ASP.NET Core SignalR

Real-Time Applications, Live Communication, SignalR, Hubs

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Candidates, Live Communication, Benefits

Real-Time Applications

Real-Time Applications

- **Real-Time Applications** are essentially **live communication** apps
  - They function within a time frame usually sensed as immediate
  - They have two-way communication between client and server
- **Real-Time Application** are used in many cases:
  - Gaming
  - Auctions, Betting
  - Stock quotes, Crypto
  - Email clients
  - Social media, Chats

Real-Time Applications

- **RTAs** use live communication to optimize functionality
  - This makes them more interactive and comfortable to use
- **Live communication** often requires additional web protocols
  - Like the **WebSocket** communication protocol for example
- **Live communication** requires some, unnatural for **HTTP**, processes
  - Server **sending** data **without** the Client **requesting** it
    - This feature is also known as **Server Push** – it is included in **HTTP/2**
  - Two-way data transfer over a single connection (**Full-Duplex**)

Real-Time Applications

- **RTAs** solve many problems in the web applications world
  - **Fast Information delivery**
    - Imagine having to refresh a page to check actual live data
    - This would be catastrophic for crypto apps / betting apps
  - **Interactivity**, **Comfort** and **Usability**
    - Imagine having to refresh a chat to check if your friend sent a message
    - Your clients won't be satisfied with such functionality needs

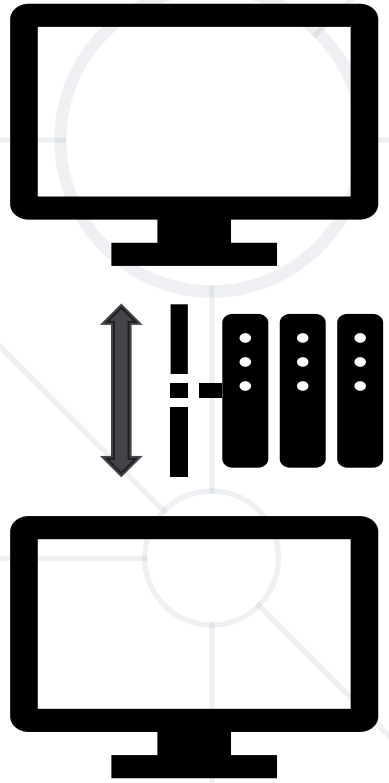
Real-Time Applications

- **Live communication** is currently a very common thing
  - In fact, you are probably watching a **live-stream** at the moment
  - This is also considered live communication
- **Live communication** is probably used the most in the gaming industry
  - **Multiplayer Games** need a live connection with players
    - There are many in-game events that require this feature
    - It won't be very appropriate for players to restart the game just to realize they lost
  - Even the simplest online game of **Chess** uses **live communication**

Polling, Server-Sent Events, Remote Procedure Calls

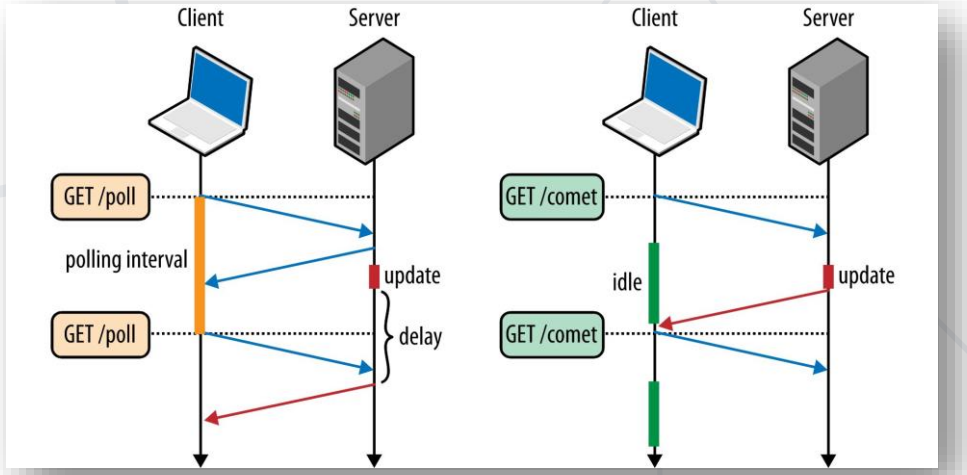
Polling

- **Polling** is a technique by which the client requests data regularly
  - New data is **requested** at **frequent intervals**
  - Works with **HTTP requests** and **responses**
- There are generally two ways of **Polling**
  - **Short Polling**
    - An AJAX-based timer, that calls at **fixed delays**
  - **Long Polling**
    - The server **holds** the **request open** until **new data** is available



