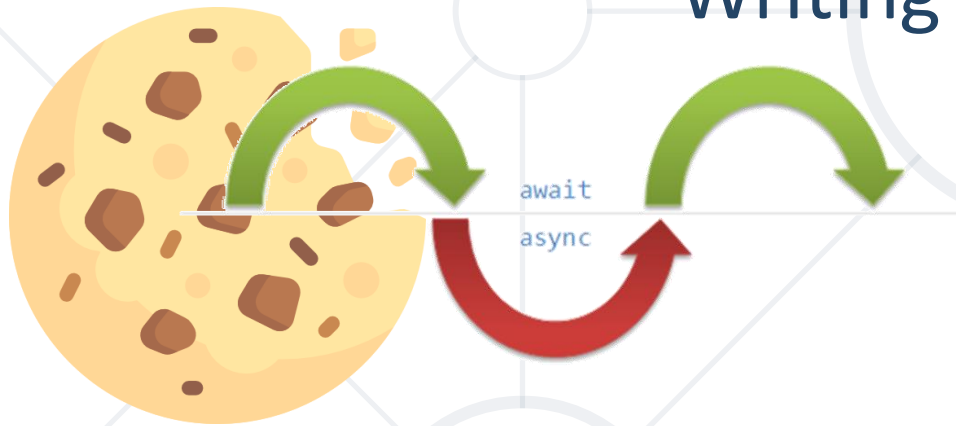


State Management

Asynchronous Processing

Cookies and Sessions
Writing Concurrent Code in C#



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sli.do

#csharp-web

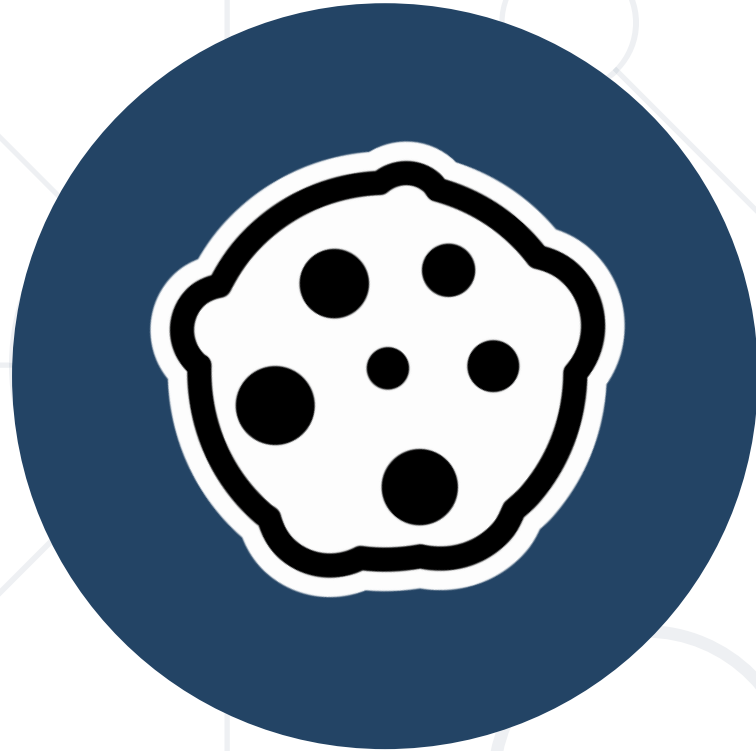
1. State Management

- Cookies
- Sessions
- Session vs Cookies

2. Asynchronous Processing

- Synchronous Programming
- Asynchronous Programming
- Threads
- Tasks in C# (async and await)





HTTP Cookies

Usages and Control

What Are Cookies?

- A small file of plain text with no **executable code**
 - Sent by the server to the client's browser
 - **Stored** by the browser on the **client's device** (computer, tablet, etc.)
 - Hold small piece of data for a **particular client** and a web site

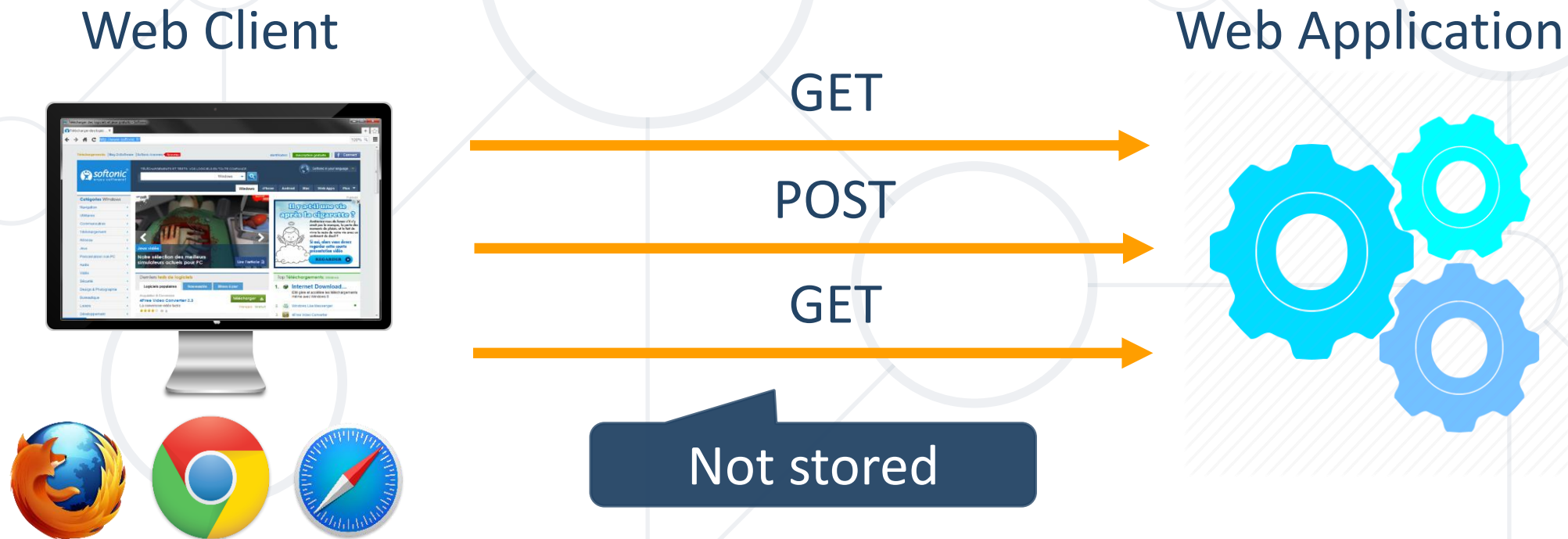


What Are Cookies Used for?

- Session management
 - Logins, shopping carts, game scores or anything else the **server should remember**
- Personalization
 - User preferences, themes and other **custom settings**
- Tracking
 - Recording and analyzing **user behavior**
- Breakfast
 - But that's not what we are currently talking about

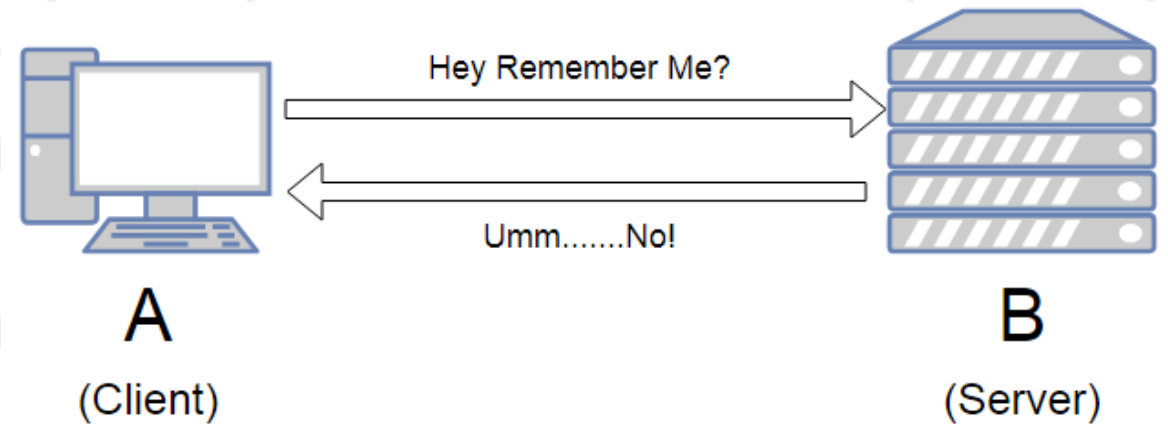


- The HTTP object is **stateless**
 - It **doesn't store** information about the requests



