10 surprising webRTC apps and the tricks that make them tick

Leveraging web APIs for user joy.

Tim Panton (tim@pi.pe) Oct 2021

Tim Panton
CTO @ pi.pe GmbH

- |pipe| licenses a lightweight cleanroom WebRTC stack for IoT devices.
- cofounded a web-based telephony company, sold the IPR to Tropo Inc., which was then acquired by Cisco.
- technical cofounder of Westpoint, a web security company acquired by Capita.
- writes |pipe| software
- helps define WebRTC standards at the W3C and IETF

photo by Neda Navaee

Lockdown

What do ?

Build some JOY!

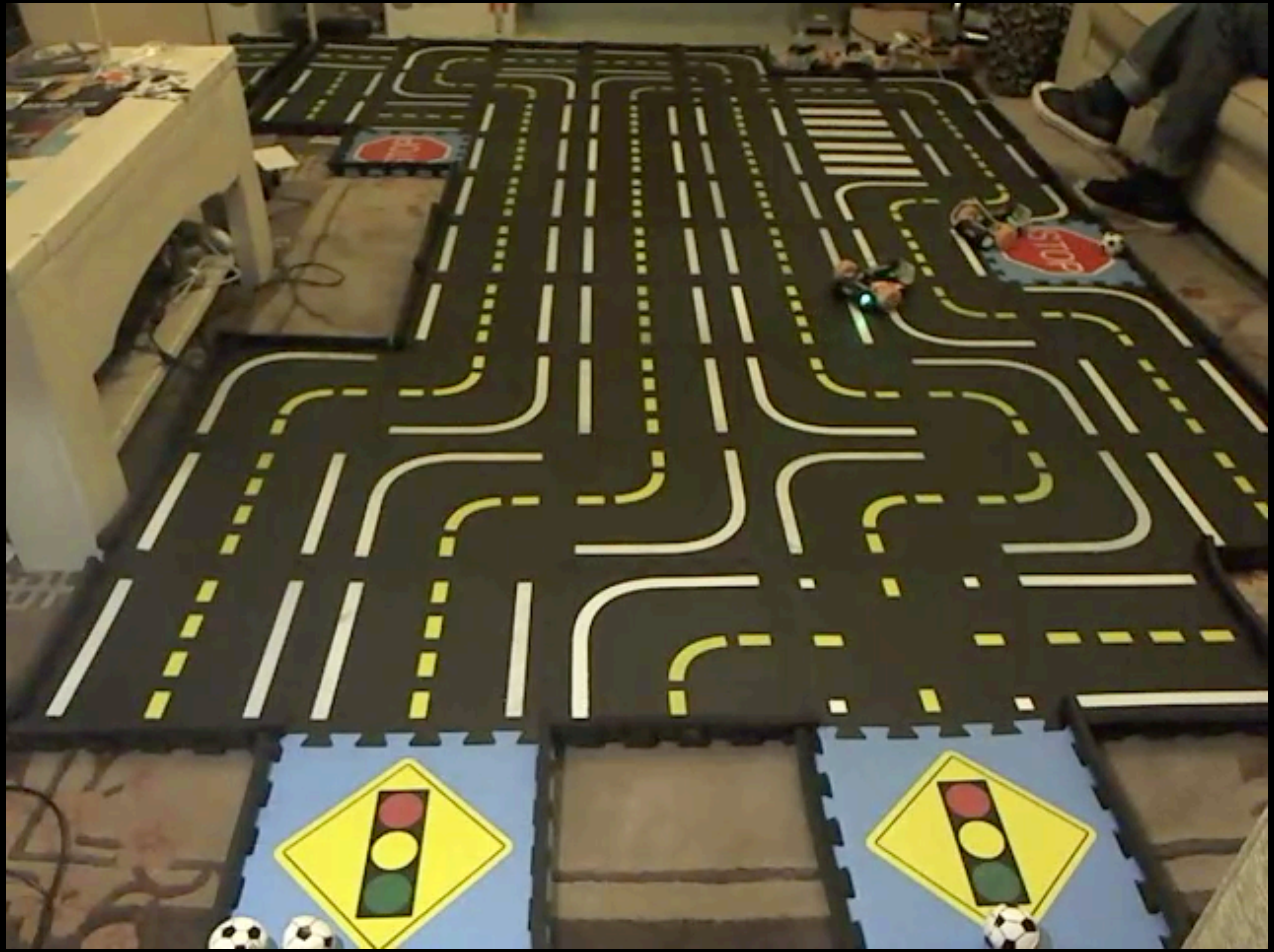
With WebRTC

1: Kid’s Birthday Party

**8 year old associated Zoom with school
but wanted to party with friends**

Trick: Standards

- WebRTC is a standard
- Multiple implementations:
  pick the one that works for your app
- This used |pipe|'s lightweight
  Arm friendly stack
- To view and control up to 6 droids
- Based on raspi zero
- Zero install but lots of laughs!



Code:

Various webRTC Implementations

- https://pi.pe
- https://freeswitch.org
- https://pion.ly
- https://www.frozenmountain.com
- https://janus.conf.meetecho.com
- https://webrtc.googlesource.com/src/

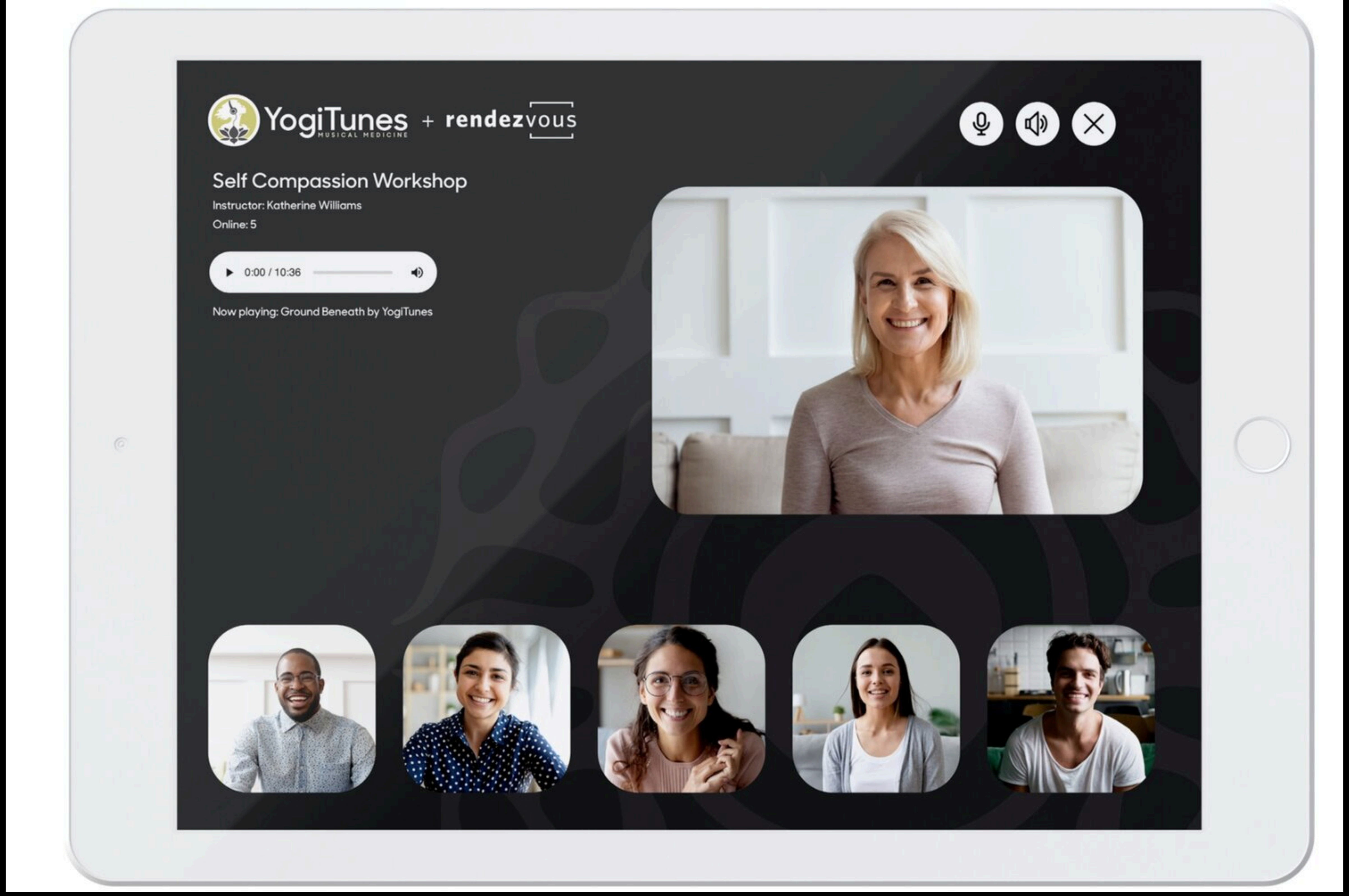
2: Yoga Vibes

Yoga teachers want to teach remote students with ambience and high quality music

Trick: WebAudio as MCU

https://rendezvous.yoga

- N-1 stereo mix for each user
- Plus stereo music from teacher's browser
- Provides synchronised music
- Audio ambience
- Music is licensed to the teacher by YogiTunes