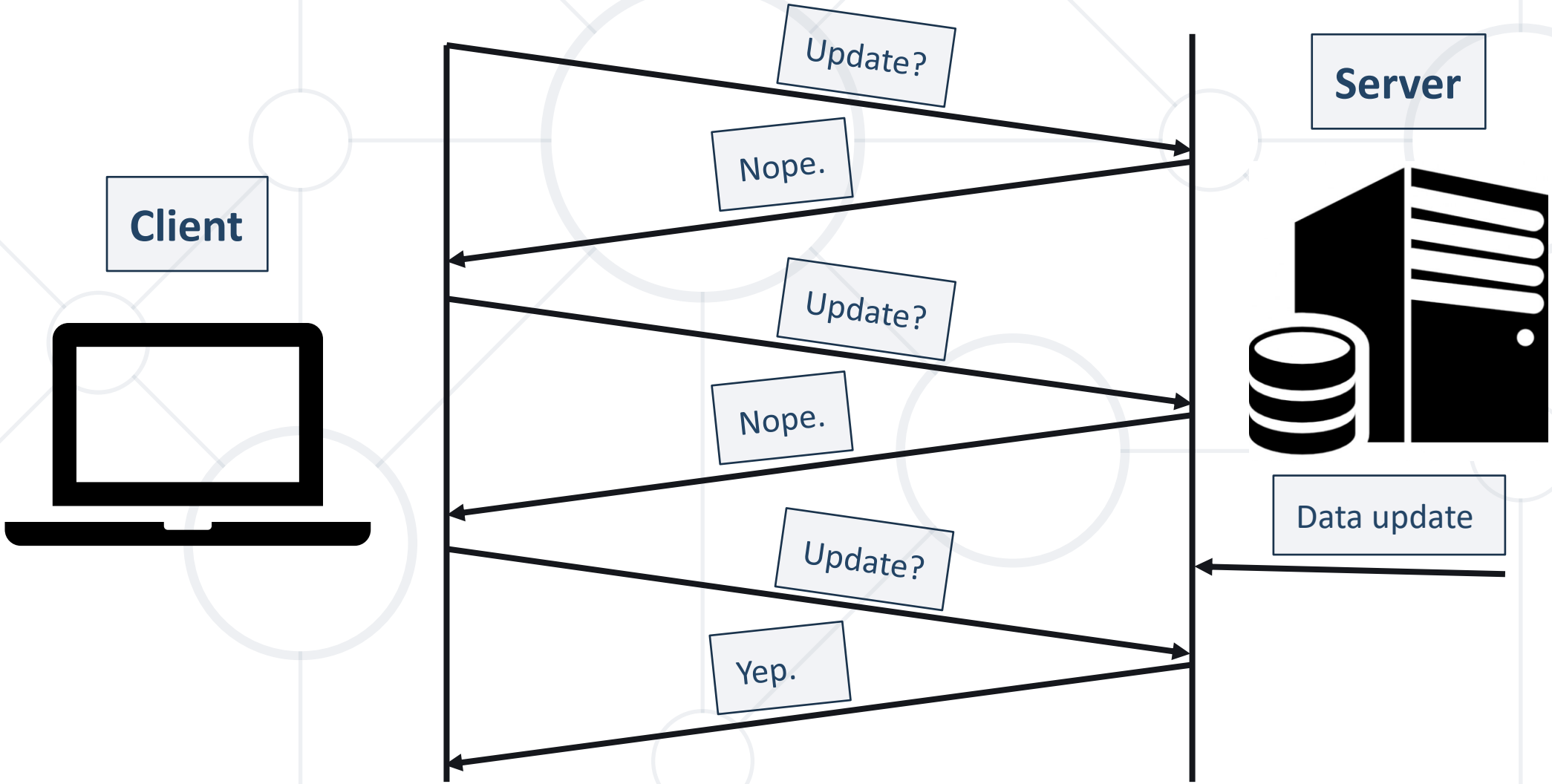
Polling

- Each of the 2 ways of **Polling** has its advantages and disadvantages
- **Short Polling** requires less server resource consumption
  - Practically useless if you need server event notification with **no delay**
  - Blasts your clients' **internet data** (if its limited)
- **Long Polling** notifies you about server events with **no delay**
  - Good for the bandwidth
  - More complex to develop and manage
  - Requires more server resources