Stateless HTTP – the Problem

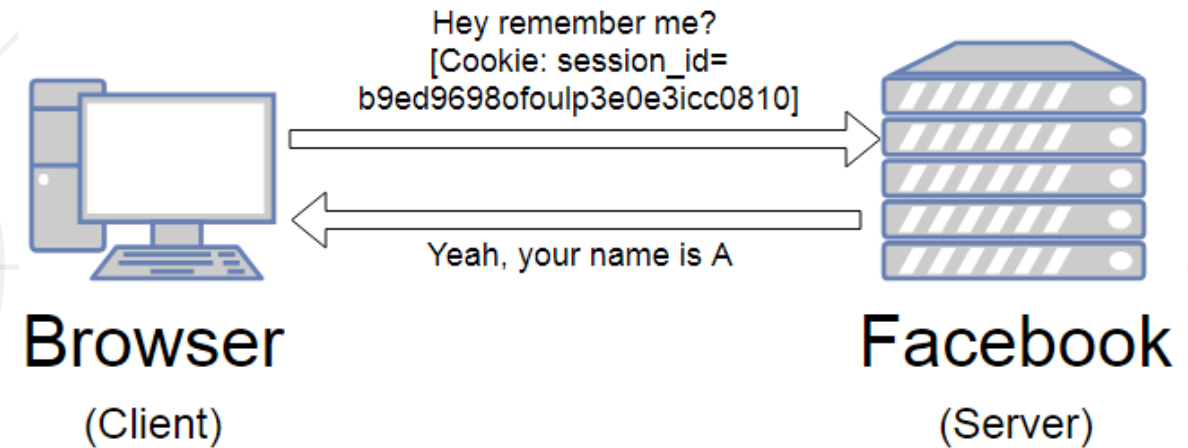
- The server **doesn't know** if two requests come from the same **client**
- State management problems
 - **Navigation** through pages requires **authentication** each time
 - **Information** about the pages is lost between the **requests**
 - Harder **personalization** of functionality of pages



Stateless HTTP – the Cookie Solution

- A reliable mechanism for websites to remember **stateful information**

- To know whether the **user** is **logged in** or **not**
- To know which account the **user is logged in** with
- To record the user's **browsing activity**
- To **remember** pieces of information **previously** entered into form fields (usernames, passwords, etc.)



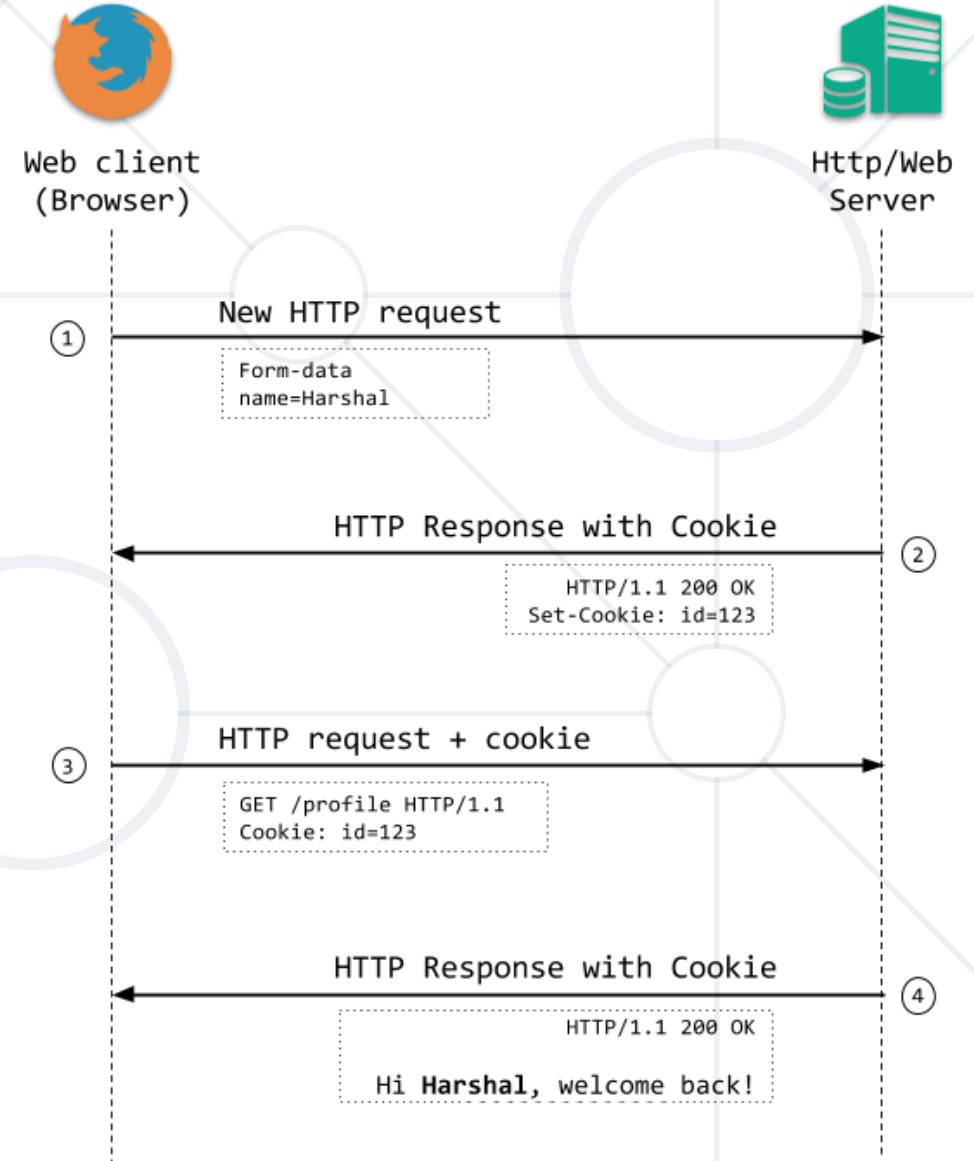
How Are Cookies Used?

- The response holds the cookies to be saved within the **Set-Cookie** header

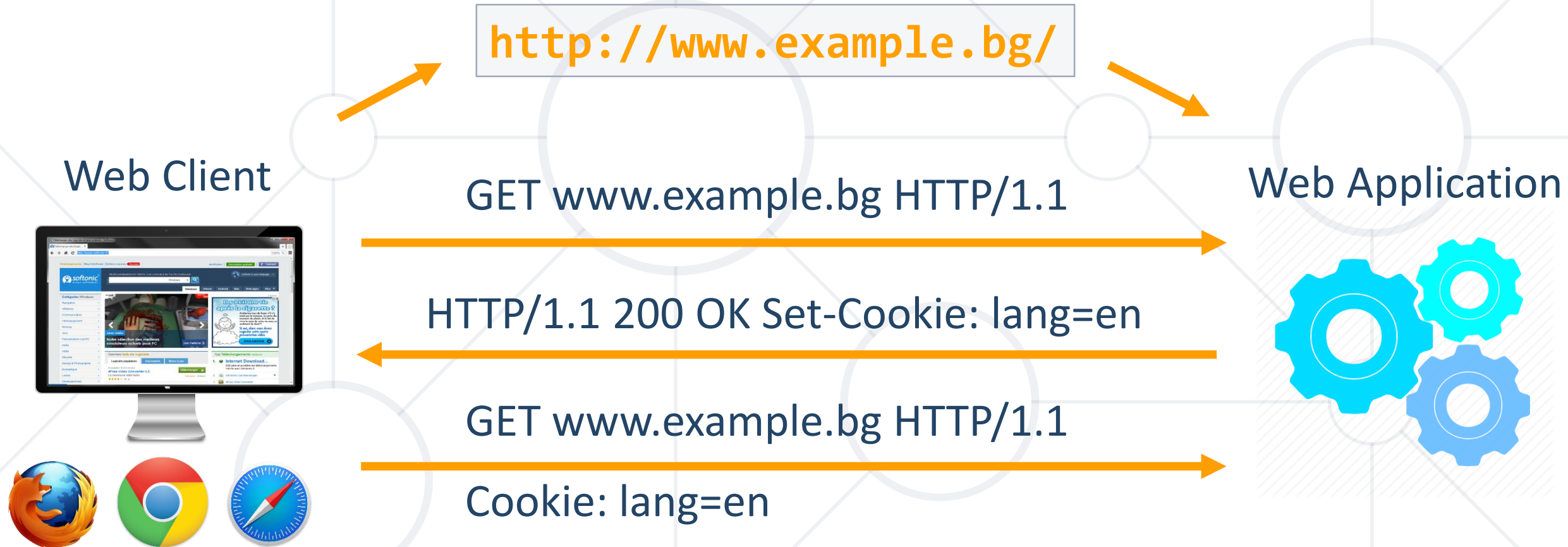
```
HTTP/1.1 200 OK  
Set-Cookie: lang=en
```

- The request holds the specific web site cookie within the **Cookie** header

```
GET www.example.bg HTTP/1.1  
Cookie: lang=en
```



Server-Client Cookies Exchange



- The cookie consists of **Name**, **Value** and **Attributes** (optional)
- The attributes are **key-value pairs** with additional information
- Attributes are **not included** in the **requests**
- Attributes are used by **the client** to control the **cookies**