Self Compassion Workshop

Instructor: Katherine Williams

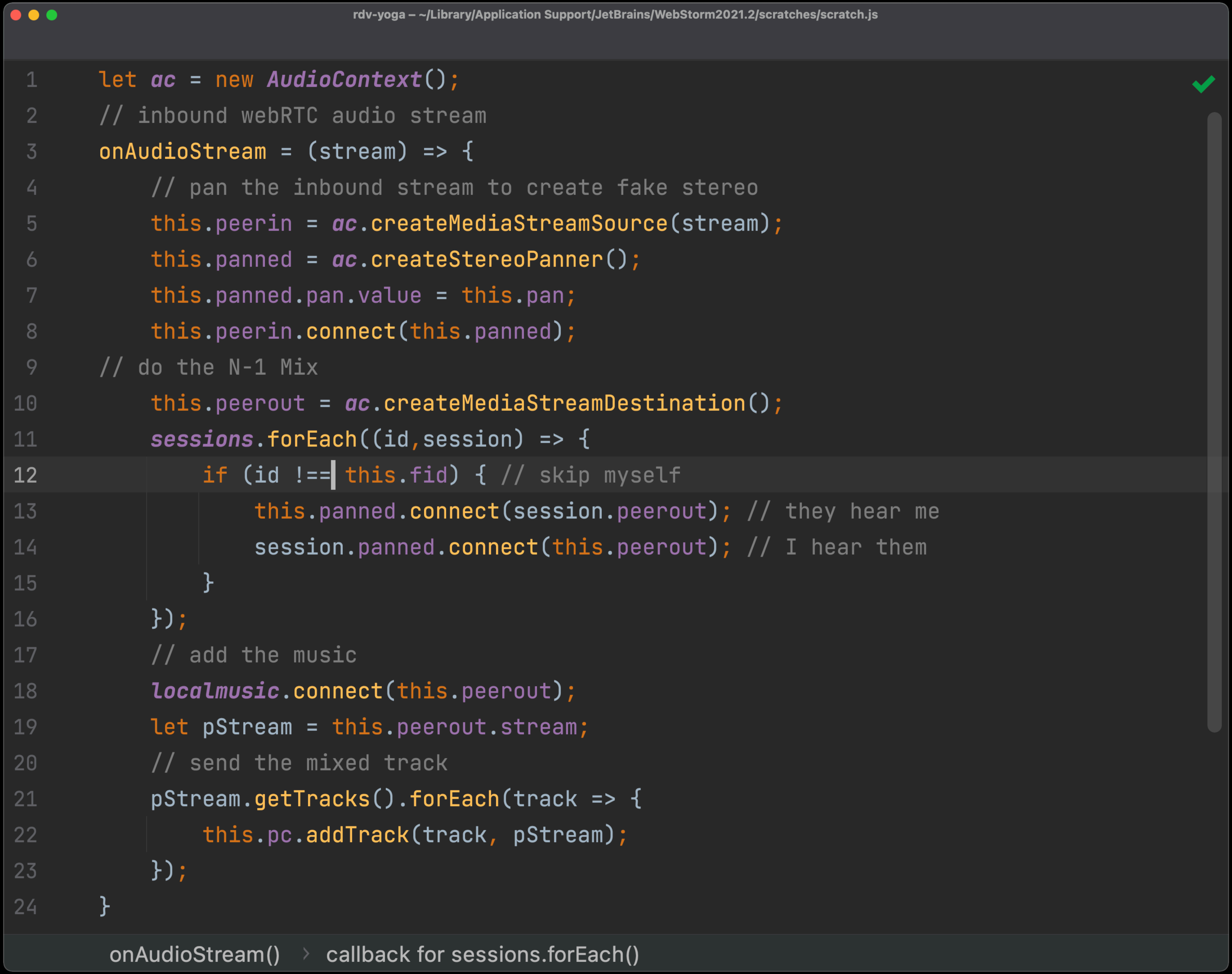
Online: 5

Now playing: Ground Beneath by YogiTunes

Code:

WebAudio mix

- Create an AudioContext
- Wrap inbound WebRTC audio
- Pan the audio
- N-1 Mix the panned tracks (omit own audio)
- Add the music
- Send result back to WebRTC


rdv-yoga – ~/Library/Application Support/JetBrains/WebStorm2021.2/scratches/scratch.js
onAudioStream() › callback for sessions.forEach()

```
let ac = new AudioContext();
// inbound webRTC audio stream
onAudioStream = (stream) => {
    // pan the inbound stream to create fake stereo
    this.peerin = ac.createMediaStreamSource(stream);
    this.panned = ac.createStereoPanner();
    this.panned.pan.value = this.pan;
    this.peerin.connect(this.panned);
// do the N-1 Mix
    this.peerout = ac.createMediaStreamDestination();
    sessions.forEach((id,session) => {
        if (id !== this.fid) { // skip myself
            this.panned.connect(session.peerout); // they hear me
            session.panned.connect(this.peerout); // I hear them
        }
    });
    // add the music
    localmusic.connect(this.peerout);
    let pStream = this.peerout.stream;
    // send the mixed track
    pStream.getTracks().forEach(track => {
        this.pc.addTrack(track, pStream);
    });
}
```

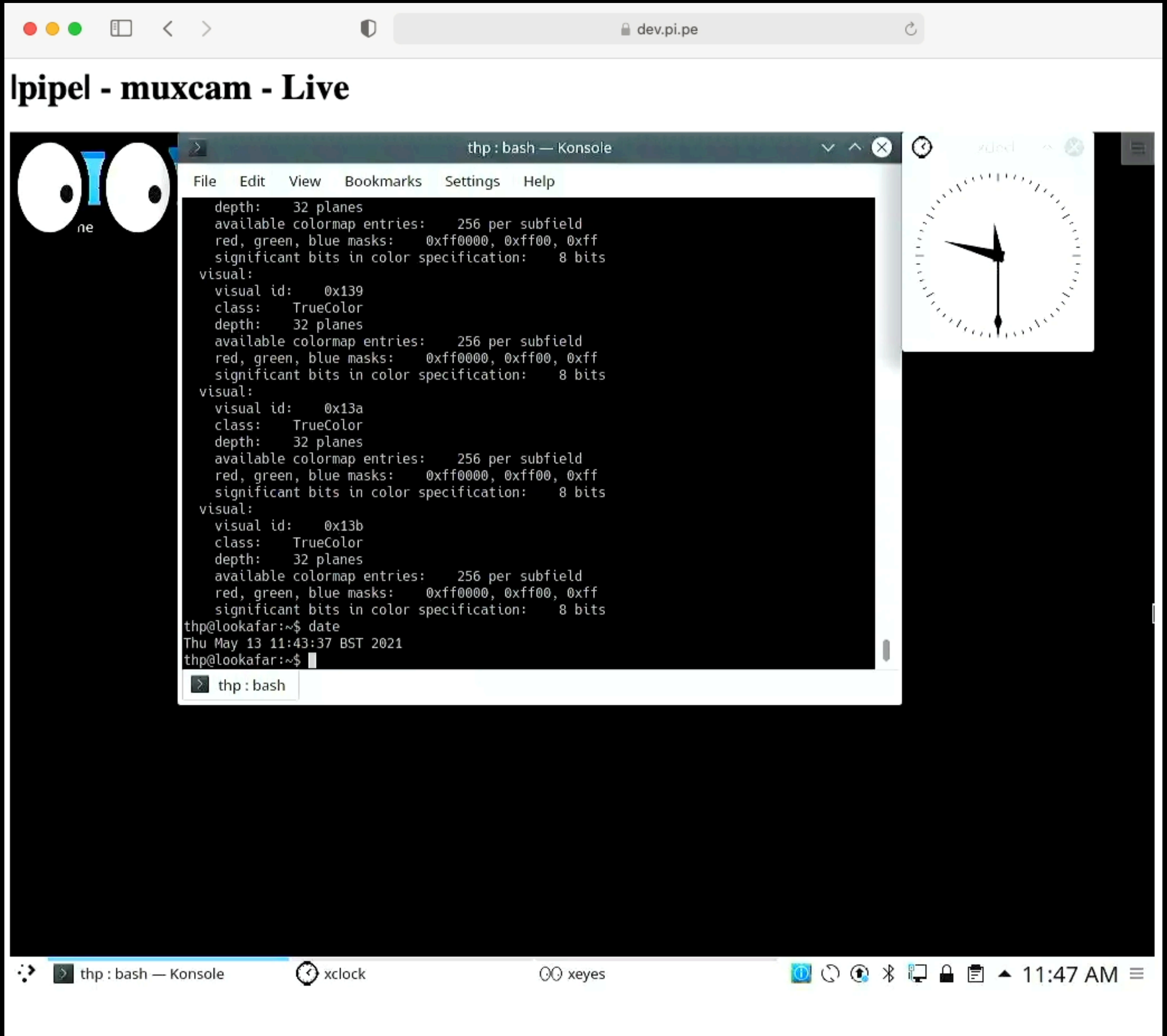
3: ${Home} from Home

Users need remote access to machines.
Without going into the office or installing an app.