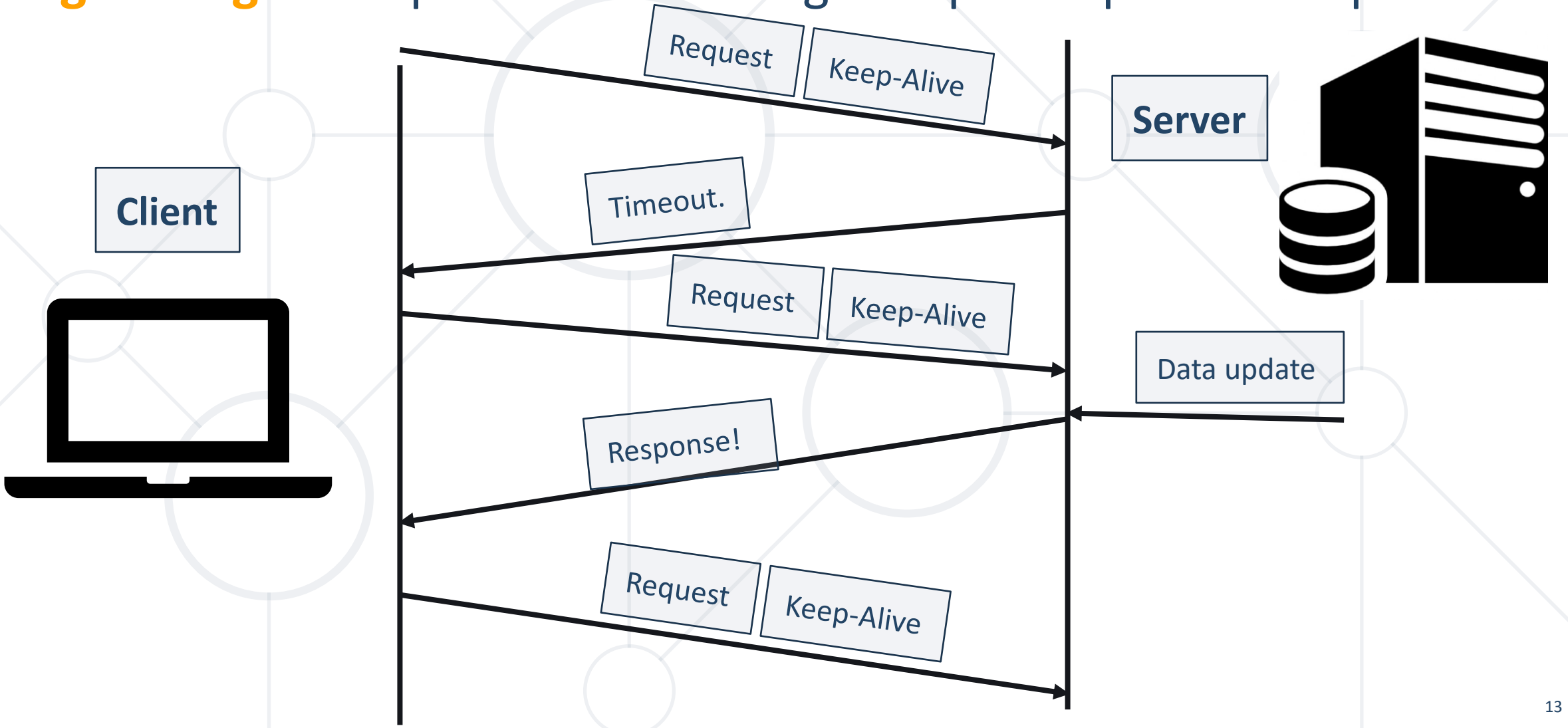
Short Polling – Process Explained

- **Short Polling** is the process of frequent calls (checks) for actual data



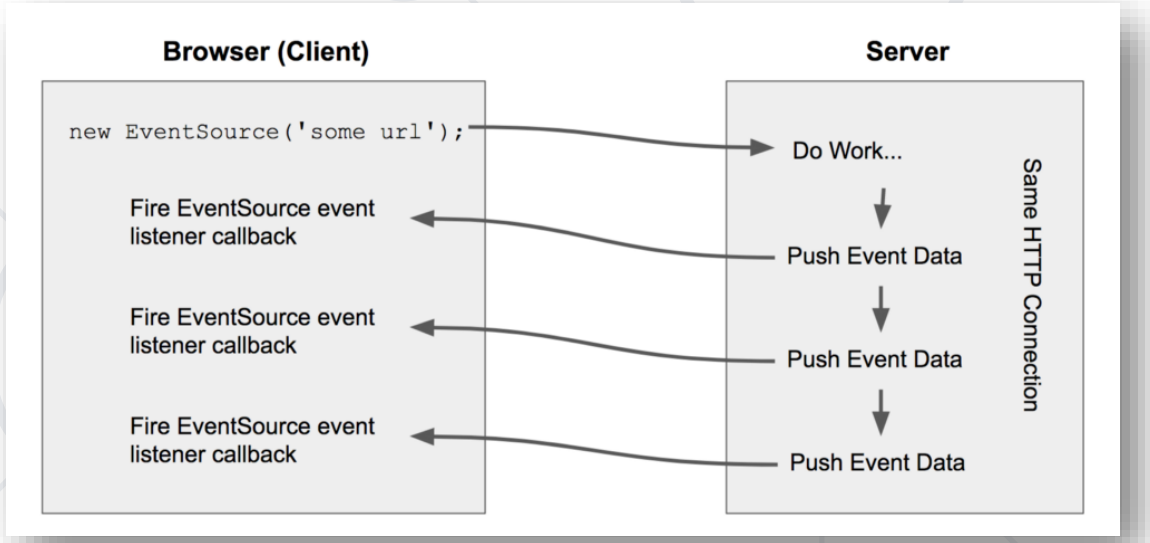
Long Polling – Process Explained

- **Long Polling** is the process of holding a request open until update



Server-Sent Events

- **SSE** is a technology enabling a browser to receive automatic updates from a server via HTTP connection
  - Client doesn't have to make a request to check if updates are available
  - It is a **one-way** channel
- **SSE** requires an initial handshake
  - Server leaves the response open
    - Until there are no more events
    - Until the connection has been considered stale
    - Until the client explicitly closes the initial request



WebSocket

- **WebSocket** is a computer communication protocol
  - Provides **full-duplex** (**two-way**) communication channels
  - Channels are provided over a single **TCP connection**
- **WebSocket** is different from **HTTP**, although they are compatible
  - Works over a standard connection (**ws://**) and SSL (**wss://**)
  - Supports **HTTP** proxies and intermediaries
  - **WebSocket** enables **streams** of **messages** on top of **TCP**
  - Supported in most modern browsers, nowadays

WebSocket

- **WebSocket** introduces a whole **new way** of two-way communication
  - Two-way communication (**browser-server**) is certainly a convenience
- Before **WebSocket**, this was achieved in a rather non-standardized way
  - Using stopgap technologies such as **Comet**, for example
- **WebSocket** communication is initiated trough a casual handshake

Client Request

```
GET /chat HTTP/1.1
Host: server.example.com
Upgrade: websocket
Connection: Upgrade
Sec-WebSocket-Key: x3JJHMbDL1EzLkh9GBhXDw==
Sec-WebSocket-Protocol: chat, superchat
Sec-WebSocket-Version: 13
Origin: http://example.com
```