Name=Value

Attributes

Set-Cookie: **SSID=Ap4P...GTEq;** Domain=foo.com; Path=/
Expires=Wed, 13 Jan 2021 22:23:01 GMT; Secure; HttpOnly

- Defined by the attributes **Domain** and **Path**
- **Domain** – defines the website that the cookie belongs to
- **Path** – Indicates a **URL** path that must exist in the requested resource before sending the **Cookie** header

```
Set-Cookie: SSID=Ap4P...GTEq; Domain=foo.com; Path=/;  
Expires=Wed, 13 Jan 2021 22:23:01 GMT; Secure; HttpOnly
```

- Defined by the attributes **Expires** and **Max-Age**
- **Expires** – defines the date the browser should delete the cookie
 - By default the cookies are deleted after the end of the session
- **Max-Age** – interval of seconds before the cookie is deleted

```
Set-Cookie: SSID=Ap4P...GTEq; Domain=foo.com; Path=/  
Expires=Wed, 13 Jan 2021 22:23:01 GMT; Secure; HttpOnly
```

- Security flags do not have associated values
- **Secure** - tells the browser to use cookies only via **secure/encrypted** connections
- **HttpOnly** – defines that the cookie cannot be accessed via client-side scripting languages

```
Set-Cookie: SSID=Ap4P...GTEq; Domain=foo.com; Path=/;  
Expires=Wed, 13 Jan 2021 22:23:01 GMT; Secure; HttpOnly
```

What is in the Cookie?

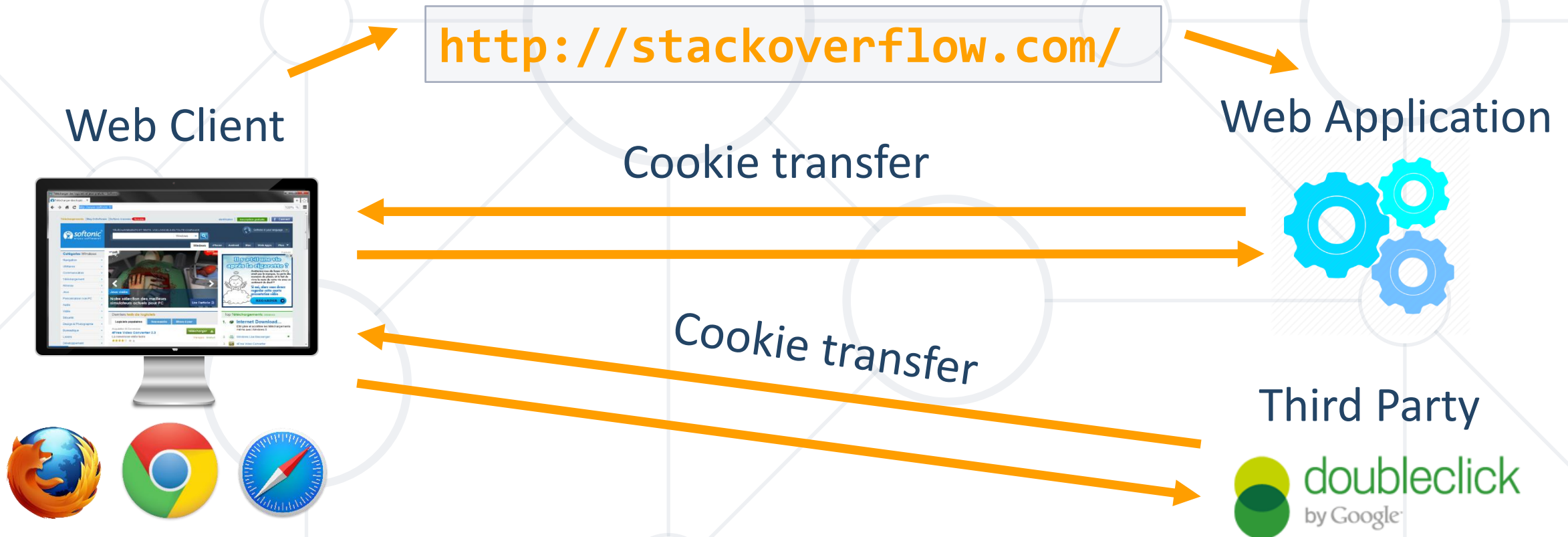
- The cookie file contains a table with **key-value** pairs

Name:	ELOQUA
Content:	GUID=50B3A712CDAA4A208FE95CE1F2BA7063
Domain:	.oracle.com
Path:	/
Send for:	Any kind of connection
Accessible to script:	Yes
Created:	Monday, August 15, 2016 at 11:38:50 PM
Expires:	Wednesday, August 15, 2018 at 11:38:51 PM

Remove

Third Party Cookies

- Cookies stored by an **external party** (different **domain**)
- Mainly used for advertising and tracking across the web