Trick: DataChannel

https://pi.pe/securekvm/

- Remote access to linux on Mac
- H264 video + 2 Datachannels
- Low latency mouse/kbd data
- Encrypted E2E P2P
- Zero install (browser based)

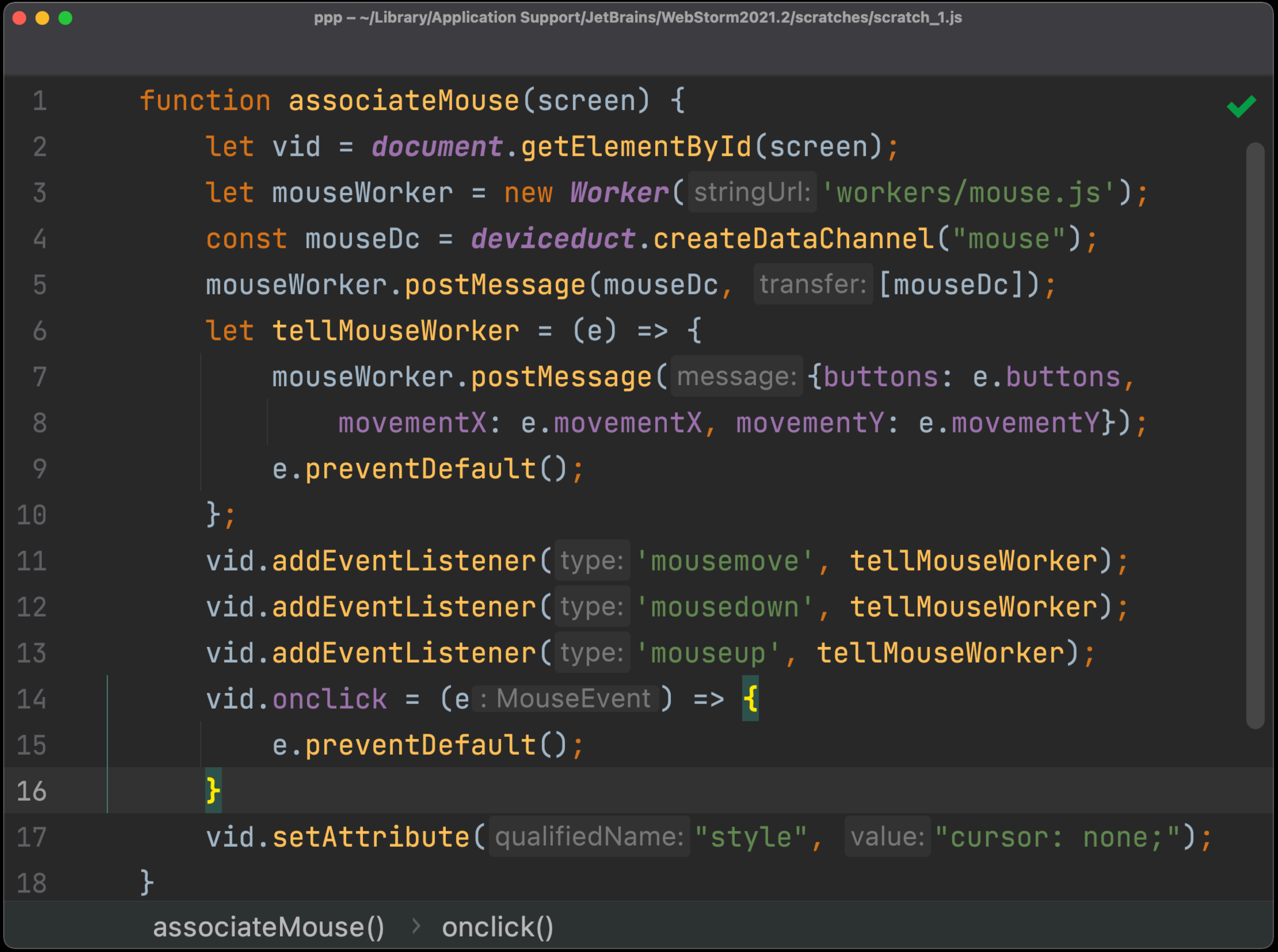


```
    depth:    32 planes
    available colormap entries:    256 per subfield
    red, green, blue masks:    0xff0000, 0xff00, 0xff
    significant bits in color specification:    8 bits
  visual:
    visual id:    0x139
    class:    TrueColor
    depth:    32 planes
    available colormap entries:    256 per subfield
    red, green, blue masks:    0xff0000, 0xff00, 0xff
    significant bits in color specification:    8 bits
  visual:
    visual id:    0x13a
    class:    TrueColor
    depth:    32 planes
    available colormap entries:    256 per subfield
    red, green, blue masks:    0xff0000, 0xff00, 0xff
    significant bits in color specification:    8 bits
  visual:
    visual id:    0x13b
    class:    TrueColor
    depth:    32 planes
    available colormap entries:    256 per subfield
    red, green, blue masks:    0xff0000, 0xff00, 0xff
    significant bits in color specification:    8 bits
thp@lookafar:~$ date
Thu May 13 11:43:37 BST 2021
thp@lookafar:~$ 
```

Code:

DataChannel transfer

- Create a worker
- Create a DataChannel
- Post DataChannel to worker
- Send mouse events to worker
- Worker sends mouse actions
- Turn off click
- Zap local cursor



ppp – ~/Library/Application Support/JetBrains/WebStorm2021.2/scratches/scratch_1.js

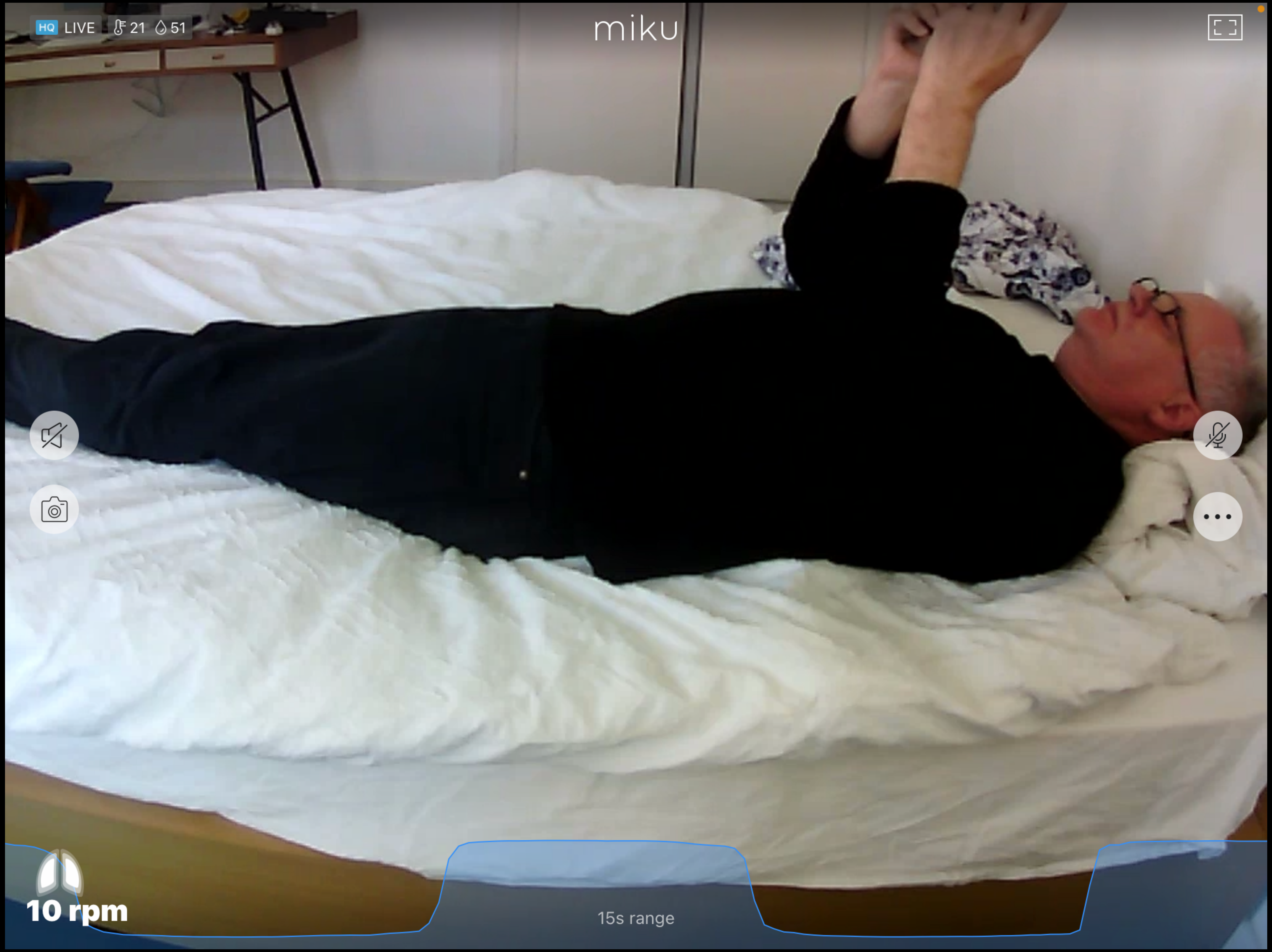
```javascript
function associateMouse(screen) {
    let vid = document.getElementById(screen);
    let mouseWorker = new Worker( stringUrl: 'workers/mouse.js');
    const mouseDc = deviceduct.createDataChannel("mouse");
    mouseWorker.postMessage(mouseDc,  transfer: [mouseDc]);
    let tellMouseWorker = (e) => {
        mouseWorker.postMessage( message: {buttons: e.buttons,
            movementX: e.movementX, movementY: e.movementY});
        e.preventDefault();
    };
    vid.addEventListener( type: 'mousemove', tellMouseWorker);
    vid.addEventListener( type: 'mousedown', tellMouseWorker);
    vid.addEventListener( type: 'mouseup', tellMouseWorker);
    vid.onclick = (e : MouseEvent ) => {
        e.preventDefault();
    }
    vid.setAttribute( qualifiedName: "style",  value: "cursor: none;");
}
```