Server Response

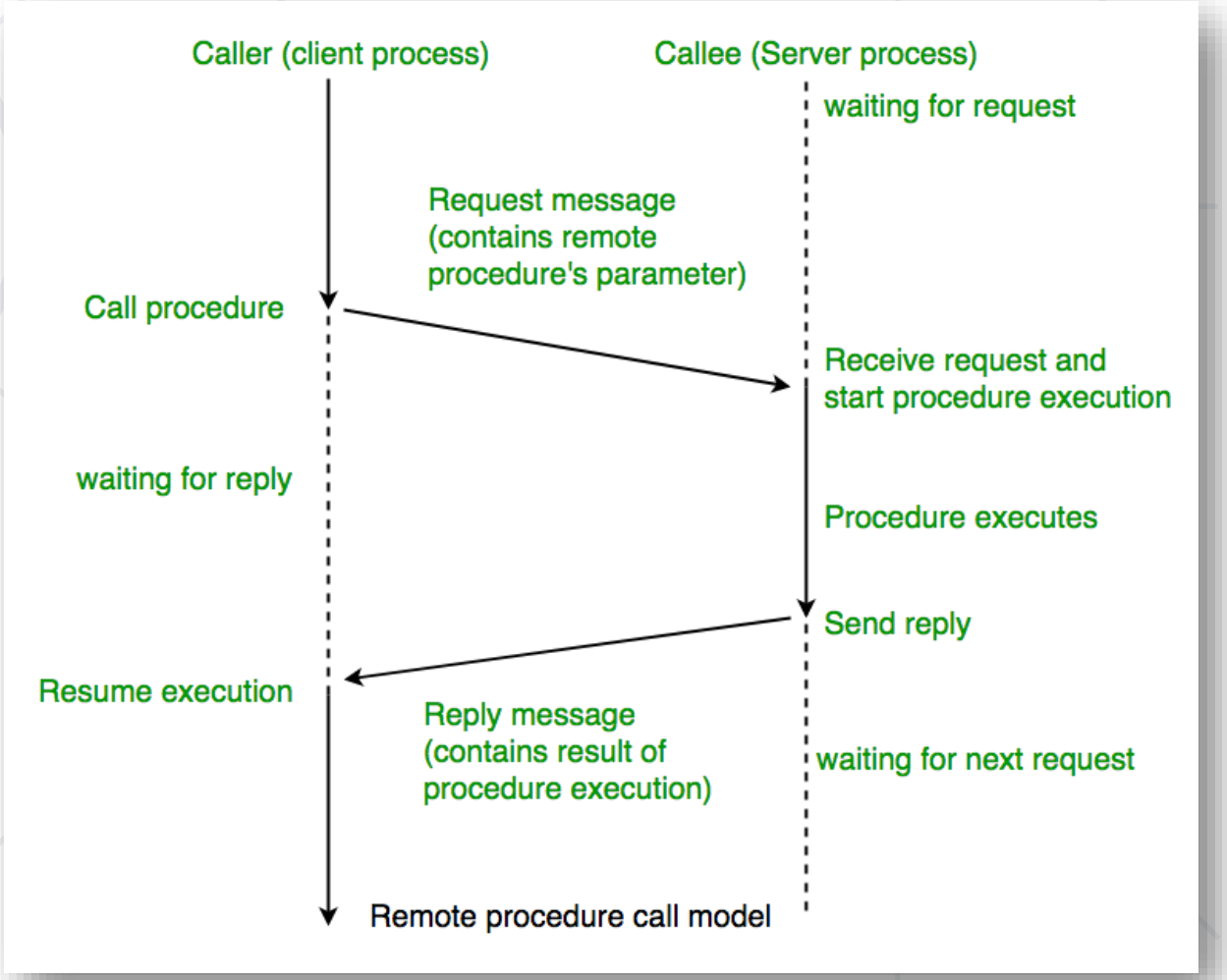
```
HTTP/1.1 101 Switching Protocols
Upgrade: websocket
Connection: Upgrade
Sec-WebSocket-Accept: HSmrc0sMlYUkAGmm5OPpG2HaGWk=
Sec-WebSocket-Protocol: chat
```

Remote Procedure Call

- **Remote Procedure Call** is an interprocess communication technique
  - A software causes a **procedure execution** in a different address space
  - Uses the **Client-Server** model
  - Used for **point-to-point** communication between apps
  - Sometimes called a **function** call / **subroutine** call
- **Remote Procedure Calls** are naturally **synchronous**
  - The **Sender** (Client) must wait for the **Executor** (Server)'s result
  - There are some ways of achieving **concurrency** though

Remote Procedure Call

- When making a **RPC**
  - Procedure **name** and **parameters** are transferred over the **network**
    - **Serialized**
  - Procedure is **executed** and produces **results**
  - **Results** are transferred **back**
    - **Serialized**
  - Execution process **resumes**



