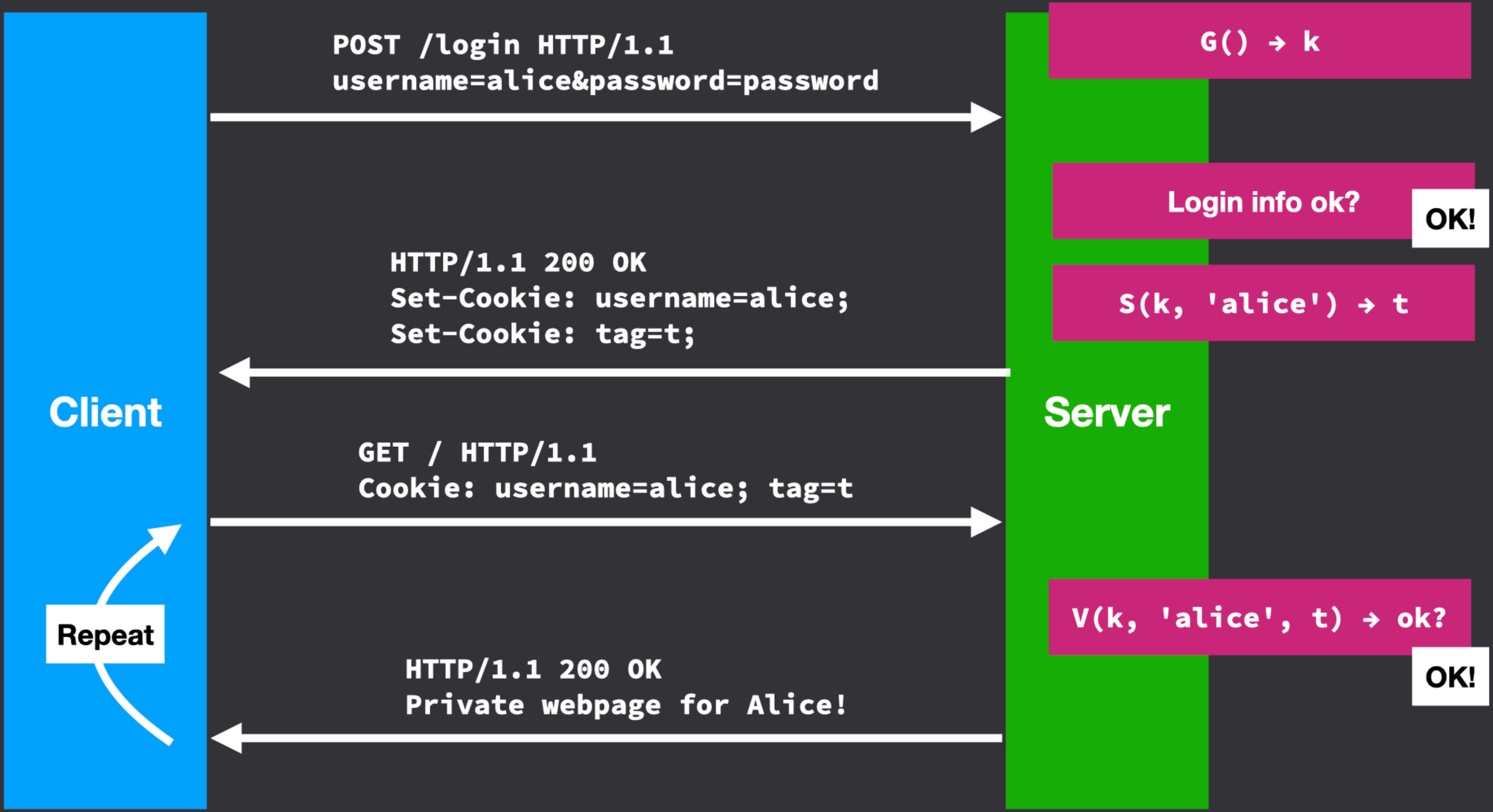


```
POST /login HTTP/1.1
username=alice&password=password
```

```
HTTP/1.1 200 OK
Set-Cookie: username=alice;
Set-Cookie: tag=t;
```

```
GET / HTTP/1.1
Cookie: username=alice; tag=t
```

```
HTTP/1.1 200 OK
Private webpage for Alice!
```



```
POST /login HTTP/1.1
username=alice&password=password
```

```
HTTP/1.1 200 OK
Set-Cookie: username=alice;
Set-Cookie: tag=t;
```

```
GET / HTTP/1.1
Cookie: username=alice; tag=t
```

```
HTTP/1.1 200 OK
Private webpage for Alice!
```