4: Trusted IoT

Baby Monitor should be secure without cloud data

Trick: ICE finds local path

- Realtime
  - Audio/Video/Data
  - Stays local if possible (P2P)
  - Encrypted E2E
- Key features work off-line (e.g. when ISP goes down) because ICE finds local path
- Can’t do this as pure web



Code:

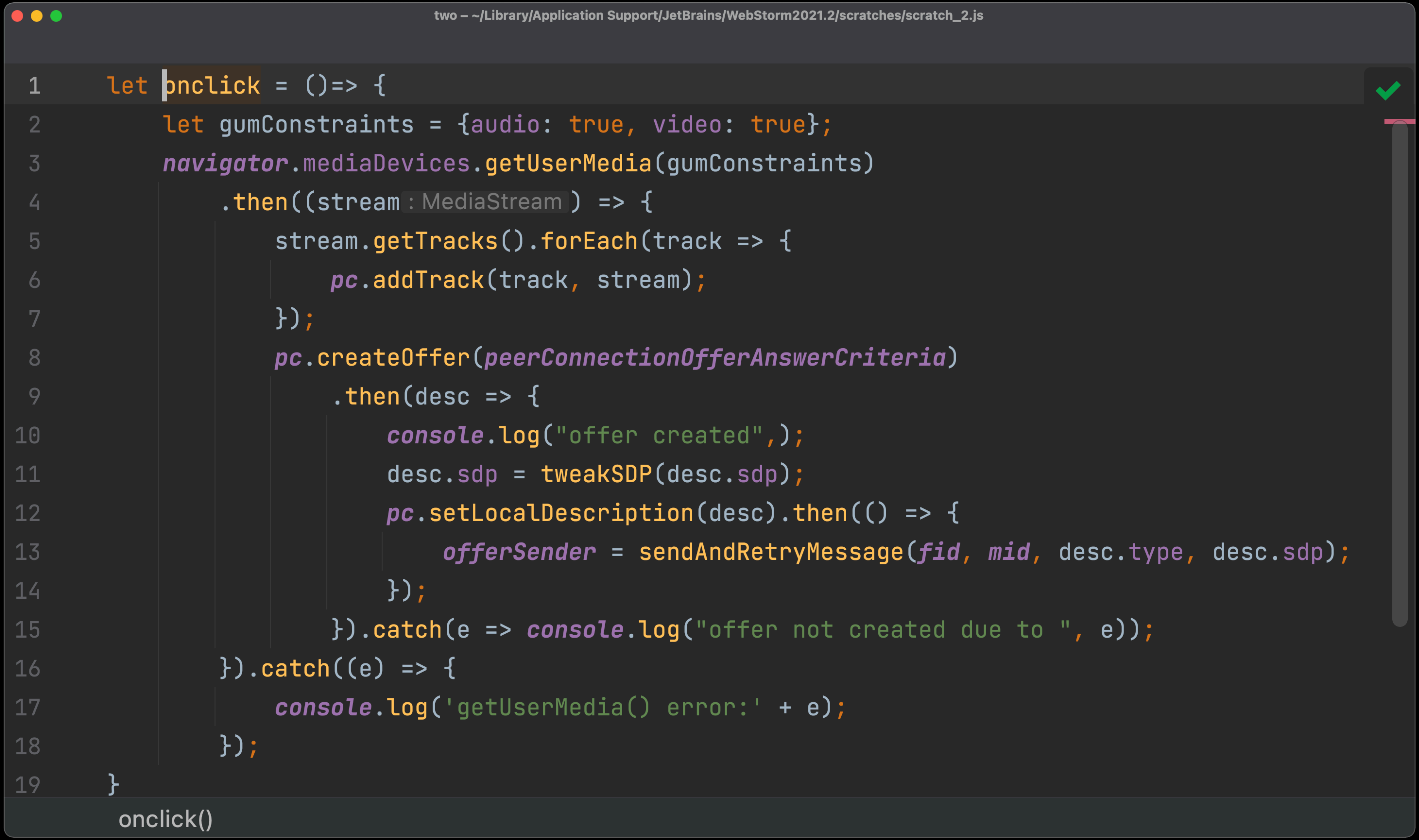
Create offer in onClick

- Safari privacy blocks local
  address candidate generation

- Unless you have Mic/cam permissions in the current gesture

- Even then Only MDNS (not IP but MDNS .locals)

- Devices can use prflx


two – ~/Library/Application Support/JetBrains/WebStorm2021.2/scratches/scratch_2.js