Adding Real-Time Functionality to Your Apps

ASP.NET Core SignalR

ASP.NET Core SignalR

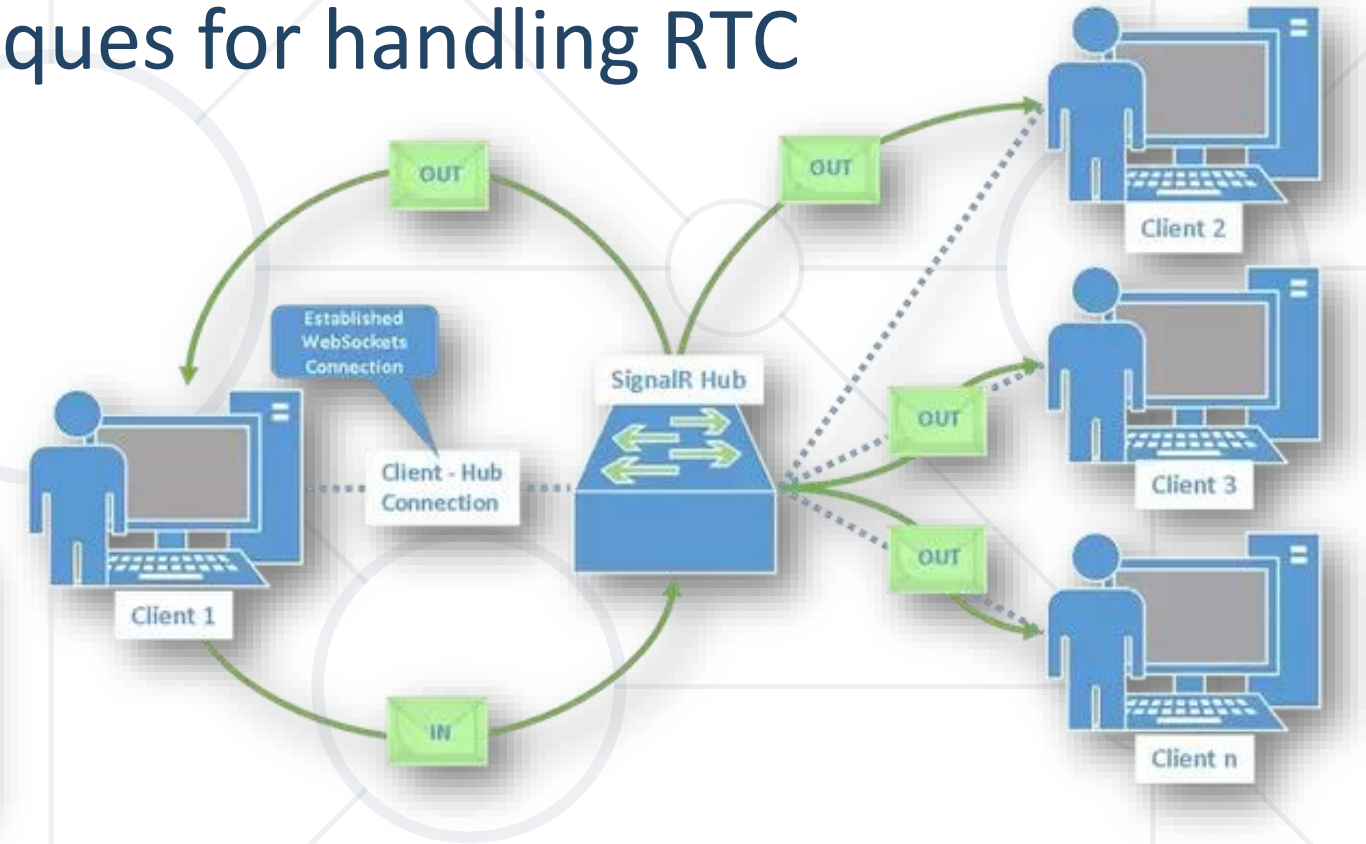
- **ASP.NET Core SignalR** is a library that simplifies adding **RTC** in web apps
  - **RT** functionality enables **server content** to be **pushed** to clients **instantly**
- Good candidates for **SignalR** implementation include:
  - Apps that require **high-frequency updates** from the server
    - Gaming, Social Networks, Chat, Voting, Auction, Maps & GPS, etc.
  - **Dashboards** and **monitoring** apps – travel alerts, sales updates, etc.
  - **Collaborative** apps – Agile apps, Team Meeting apps, etc.
  - **Apps** that **require notifications** – Email, Chat, Social networks

ASP.NET Core SignalR

- **SignalR** provides **API** for creating **server-to-client RPCs**
  - The **RPCs** call **JavaScript** functions on **clients** and vice-versa
  - The **RPCs** are called from **server-side** .NET Code
- Some of the core features of **SignalR** include:
  - Handling **connection management** automatically
  - Sending messages to all connected clients simultaneously (**broadcast**)
  - Sending messages to a specific client or **group** of **clients**
  - Scaling to handle increasing traffic (**Azure SignalR Service**)

ASP.NET Core SignalR

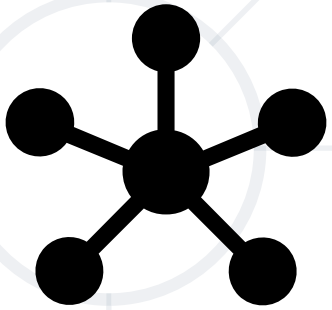
- **SignalR** supports 3 techniques for handling RTC
  - WebSockets
  - Server-Sent Events
  - Long Polling