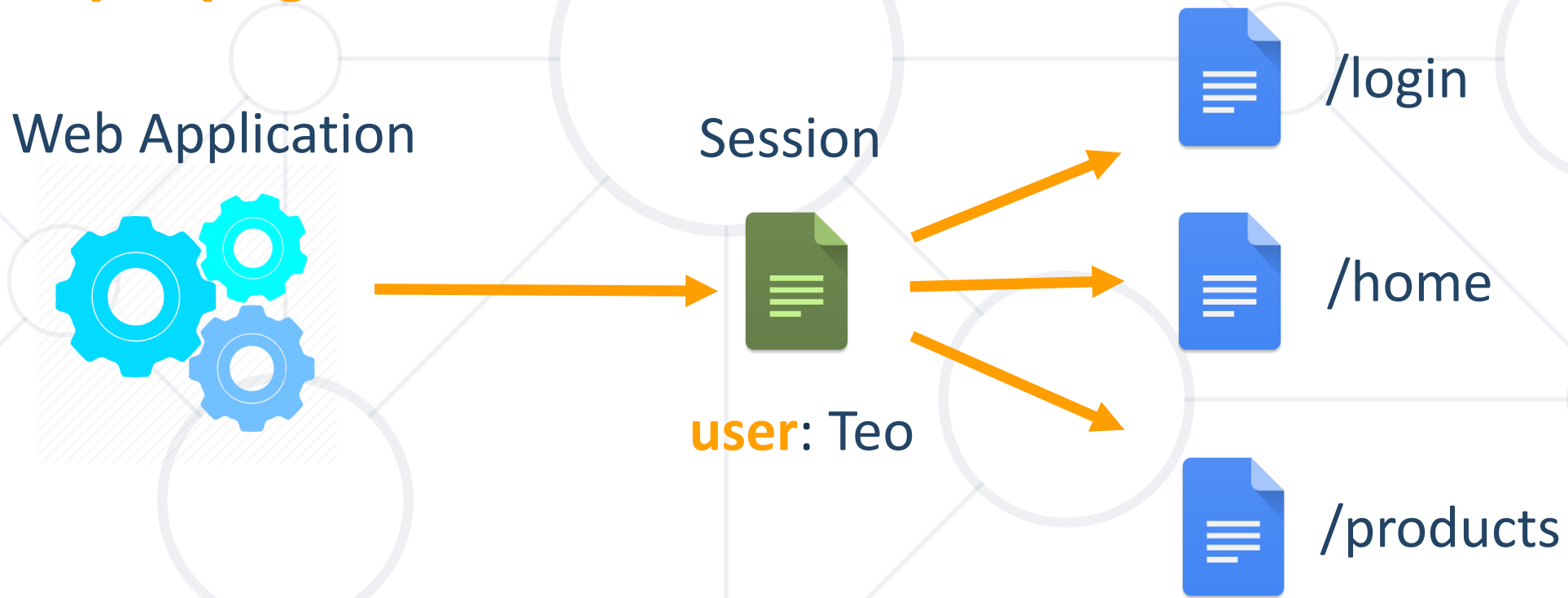




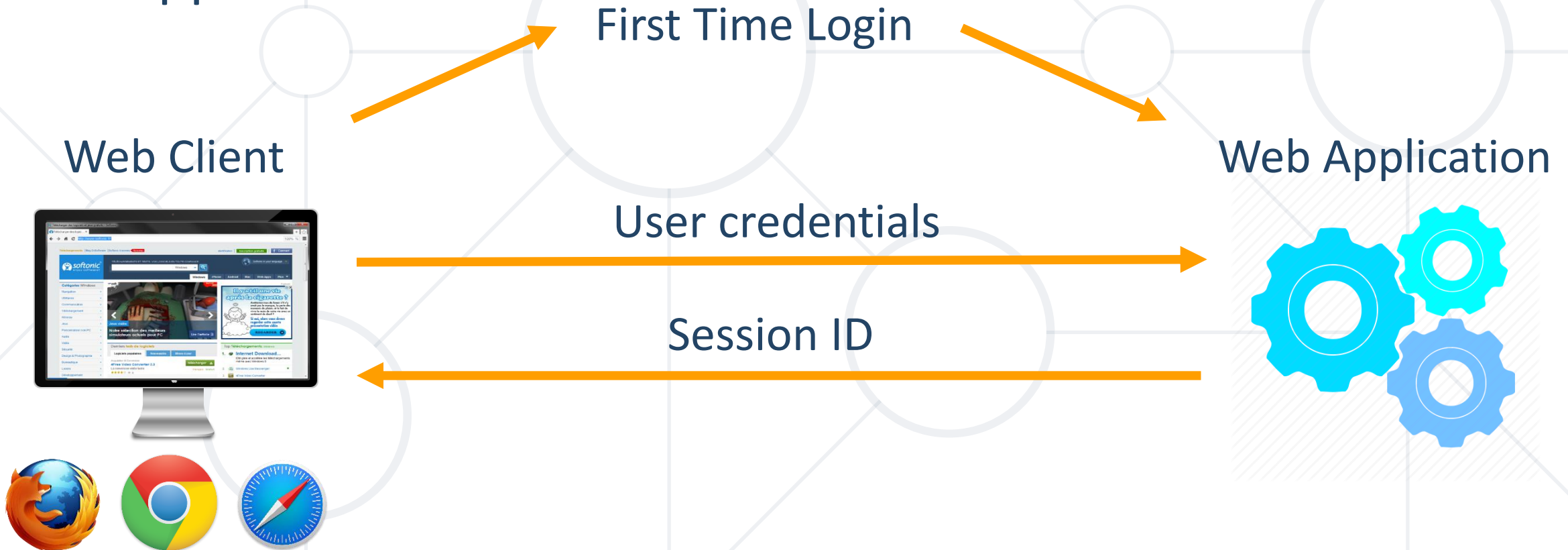
HTTP Sessions

What Are Sessions?

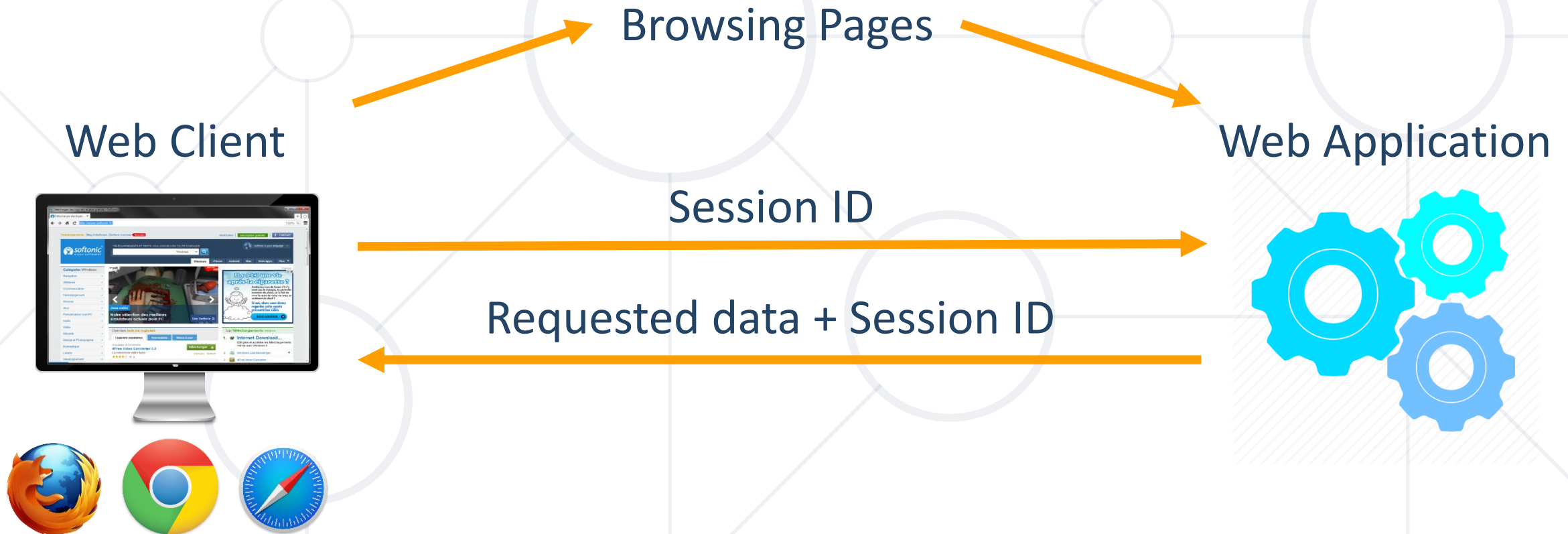
- A way to store information about a user to be used across **multiple pages**



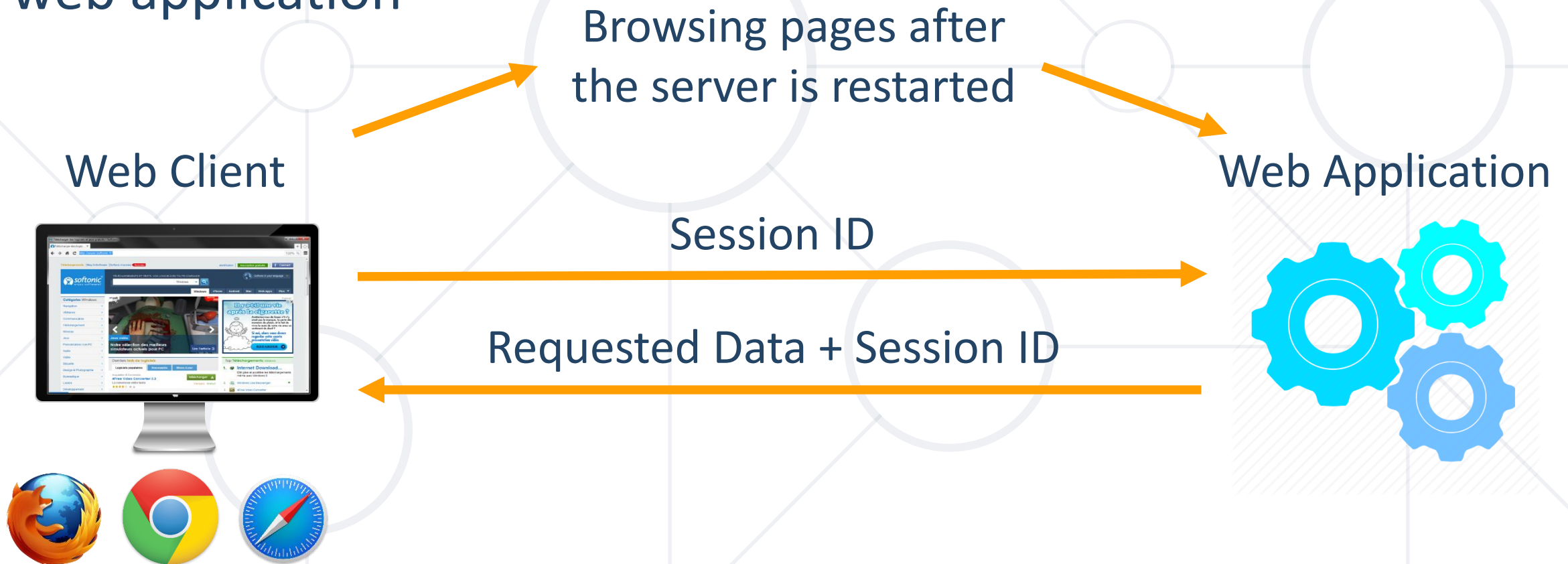
- The exchange mechanism be used between the user and the web application