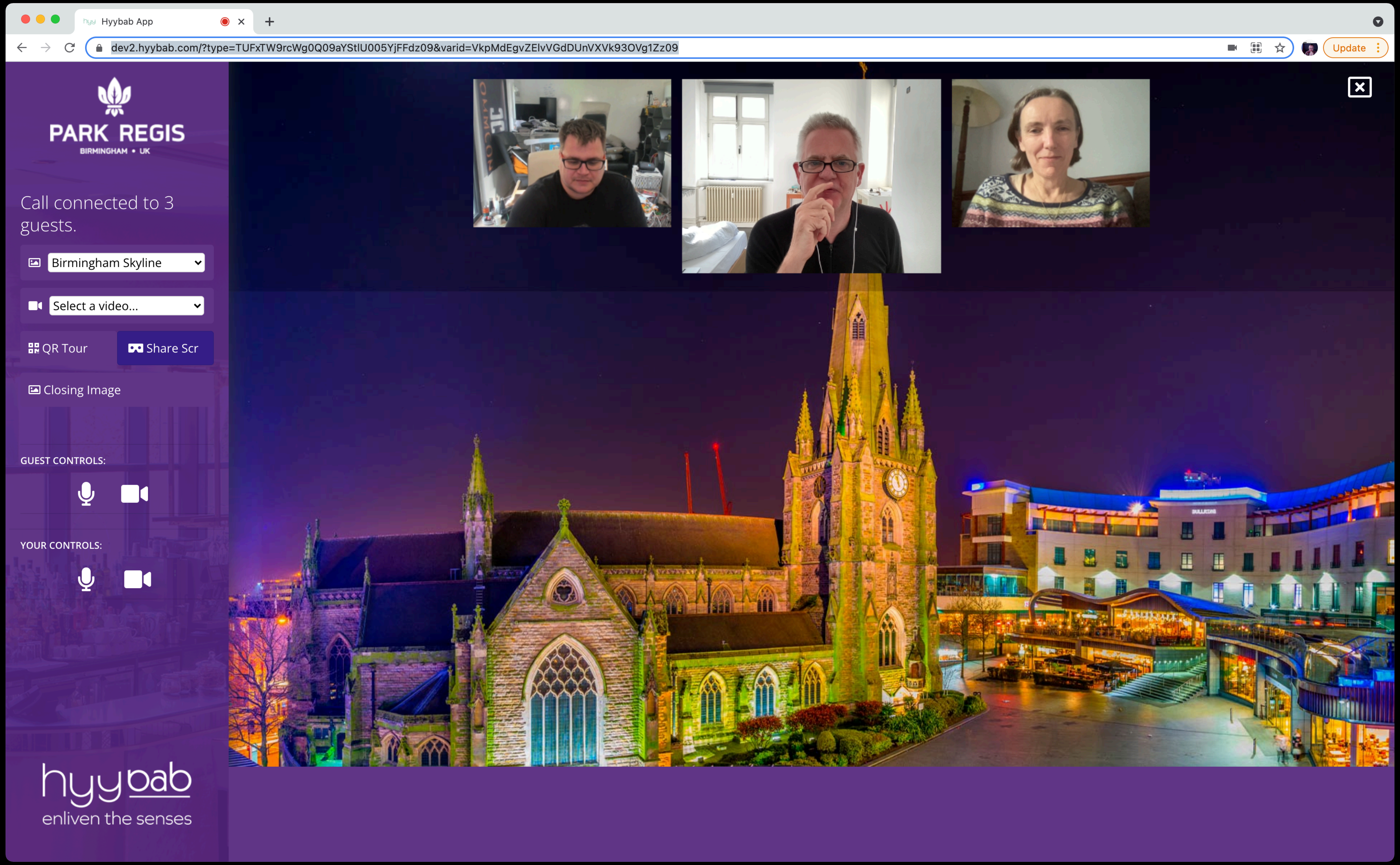
```
let onclick = ()=> {
    let gumConstraints = {audio: true, video: true};
    navigator.mediaDevices.getUserMedia(gumConstraints)
        .then((stream : MediaStream ) => {
            stream.getTracks().forEach(track => {
                pc.addTrack(track, stream);
            });
            pc.createOffer(peerConnectionOfferAnswerCriteria)
                .then(desc => {
                    console.log("offer created",);
                    desc.sdp = tweakSDP(desc.sdp);
                    pc.setLocalDescription(desc).then(() => {
                        offerSender = sendAndRetryMessage(fid, mid, desc.type, desc.sdp);
                    });
                }).catch(e => console.log("offer not created due to ", e));
        }).catch((e) => {
            console.log('getUserMedia() error:' + e);
        });
}
```

5: Spread the Love

Conference venues are booked years ahead.
Virtual site visits secure the sales pipeline.

Trick: Smooth video switches

- Virtual site visits use multiple video sources
  - Static images
  - Brady bunch faces
  - Produced video clips
  - Guided VR Tours
- Need to switch between them



dev2.hyybab.com/?type=TUFxTW9rcWg0Q09aYStlU005YjFFdz09&varid=VkpMdEgvZElvVGdDUnVXVk93OVg1Zz09

Call connected to 3 guests.

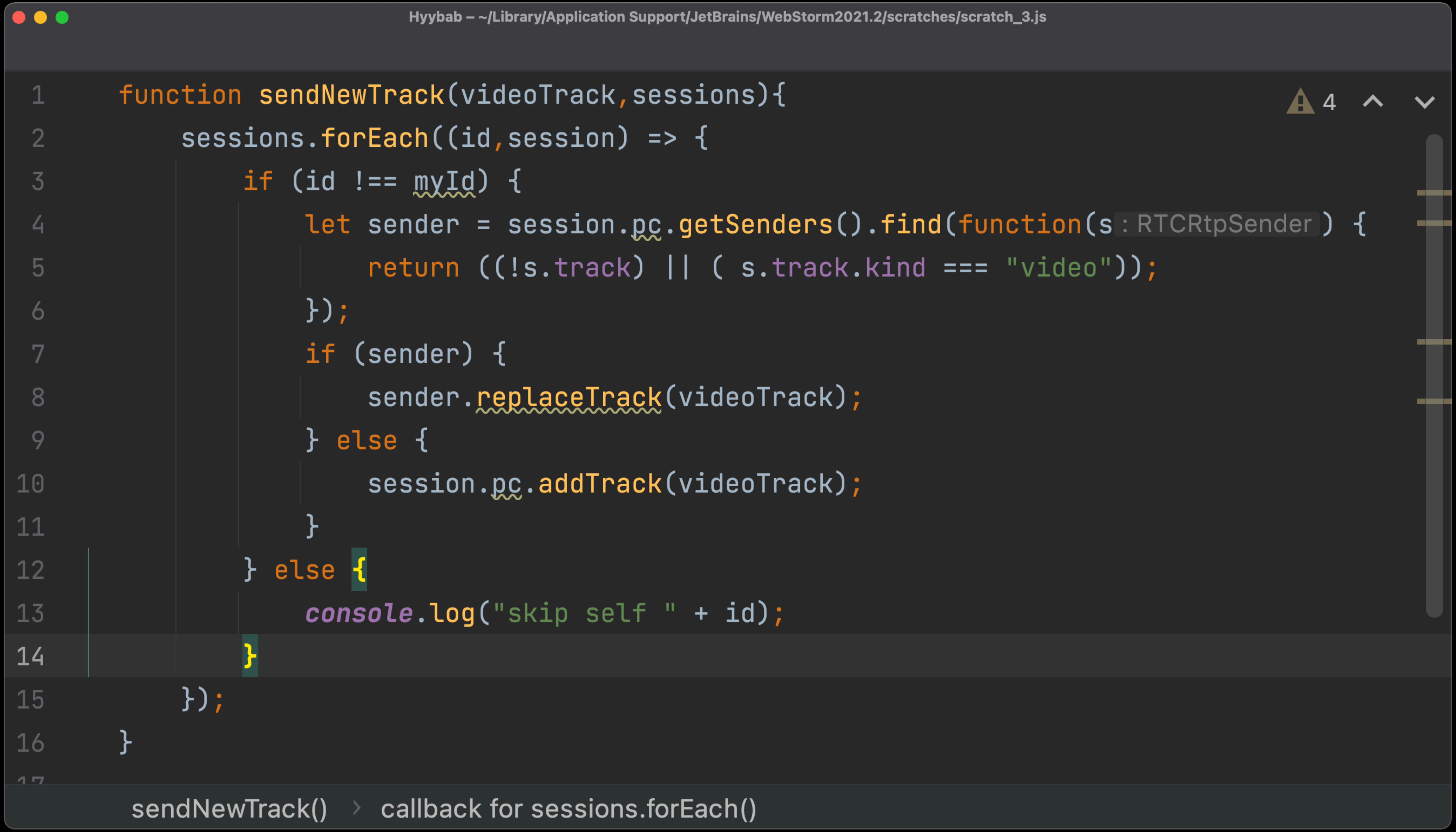
Birmingham Skyline

Select a video...

Code:

ReplaceTrack

- Avoids O/A round trip
- Find active sender
  - Of same media type
- If there is one
  Replace the track
- Otherwise
  Add the track
- Note: SFU in browser…


Hyybab – ~/Library/Application Support/JetBrains/WebStorm2021.2/scratches/scratch_3.js
4
sendNewTrack()
callback for sessions.forEach()

```javascript
function sendNewTrack(videoTrack,sessions){
    sessions.forEach((id,session) => {
        if (id !== myId) {
            let sender = session.pc.getSenders().find(function(s : RTCRtpSender) {
                return ((!s.track) || ( s.track.kind === "video"));
            });
            if (sender) {
                sender.replaceTrack(videoTrack);
            } else {
                session.pc.addTrack(videoTrack);
            }
        } else {
            console.log("skip self " + id);
        }
    });
}
```