- **SingalR** automatically chooses the best transport method
  - Chosen within the **capabilities** of the **Server** and **Client**

ASP.NET Core SignalR Hubs

- **SignalR** uses **hubs** to establish communication client ↔ server
  - A **hub** is **high-level pipeline**
  - Allows a **Client** and **Server** to **call methods** on each other



- **Hubs** call **client-side** code by **sending messages**
  - These messages contain the **method name** and the **parameters**
  - Objects sent as **method parameters** are **deserialized**
  - The client tries to find a method, matching the **given name**
  - When the **Client** finds the method, it **passes** the **parameters** to it

ASP.NET Core SignalR Hubs

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- You can pass **Strongly-typed** parameters to methods
  - This enables model binding on the server and vice-versa
  - These parameters are **deserialized**, using a **configured protocol**
- **SignalR** provides 2 built-in hub protocols
  - A **text protocol** based on **JSON**
  - A **binary protocol** based on **MessagePack**
  - **MessagePack** generally creates smaller messages
    - Compared to the JSON format

```
{"compact":true}
```

MessagePack

- **MessagePack** is an efficient, **binary** serialization format
  - It's like JSON, but fast and small
- **MessagePack** lets you exchange data among multiple languages
  - Small integers are encoded into a **single byte**
  - Typical short strings require only **one extra byte**
    - In addition to the strings themselves

JSON 27 bytes

```
{ "compact": true, "schema": 0 }
```

Hub

- **SignalR Hubs API** provides a **Hub** class for applications to consume
  - The **Hub** class manages connections, groups, messaging
  - It also automatically manages the **Identity** system
  - This provides convenience and comfort when developing Hubs
- The **Hub** class contains several helpful members
  - The Hub **Context**, The Hub **Clients**, The Group **Manager**
- The **Hub** class contains methods for capturing Connection **events**
  - **`OnConnectedAsync()`** & **`OnDisconnectedAsync()`**

Context

- The **Hub Context** is represented by the **`Context`** property
  - It contains properties with information about the connection
- The most important properties provided by the **`Context`** are:
  - **`ConnectionId`** – Gets the unique Id for the connection
  - **`UserIdentifier`** – Gets the user identifier – **`ClaimTypes.NameIdentifier`**
  - **`User`** – Gets the **ClaimsPrincipal** associated with the current user
  - **`Items`** – Gets a **key-value-pair** collection, used for data sharing
- The **`Context`** also holds the methods **`GetHttpContext`** and **`Abort`**

Clients

- The **Hub Clients** is represented by the `Clients` property
  - It contains properties for communication between server and client
- The most important members provided by the `Clients` are:
  - `All` – Calls a method on **all** connected clients
  - `Caller` – Calls a method on the **client** that **invoked** the **hub method**
  - `Others` – Calls a method on all connected clients **except** the **caller client**
- The `Clients` also holds many other methods for **filtering clients**
  - These methods helps specify **particular clients**

GroupManager

- The `GroupManager` is represented by the `Groups` property
  - It contains properties for managing client clustering
  - You can add `Clients` to a specific `Group`
    - Using `AddToGroupAsync()`
  - You can remove `Clients` from a specific `Group`
    - Using `RemoveFromGroupAsync()`
- **Grouping Clients** helps you **broadcast** messages to specific auditories
  - In **real-time apps**, it is **rarely** needed to **broadcast** a message to **all clients**

SignalR Notes

- **SignalR** code is asynchronous to ensure maximum scalability
  - Use await when calling **async** methods that depend on the **Hub**
  - **Async** methods can fail if the hub method completes first
- **Hub** methods can return any type and receive any parameters
  - **SignalR** handles serialization and deserialization
- **Hubs** are transient
  - **Don't store state** in a property on the hub class
  - Every hub method call is executed on a **new hub instance**