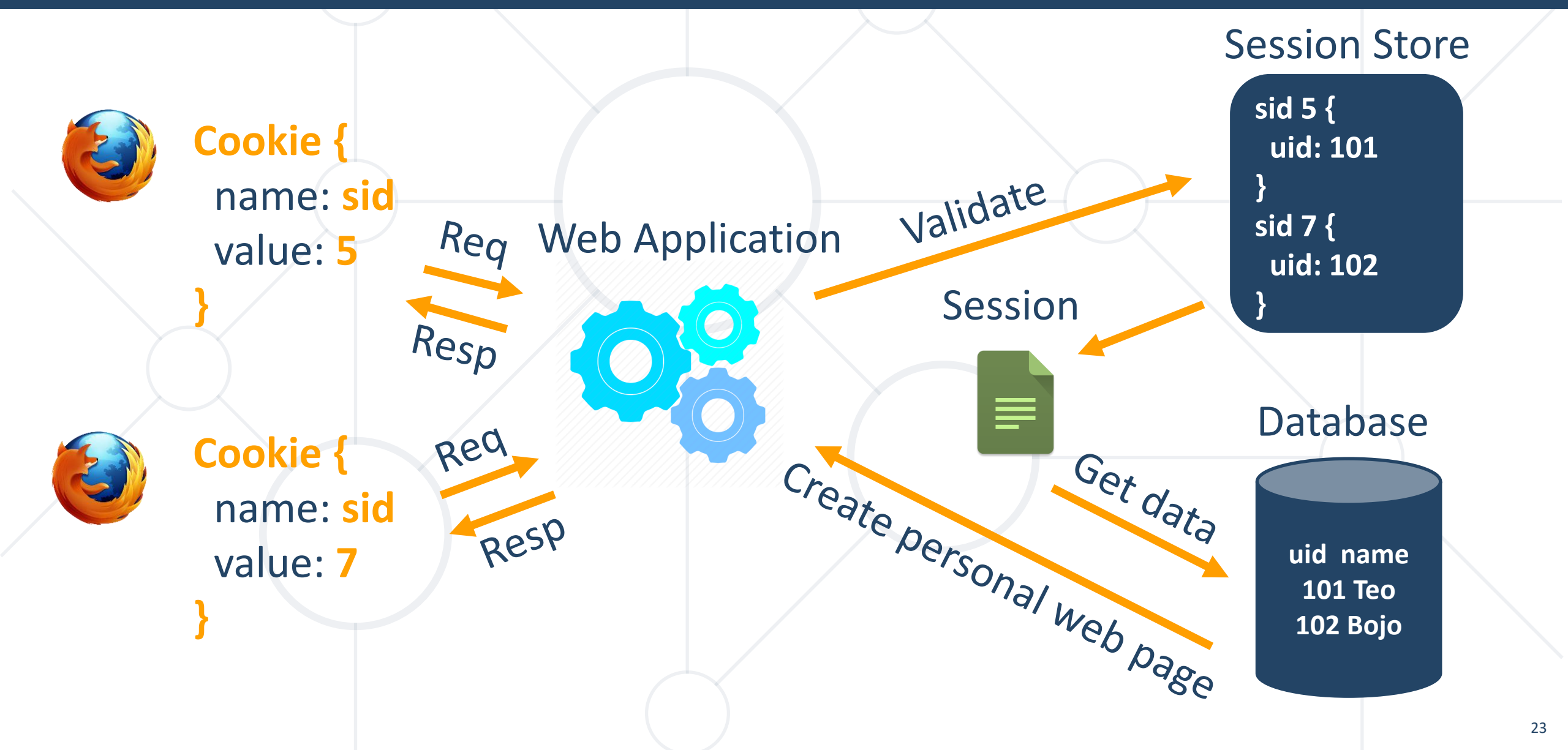
- The exchange mechanism be used between the user and the web application

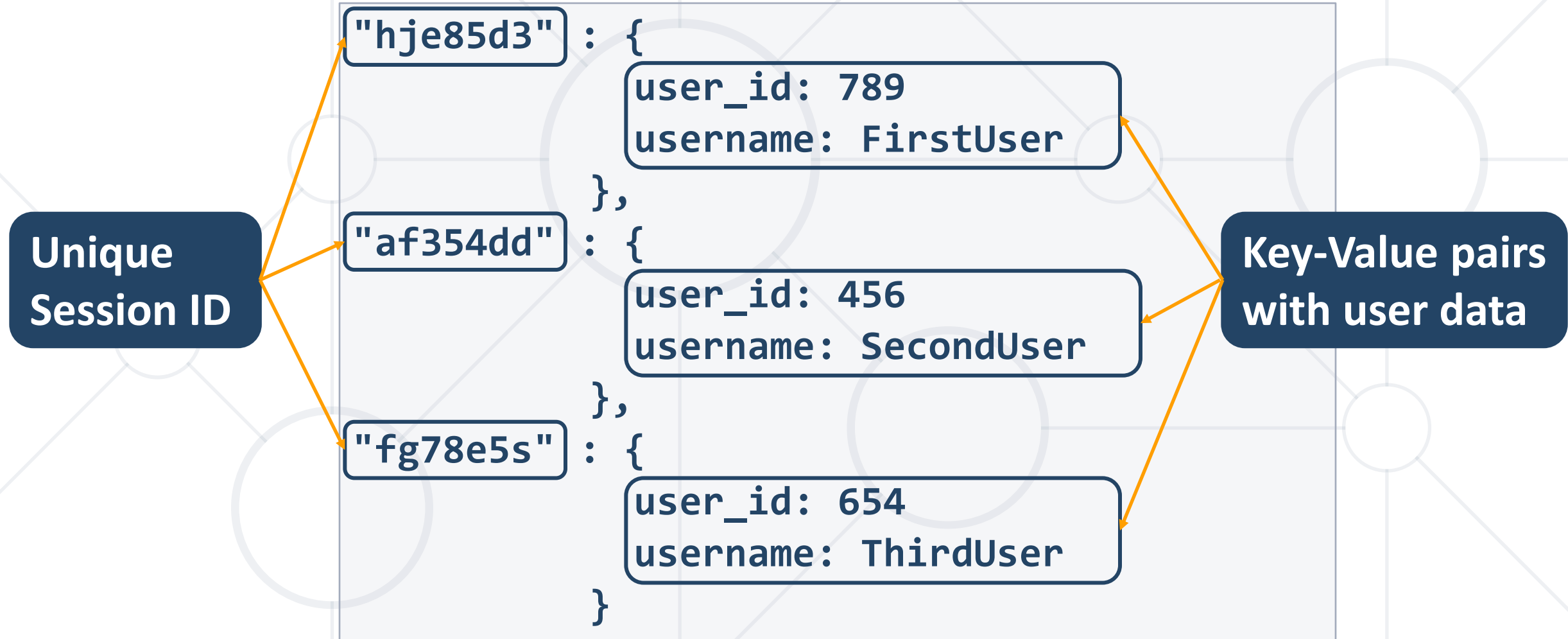


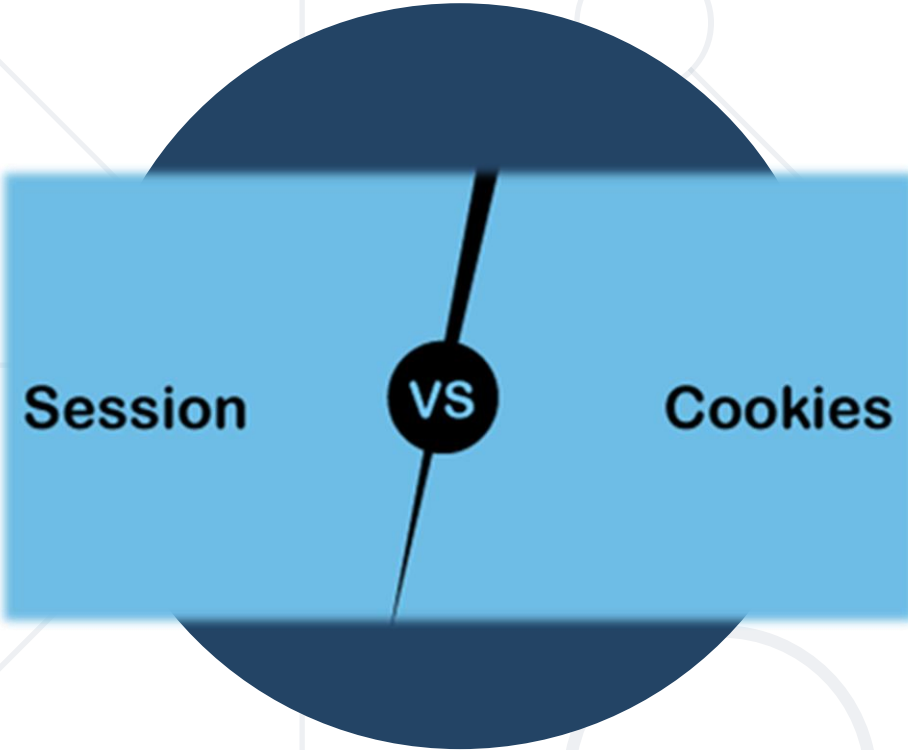
- The exchange mechanism be used between the user and the web application



Relation with Cookies







Session vs Cookies

Differences and Usage

■ Session

- Stored on the server
- Expires when the user closes the browser
- It can store an unlimited amount of data
- Depends on the cookie
- Secure –saves data in encrypted form and cannot be accessed by anyone easily

■ Cookies

- Stored on the user's computer as a text file
- Expires on its expiration date
- It can store only limited data
- Does not depend on the session
- Have security issues, as data is stored in a text file and it can be accessed by anyone easily