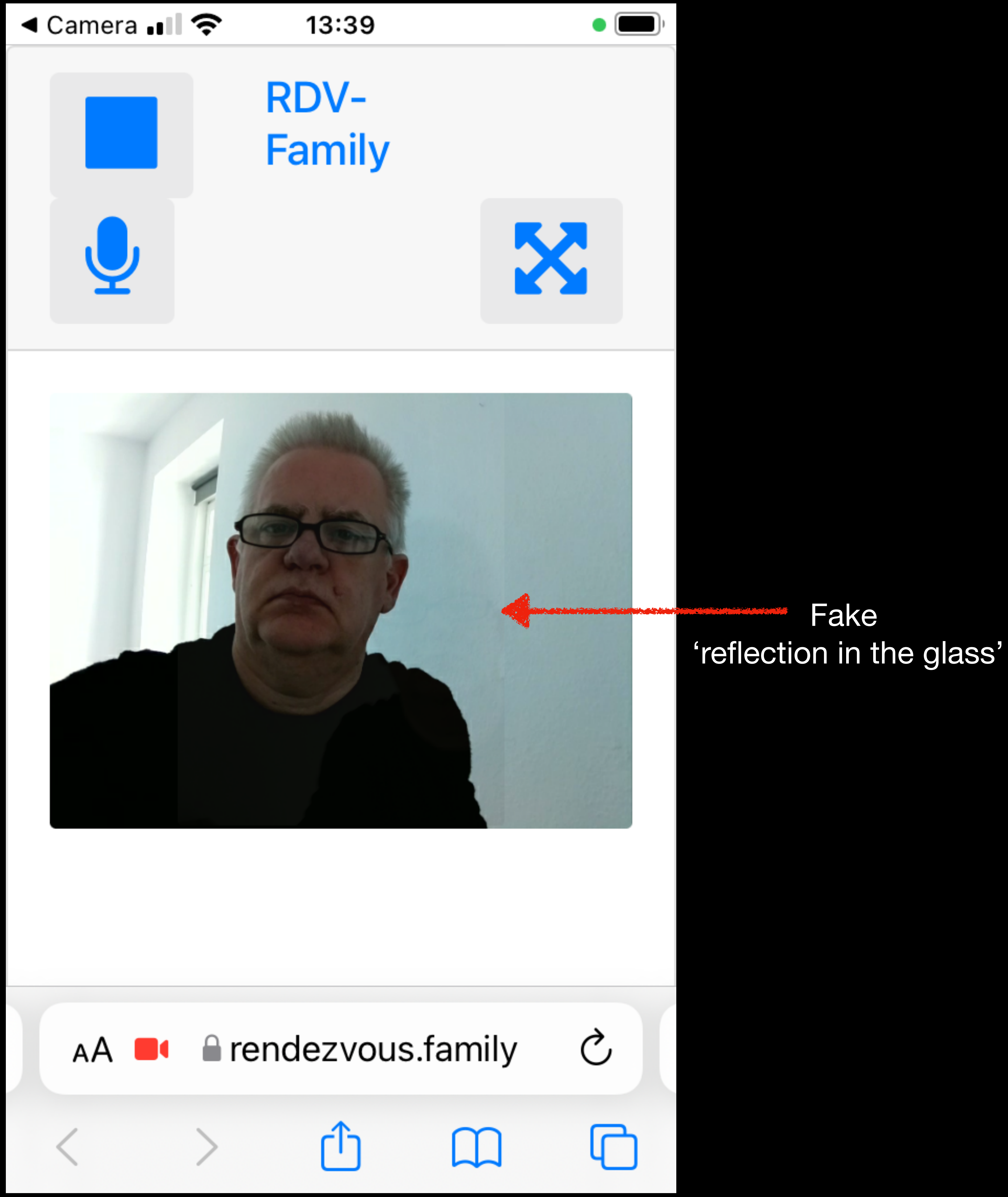
6: Connect the Shy

Not everyone wants to install your fave video app
But they may want to see your face.

Trick: use SMS

https://rendezvous.family

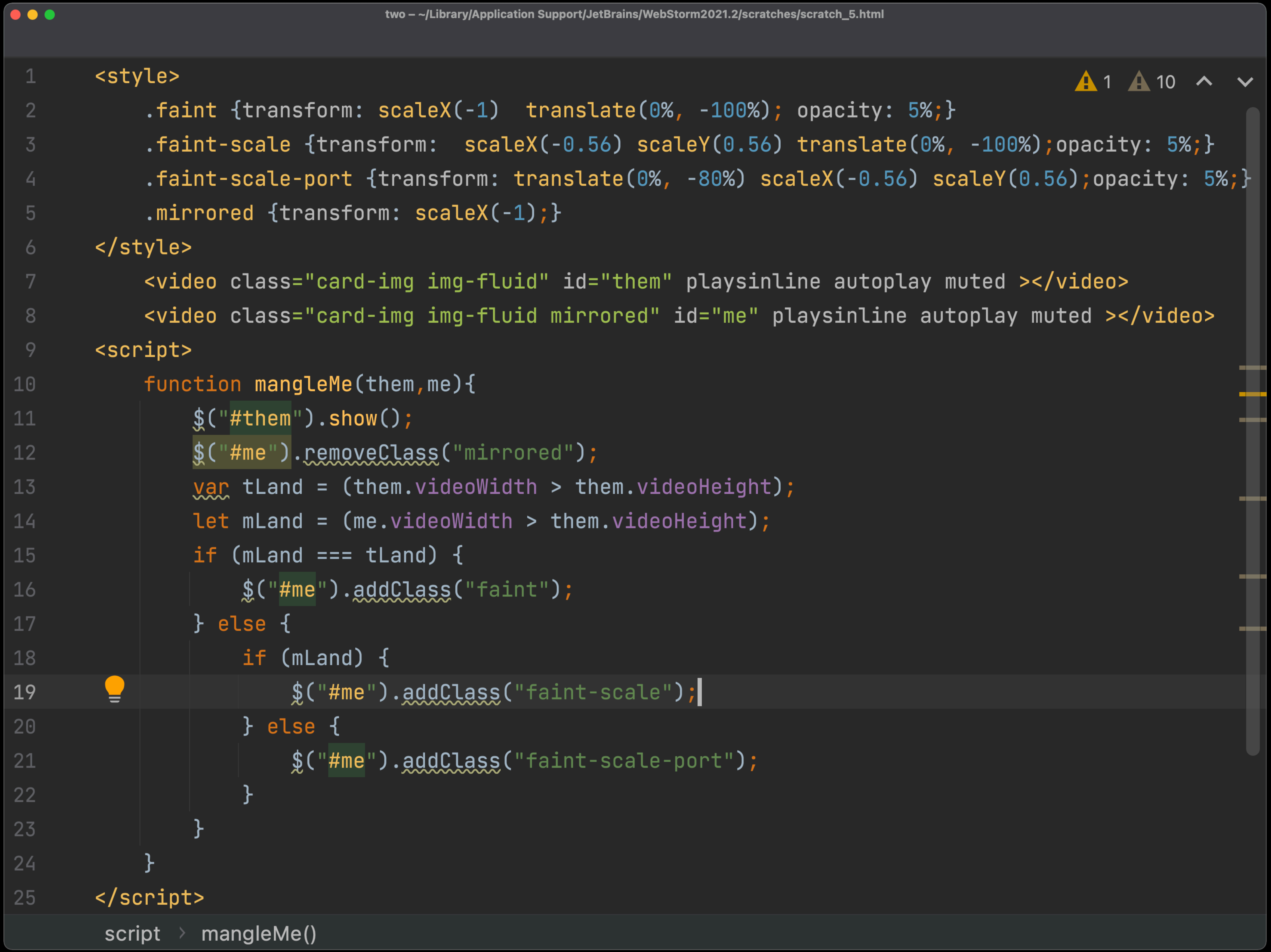
- Video call people via SMS + browser
- Ideal for folks in the ‘other’ ecosystem
- No install/setup
- Free to use (zero server costs)
- Works on all smartphones
- No self view (fake reflection)



Code:

CSS

- Place self view next to remote view
- Use CSS to make self view transparent
- Translate so that the overlay
- And fix the aspect ratio if the users orientations are different



two – ~/Library/Application Support/JetBrains/WebStorm2021.2/scratches/scratch_5.html

```
<style>
    .faint {transform: scaleX(-1)  translate(0%, -100%); opacity: 5%;}
    .faint-scale {transform:  scaleX(-0.56) scaleY(0.56) translate(0%, -100%);opacity: 5%;}
    .faint-scale-port {transform: translate(0%, -80%) scaleX(-0.56) scaleY(0.56);opacity: 5%;}
    .mirrored {transform: scaleX(-1);}
</style>
    <video class="card-img img-fluid" id="them" playsinline autoplay muted ></video>
    <video class="card-img img-fluid mirrored" id="me" playsinline autoplay muted ></video>
<script>
    function mangleMe(them,me){
        $("#them").show();
        $("#me").removeClass("mirrored");
        var tLand = (them.videoWidth > them.videoHeight);
        let mLand = (me.videoWidth > them.videoHeight);
        if (mLand === tLand) {
            $("#me").addClass("faint");
        } else {
            if (mLand) {
                $("#me").addClass("faint-scale");
            } else {
                $("#me").addClass("faint-scale-port");
            }
        }
    }
</script>
```