Creating a Very Simplistic Chat Application

Including SignalR in ASP.NET Core

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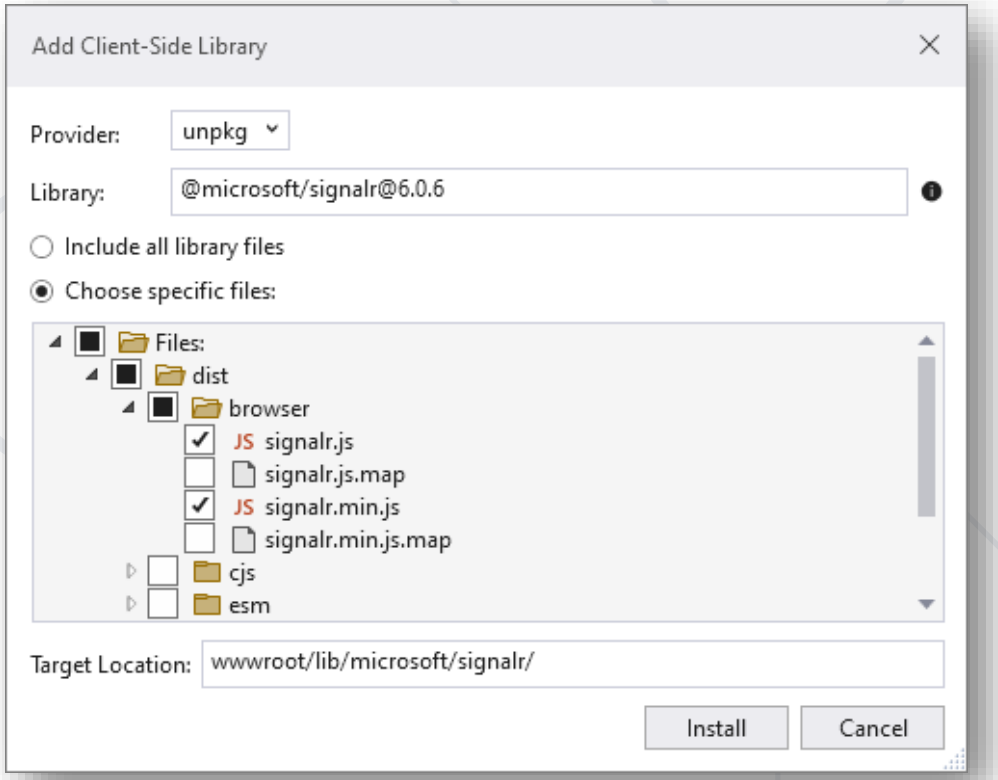
- Simple **Chat** application in **ASP.NET Core**
  - Create an empty project
  - In [**Solution Explorer**], right-click on the project, [**Add**] → [**Client-Side Library**]



Including SignalR in ASP.NET Core

- Simple **Chat** application in **ASP.NET Core**
  - Configuring **SignalR**

```
using SignalRChat.Hubs;

var builder = WebApplication.CreateBuilder(args);

builder.Services.AddSignalR();

var app = builder.Build();

app.MapHub<ChatHub>("/chatHub");
```

Including SignalR in ASP.NET Core

- Simple **Chat** application in **ASP.NET Core**
  - **ChatHub.cs** class file

```
public class ChatHub : Hub
    {
        public async Task SendMessage(string user, string message)
        {
            await Clients.All.SendAsync("ReceiveMessage", user, message);
        }
    }
}
```

  - The **ChatHub** class inherits from the **SignalR Hub** class
    - The **Hub** class manages connections, groups and messaging
  - The **SendMessage** method can be called by any connected client
    - It sends the received message to all clients

Including SignalR in ASP.NET Core

- Simple **Chat** application in **ASP.NET Core**
  - **JavaScript** (Client) code - **chat.js**

```
var connection = new signalR.HubConnectionBuilder().withUrl("/chatHub").build();
// The Receive Message Client event. This will trigger, when the Back-End calls the ReceiveMessage
method
connection.on("ReceiveMessage", function (user, message) { ... });

//An error handler for connection errors
connection.start().then(function () {
    document.getElementById("sendButton").disabled = false;
}).catch(function (err) {
    return console.error(err.toString());
});

// The Send Message DOM event. This will trigger the Back-End SendMessage method
document.getElementById("sendButton").addEventListener("click", function (event) { ... });
```

Including SignalR in ASP.NET Core

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- Simple **Chat** application in **ASP.NET Core**

```
connection.on("ReceiveMessage", function (user, message) {
    var li = document.createElement("li");
    document.getElementById("messagesList").appendChild(li);

    li.textContent = `${user} says ${message}`;
});
```

```
document.getElementById("sendButton").addEventListener("click", function (event) {
    var user = document.getElementById("userInput").value;
    var message = document.getElementById("messageInput").value;
    connection.invoke("SendMessage", user, message).catch(function (err) {
        return console.error(err.toString());
    });
    event.preventDefault();
});
```

Summary

- Real-Time Applications
- Web Communication Fundamentals
  - Short Polling, Long Polling
  - Server-Sent Events, WebSockets
- Remote Procedure Calls
- ASP.NET Core SignalR
  - Real-time chat application with SignalR

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