Demo: Insecure Session 2

```
const COOKIE_SECRET = 'G2T7SRHTX1T62DHR'
app.use(cookieParser(COOKIE_SECRET))

app.get('/', (req, res) => {
  const { username } = req.signedCookies
  if (username) {
    res.send(`
      <h1>Welcome, ${username}</h1>
      <p>Your balance is $${BALANCES[username]}</p>
    `)
  } else {
    createReadStream('index.html').pipe(res)
  }
})

app.post('/login', (req, res) => {
  const { username } = req.body
  const { password } = req.body
  if (password === USERS[username]) {
    res.cookie('username', username, { signed: true })
    res.redirect('/')
  } else {
    res.send('fail!')
  }
})

app.get('/logout', (req, res) => {
  res.clearCookie('username')
  res.redirect('/')
})
```

Demo: Insecure Session 3

```
let nextSessionId = 1
const SESSIONS = {} // sessionId -> username

app.get('/', (req, res) => {
  const { sessionId } = req.cookies
  const username = SESSIONS[sessionId]

  if (username) {
    res.send(`
      <h1>Welcome, ${username}</h1>
      <p>Your balance is $${BALANCES[username]}</p>
    `)
  } else {
    createReadStream('index.html').pipe(res)
  }
})

app.post('/login', (req, res) => {
  const { username } = req.body
  const { password } = req.body
  if (password === USERS[username]) {
    SESSIONS[nextSessionId] = username
    res.cookie('sessionId', nextSessionId)
    nextSessionId += 1
    res.redirect('/')
  } else {
    res.send('fail!')
  }
})

app.get('/logout', (req, res) => {
  const { sessionId } = req.cookies
  delete SESSIONS[sessionId]
  res.clearCookie('username')
  res.redirect('/')
})
```

Demo: Secure Session

```
const { randomBytes } = require('crypto')

const SESSIONS = {} // sessionId -> username

app.get('/', (req, res) => {
  const sessionId = req.cookies.sessionId
  const username = SESSIONS[sessionId]

  if (username) {
    res.send(`Hi ${username}. Your balance is $${BALANCES[username]}.`)
  } else {
    createReadStream('index.html').pipe(res)
  }
})

app.post('/login', (req, res) => {
  const username = req.body.username
  const password = USERS[username]
  if (password === req.body.password) {
    const sessionId = randomBytes(16).toString('hex')
    SESSIONS[sessionId] = username
    res.cookie('sessionId', sessionId)
    res.redirect('/')
  } else {
    res.send('fail!')
  }
})

app.get('/logout', (req, res) => {
  const sessionId = req.cookies.sessionId
  delete SESSIONS[sessionId]
  res.clearCookie('sessionId')
  res.redirect('/')
})
```

Sessions: Desired properties

- Browser remembers user (so user doesn't need to repeatedly log in)
- User cannot modify session cookie to login as another user
- Session cookies are not valid forever
- Sessions can be deleted on the server-side
- Sessions should expire after some time, e.g. 30 days

History of cookies

- Implemented in 1994 in Netscape and described in 4-page draft
- No spec for 17 years
  - Attempt made in 1997, but made incompatible changes
  - Another attempt in 2000 ("Cookie2"), same problem
  - Around 2011, another effort succeeded (RFC 6265)
- Ad-hoc design has led to *interesting* issues

END