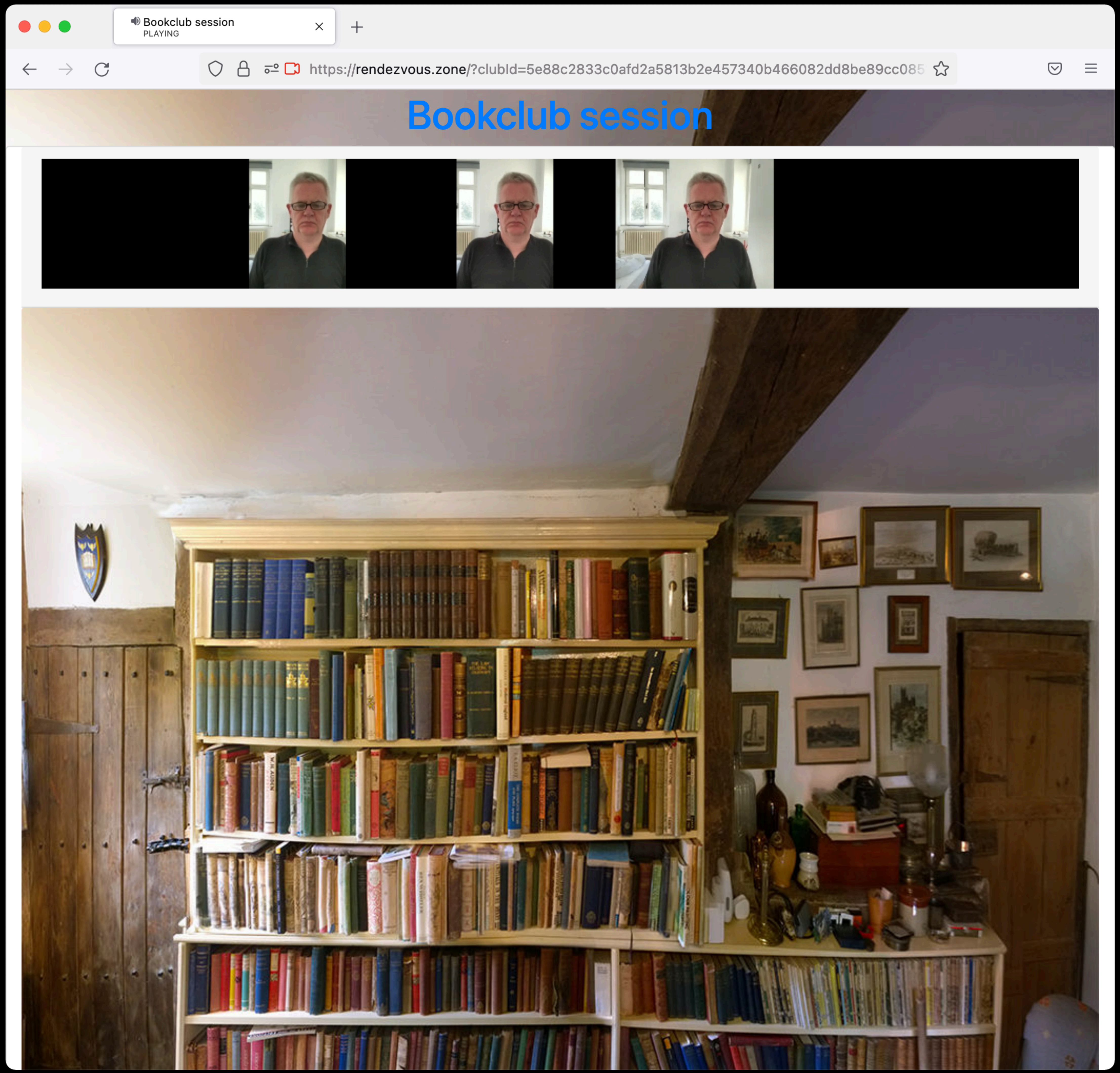
7: A cosy Space

Simple free audio + video space

Trick: MCU in browse

https://rendezvous.zone

- Provide a cosy space for bookclub meetings
- Support laugh/grunt/tuts without video flicker
- No sign in
- No costs
- Own bandwidth



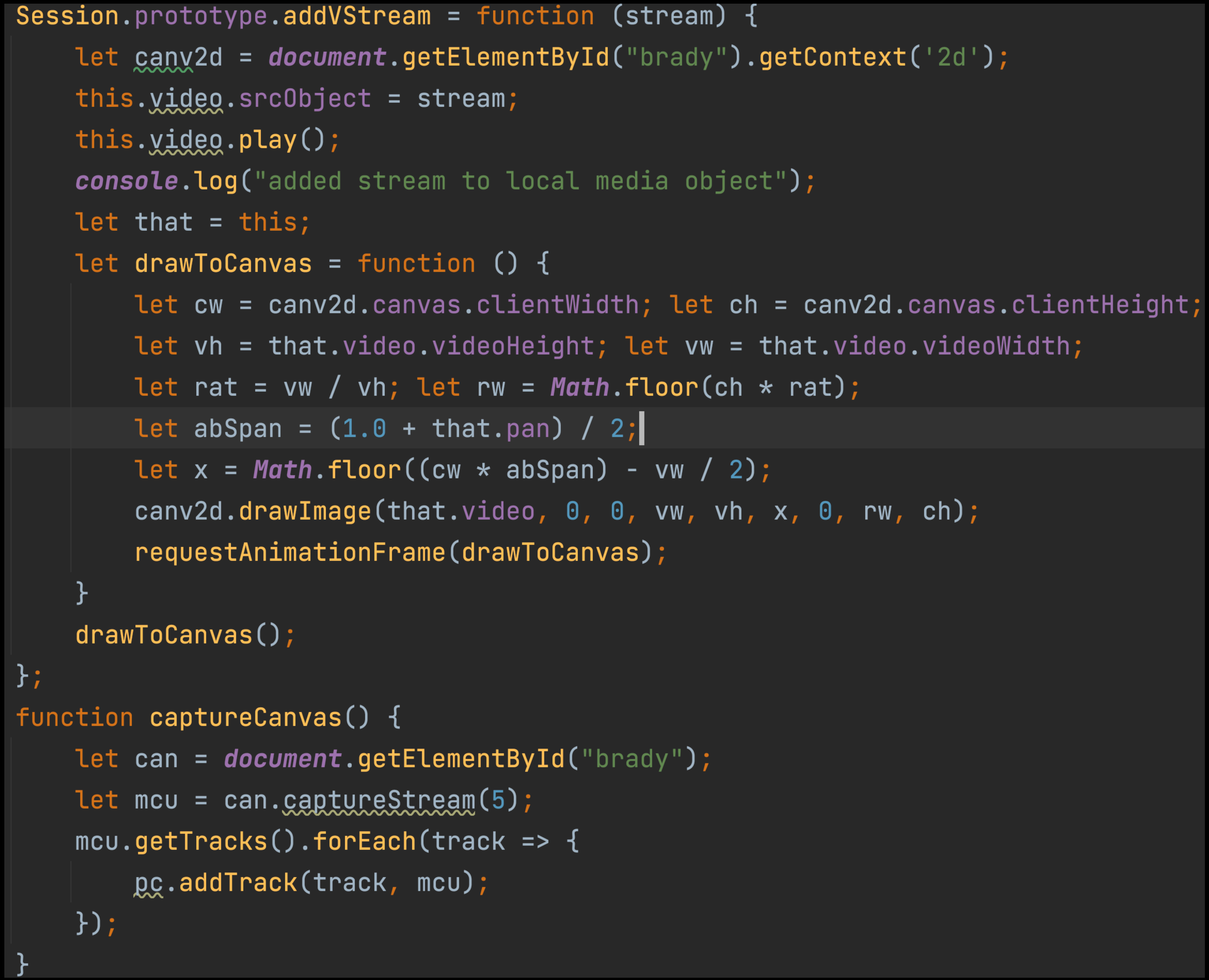
Bookclub session
PLAYING
https://rendezvous.zone/?clubId=5e88c2833c0afd2a5813b2e457340b466082dd8be89cc085

Bookclub session

Code:

Canvas as MCU

- Play inbound video into invisible <video> tags
- Paint video frames onto visible canvas offset per user
- Capture a stream from the canvas
- Send the canvas stream to the guest user(s)



```
Session.prototype.addVStream = function (stream) {
    let canv2d = document.getElementById("brady").getContext('2d');
    this.video.srcObject = stream;
    this.video.play();
    console.log("added stream to local media object");
    let that = this;
    let drawToCanvas = function () {
        let cw = canv2d.canvas.clientWidth; let ch = canv2d.canvas.clientHeight;
        let vh = that.video.videoHeight; let vw = that.video.videoWidth;
        let rat = vw / vh; let rw = Math.floor(ch * rat);
        let abSpan = (1.0 + that.pan) / 2;
        let x = Math.floor((cw * abSpan) - vw / 2);
        canv2d.drawImage(that.video, 0, 0, vw, vh, x, 0, rw, ch);
        requestAnimationFrame(drawToCanvas);
    }
    drawToCanvas();
};
function captureCanvas() {
    let can = document.getElementById("brady");
    let mcu = can.captureStream(5);
    mcu.getTracks().forEach(track => {
        pc.addTrack(track, mcu);
    });
}
```