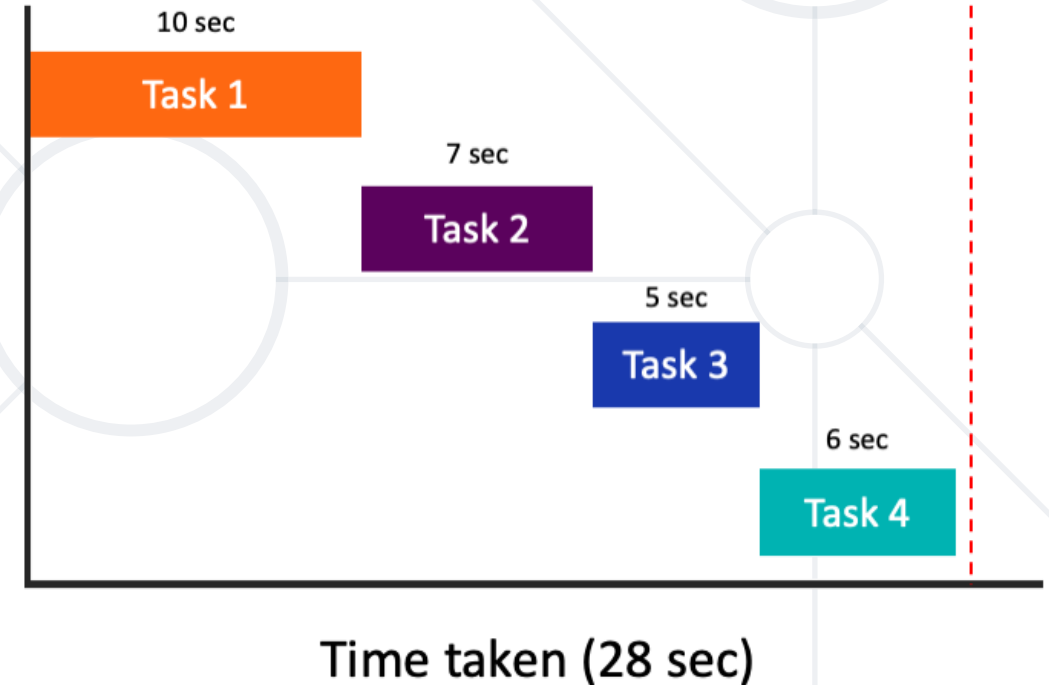




Synchronous Programming

Benefits and Drawbacks

- Executing program components **sequentially**
 - "Sequential programming"
 - Actions happen one after another
- Components **wait** for previous components to finish
- Program resources are accessible at all points



- Synchronous code is executed **step by step**

```
static void Main()
{
    int n = int.Parse(Console.ReadLine());
    PrintNumbersInRange(0, 10);
    Console.WriteLine("Done.");
}

static void PrintNumbersInRange(int a, int b)
{
    for (int i = a; i <= b; i++)
    {
        Console.WriteLine(i);
    }
}
```

`int n = int.Parse(..)`



`PrintNumbersInRange()`



`Console.WriteLine(..)`



...

Synchronous Code – Long Running Operation

```
Console.Write("Enter your name: ");  
string name = Console.ReadLine();
```

```
for (int i = 0; i < int.MaxValue; i++)  
{  
    // Execute some operations here  
}
```

```
Console.WriteLine($"Hello, {name}!");
```

You will have to wait for the long-running operation to finish before you can see the greeting

Synchronous Programming Drawbacks

- If one **component is blocked**, the **entire program is blocked**
- UI may become **unresponsive**
- No utilization of multi-core systems
- CPU-demanding tasks **delay execution** of all other tasks
- **Accessing resources** blocks entire program
 - Especially problematic with web resources

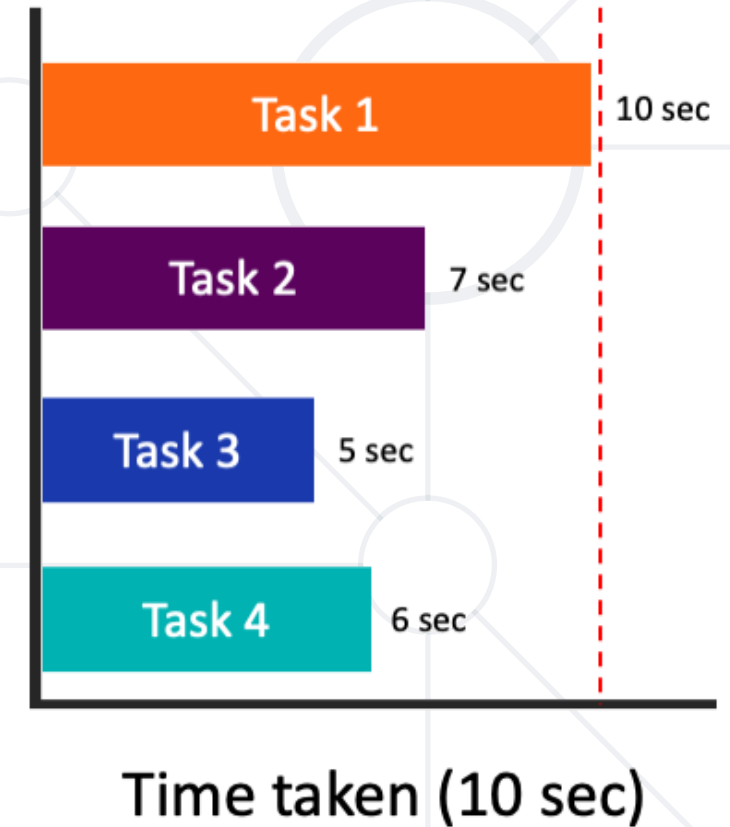




Asynchronous Programming

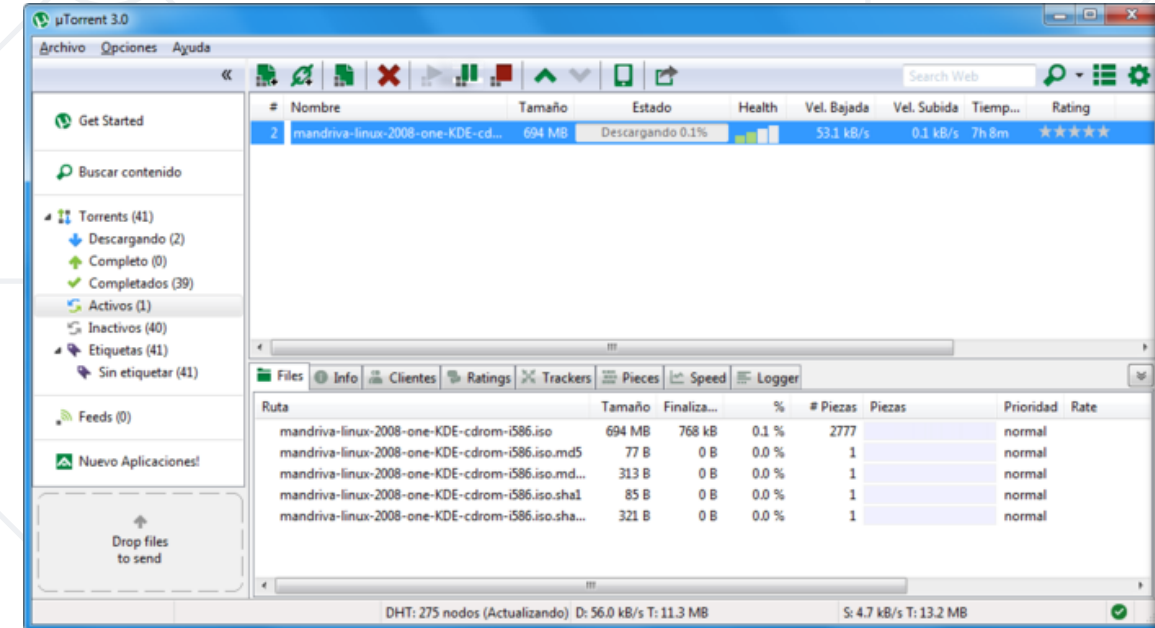
Benefits and Drawbacks

- Program components can execute in **parallel**
 - Some actions run alongside other actions
 - Each action can happen in a **separate** thread
- **Independent** components don't wait for each other
- Program resources shared between threads
 - If one thread uses a resources, others shouldn't use it

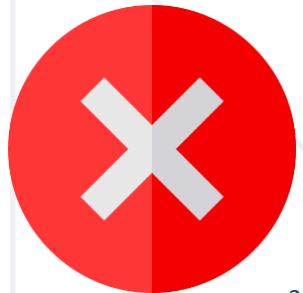
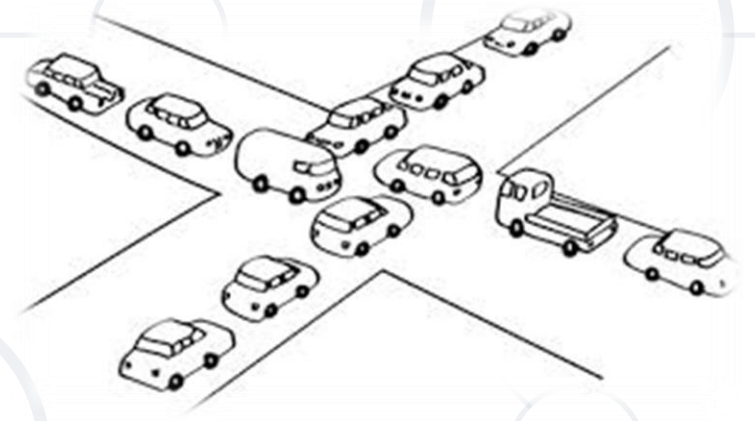


Asynchronous Programming – Benefits

- If a component is blocked, other **components still run**
 - UI runs separately and always remains responsive
- Utilization of multi-core systems
 - Each core executes **one or more** threads
- CPU-demanding tasks run on "**background**" threads
- Resource access runs on "**background**" threads



- Hard to know which code parts are running at a specific time
- Harder than usual to **debug**
- Have to **protect resources**
 - One thread uses a resource
 - Other threads must wait for the resource
- **Hard to synchronize** resource access
 - **Deadlocks** can occur

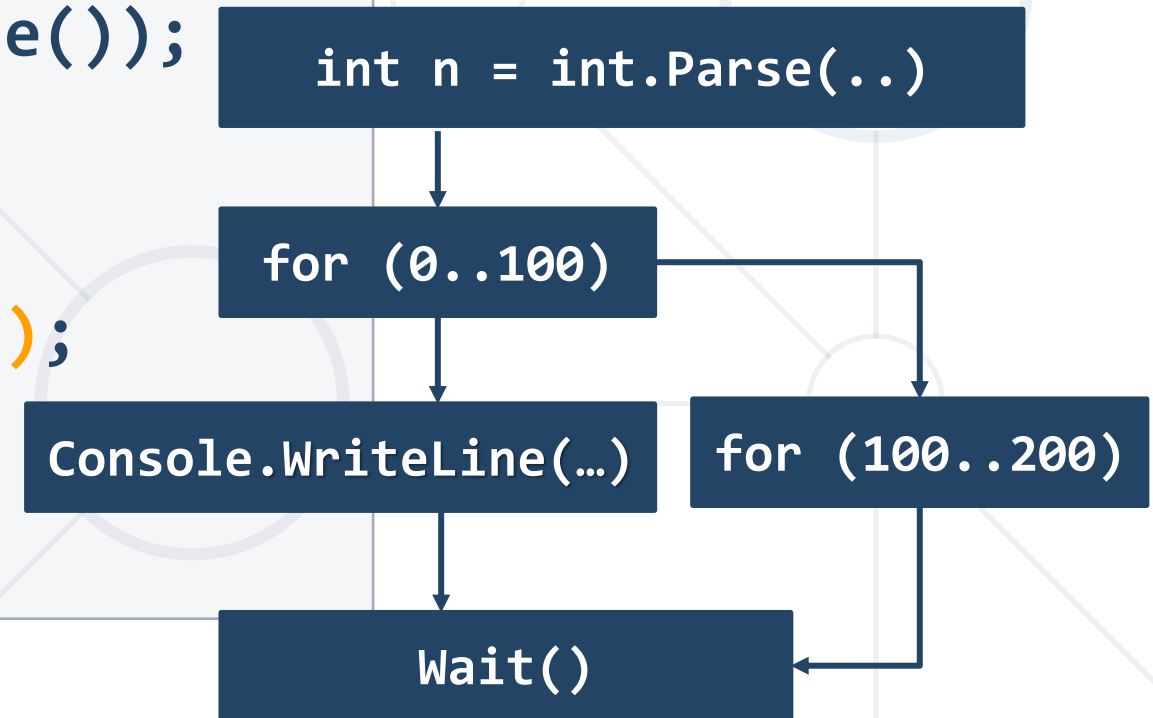


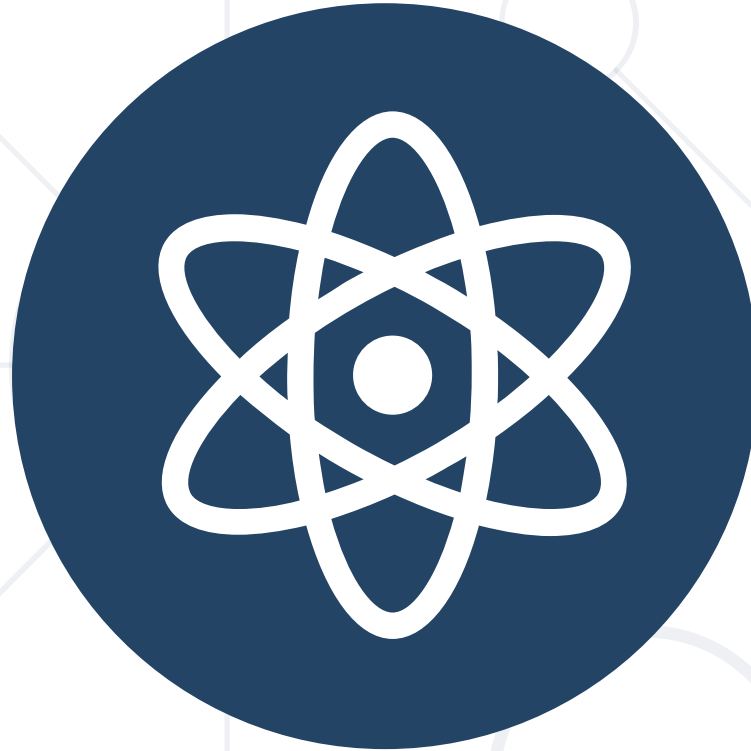
- Asynchronous programming allows the execution of code **simultaneously**

```
int n = int.Parse(Console.ReadLine());
```

```
PrintNumbersInRange(0, 100);  
var task = Task.Run(() =>  
    PrintNumbersInRange(100, 200));
```

```
Console.WriteLine("Done.");  
task.Wait();
```





Threads

Call Stack, Thread-Safety, Exception Handling

- Each program's code is translated to CPU instructions

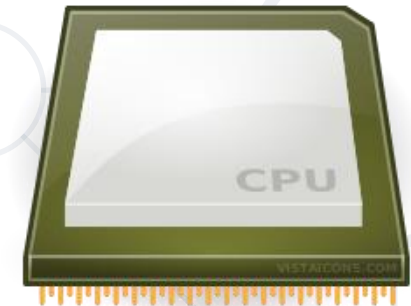
Program.cs

```
int a = 5;  
int b = 4;  
Console.WriteLine(a + b);
```

↓ Compilation

Program.exe

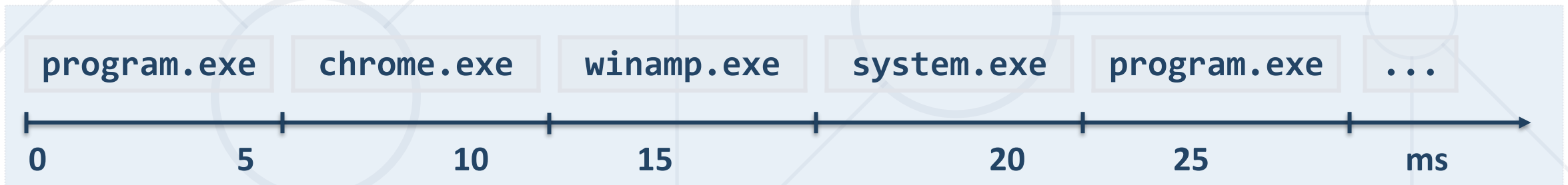
```
00DA2655  mov     dword ptr [ebp-40h],5  
00DA265C  mov     dword ptr [ebp-44h],4  
00DA2663  mov     ecx,dword ptr [ebp-40h]  
00DA2666  add     ecx,dword ptr [ebp-44h]  
00DA2669  call    73B5A920  
00DA266E  nop
```



Single-Core CPU

**Instructions are
executed one by
one**

- A computer can run **many processes** (applications) at once
 - But each CPU core can only execute one instruction at a time
 - **Parallelism** is achieved by the operating system's **scheduler**
 - Grants each **thread** a small interval of time to run



- A **thread** is a fundamental unit of code execution
- Commonly, processes (programs) use more than one thread
 - In .NET, there is always more than one thread (e.g. GC)
- Each thread has a **memory area** associated with it known as a **Call Stack**
 - Stores **local variables**
 - Stores the **currently invoked methods** in order of invocation

Multithreaded programming



- Threads in C# can be created using the **System.Thread** class
- Constructor accepts a **method** (delegate) to execute on a separate thread

```
Thread thread = new Thread(() =>
{
    for (int i = 0; i < 10; i++)
    {
        Console.WriteLine(i);
    }
});
```

- **Start()** – schedules the thread for execution
- **Join()** – waits for the thread to finish its work (blocks the calling thread)

```
Thread primes = new Thread(() =>  
    PrintPrimesInRange(1, 10000));  
primes.Start();
```

```
Console.WriteLine("Waiting for thread to finish work...");  
primes.Join();
```

Thread – Example

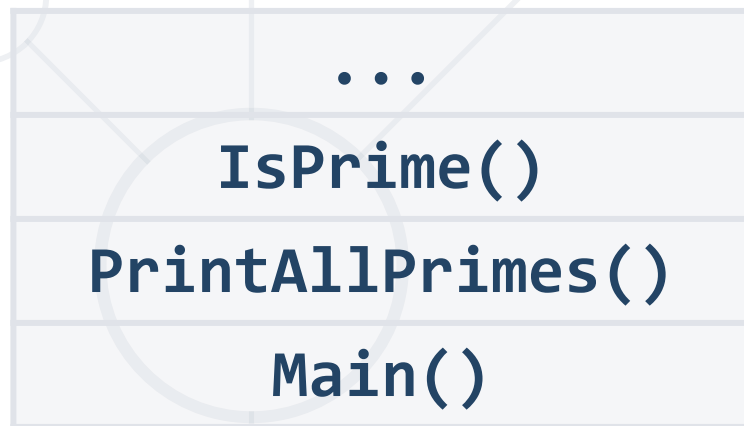
```
List<long> numbers = new List<long>();  
Thread t = new Thread(() =>  
    SumOddNumbers(numbers, 10, 1000000000L));  
t.Start();
```

```
Console.WriteLine("What should I do?");  
while (true)  
{  
    string command = Console.ReadLine();  
    if (command == "exit") break;  
}
```

```
t.Join();
```

**Console interface
remains unblocked**

- Each thread has its own **stack**
 - The start (bottom) of the stack is the method from which the thread began execution
 - Each method (frame) stores local variables



main thread



background thread

- A **race condition** occurs when two or more threads access shared data and they try to change it at the same time

```
List<int> numbers = Enumerable.Range(0, 10000).ToList();
for (int i = 0; i < 4; i++)
{
    new Thread(() =>
    {
        while (numbers.Count > 0)
            numbers.RemoveAt(numbers.Count - 1);
    }).Start();
}
```



- A thread-safe resource can be safely accessed by multiple threads
- **lock** keyword grants access to only one thread at a time
 - Avoids race conditions
 - Blocks any other threads until the lock is released

```
lock (numbers)
{
    if (numbers.Count == 0) break;
    int lastIndex = numbers.Count - 1;
    numbers.RemoveAt(lastIndex);
}
```



- Exceptions cannot be handled outside a thread

```
try
{
    new Thread(DoWork).Start();
}
catch (Exception ex)
{
    Console.WriteLine("Exception!");
}
```

**This part will never
be reached**

```
public static void DoWork()
{
    throw new ArgumentNullException();
}
```

Exception Handling – the Right Way

```
new Thread(DoWork).Start();  
public static void DoWork()  
{  
    try  
    {  
        throw new ArgumentNullException();  
    }  
    catch (Exception ex)  
    {  
        Console.WriteLine("Exception handled!");  
    }  
}
```

Exceptions should be handled inside the executed method(s)



Tasks in C#

Task Parallel Library

- A task is a high-level representation of concurrent work
 - Runs in **parallel** with the main thread
 - May not run on a new thread (the CLR decides)
 - Offers several operations
 - Creating, running and **returning** result
 - Continuing with another task (**chaining several operations**)
 - Proper exception handling
 - Progress/state reports



- Creating tasks can be done in several ways

- Initialize a new **Task** object

```
Task task = new Task(() => { Console.WriteLine(""); });
```

- **Task.Run()**

```
Task.Run(() => TraverseMatrix());
```

- **Task.Factory.StartNew()** – enables additional task customization

```
Task.Factory.StartNew(() => CopyFileContents("got-s03ep1.avi"),  
    TaskCreationOptions.LongRunning);
```

- **Task<T>** is a task that will return a result sometime in the future

```
Task<long> task = Task<long>.Run(() =>
{
    long sum = 0;
    for (int i = 0; i < 10000; i++) sum += i;
    return sum;
});
```

```
Console.WriteLine(task.Result);
```

Blocks the calling thread until the task returns a result

- **Exceptions** that have occurred within the body of a **Task** can be captured and handled outside of it

```
var task = SliceAsync(VideoPath, DestinationPath, 5);  
try  
{  
    task.Wait();  
}  
catch (AggregateException ex)  
{  
    // Handle exception...  
}
```

You can use the **AggregateException** to wrap all exceptions thrown by different threads



```
Async function() {  
  Await ...  
}
```

Async and Await

Keywords for Asynchronous Operations

- The keywords **async** and **await** are **always** used together
- **async** hints the compiler that the method might run in parallel
 - Does not make a method run asynchronously (**await** makes it)

```
static async void SliceFileAsync(string file, int parts)
```

- Tells the compiler "**this method could wait for a resource or operation**"
 - If it starts waiting, return to the calling method
 - When the wait is over, go back to called method

- **await** is used in a method which has the **async** keyword
 - Saves the context in a state machine
 - Marks waiting for a resource (a task to complete)
 - Resource should be a **Task<T>**
 - Returns **T** result from **Task<T>** when it completes

```
await DownloadStringAsync("https://softuni.org");
```

Returns **Task<string>**

Async and Await – Example

```
static void Main()
{
    DownloadFileAsync(FileUrl, "book.pdf");
    // Do some other work
}
```

After the method is over
the calling thread gets
back to the calling method

```
static async void DownloadFileAsync(string url, string fileName)
{
    Console.WriteLine("Downloading...");
    await Task.Run(() =>
    {
        // Download the file
    });
    Console.WriteLine("Download successful.");
}
```

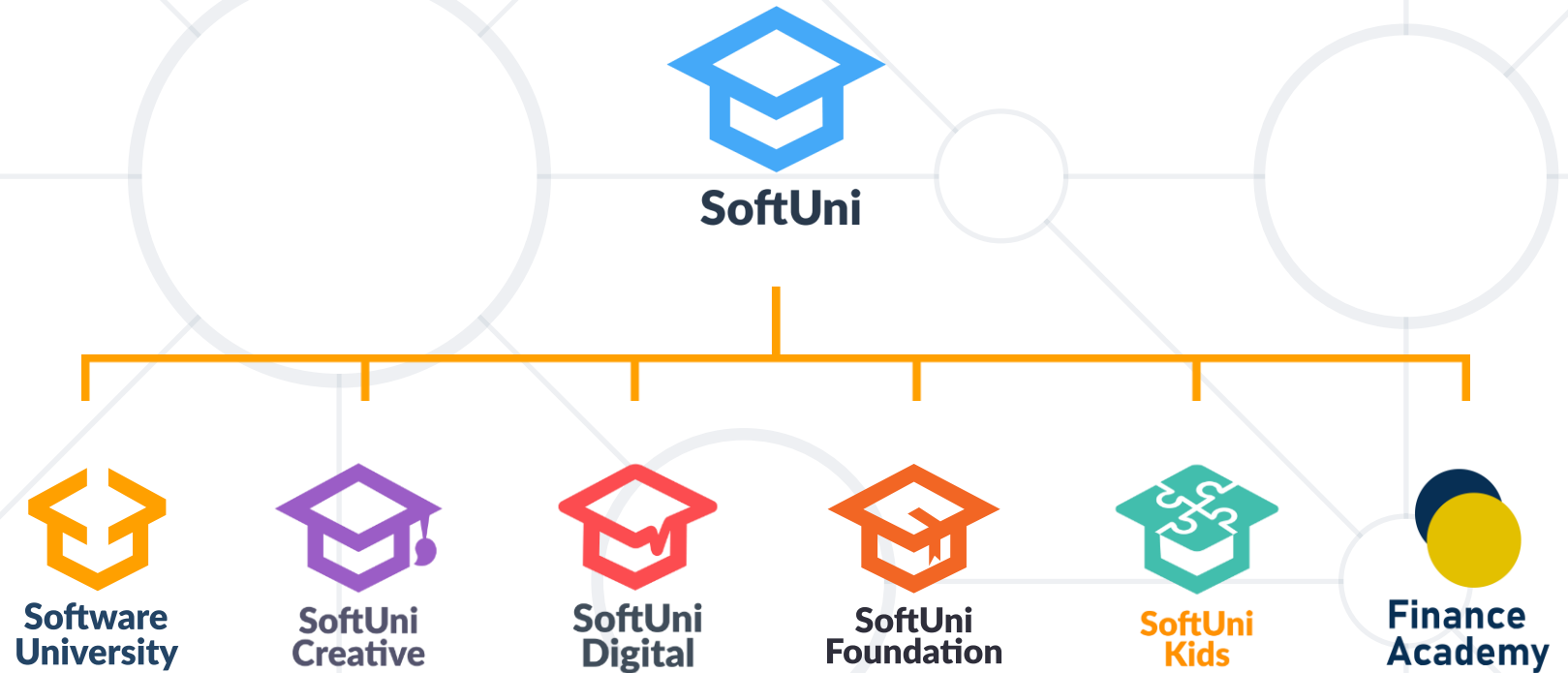
The calling thread exits
the method on **await**

When the waiting is
over, the calling
thread proceeds with
method execution

- **State management**
 - **Cookies** are client based stored information
 - **Sessions** are server-based information
- **Asynchronous processing**
 - A **thread** is a unit of code execution
 - **Multithreading**
 - **Tasks** facilitate the work with multithreading
 - **async** and **await** keywords



Questions?



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