8: Deep meaningful Chat

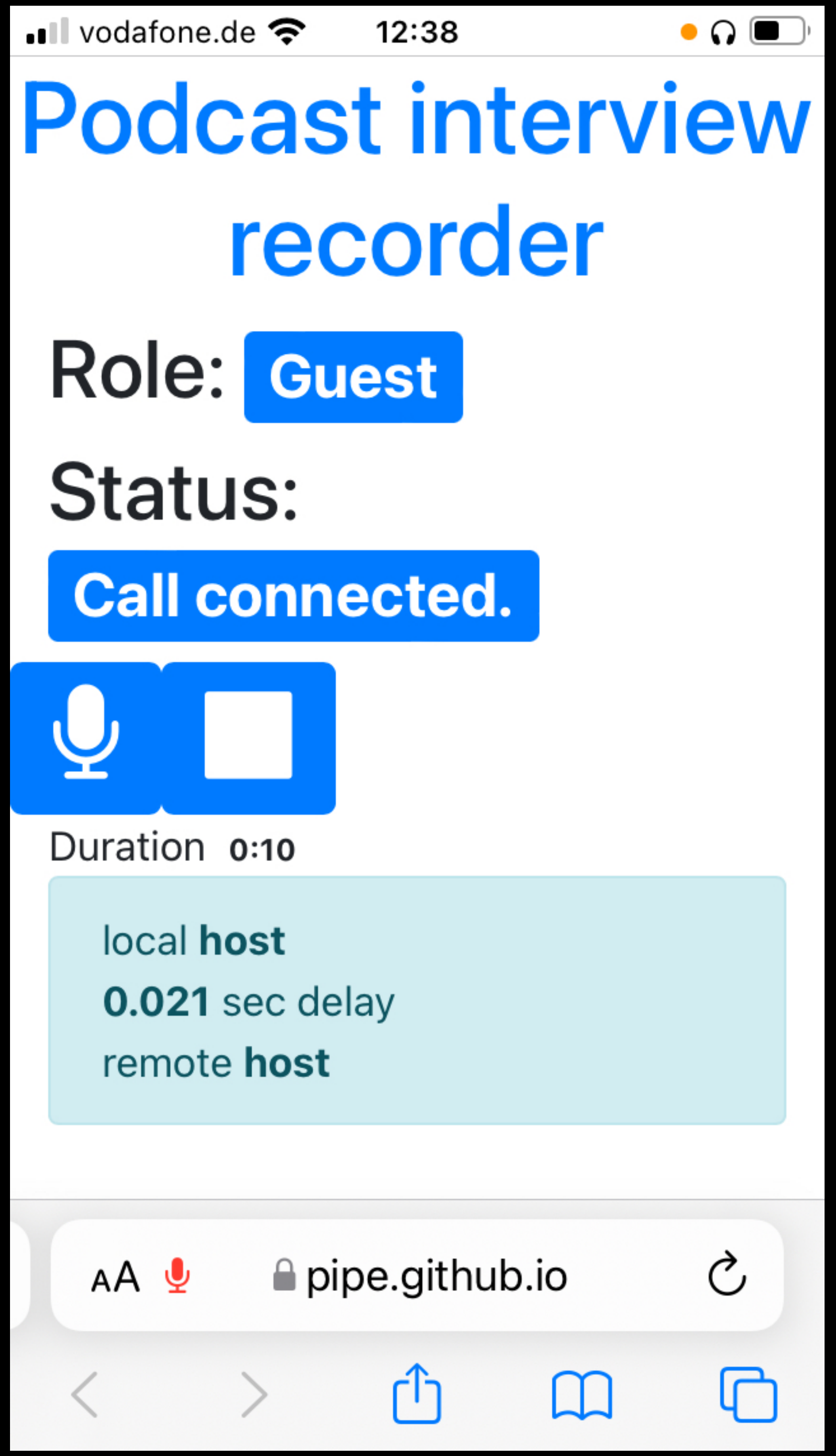
Podcasters can’t get guests into their studios

But there are many important stories to tell

Trick: Mobile Mics

https://pipe.github.io/podcall/

- Smartphone mics are great
- Especially for voice
- Everyone has one
- Send a unique url to their browser no app needed
- Guest just needs internet connectivity and a quiet room
- 60 interviews on https://Distributedfutu.re done this way.



Podcast interview recorder

Role: Guest

Status:

Call connected.

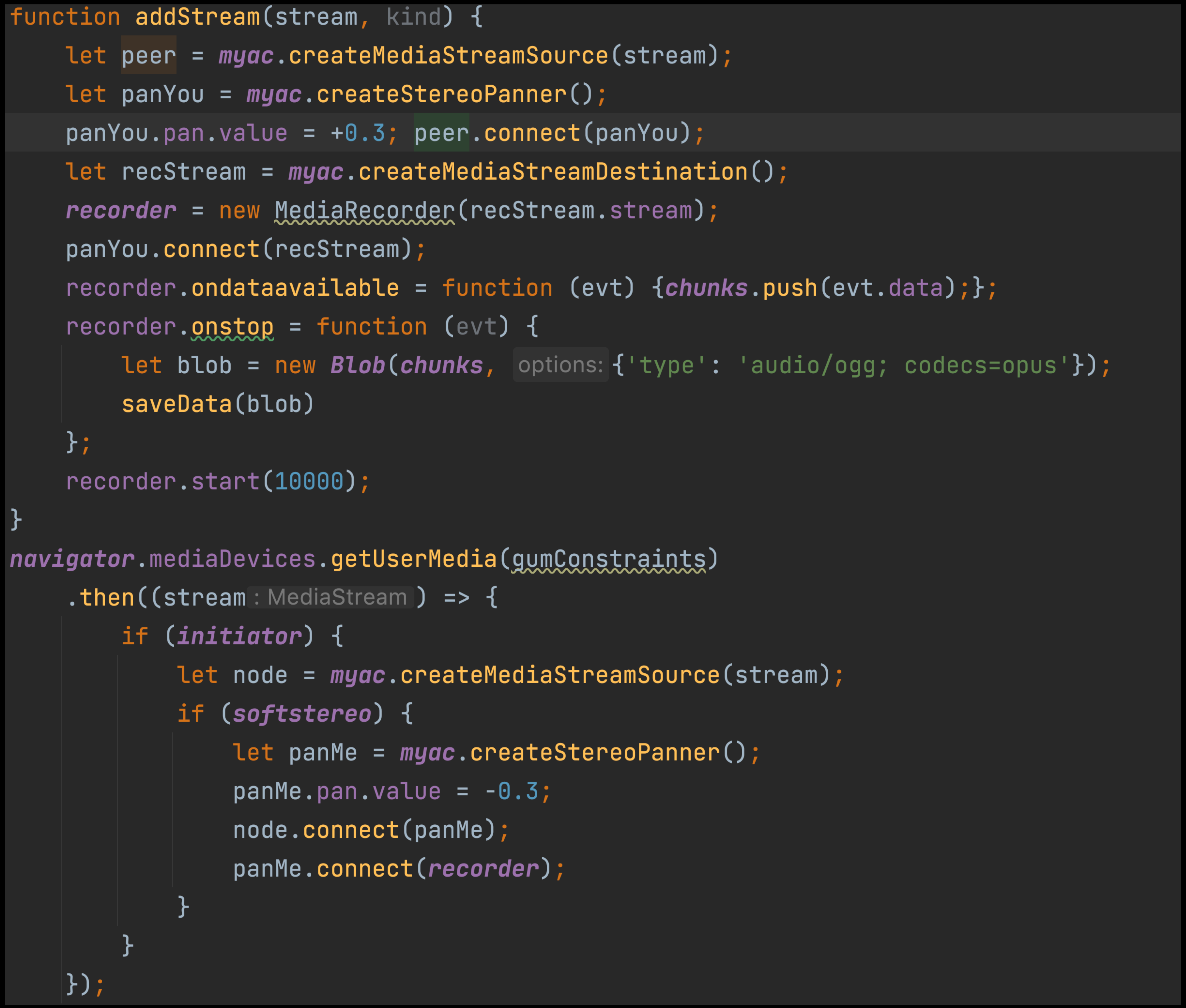
Duration 0:10

local host
0.021 sec delay
remote host

Code:

MediaRecorder + Opus

- Pan (right) inbound guest audio with WebAudio
- Create a MediaRecorder
- Pan (left) your own local audio with WebAudio
- Plug both into the Recorder
- Capture the recorded data
- Save it



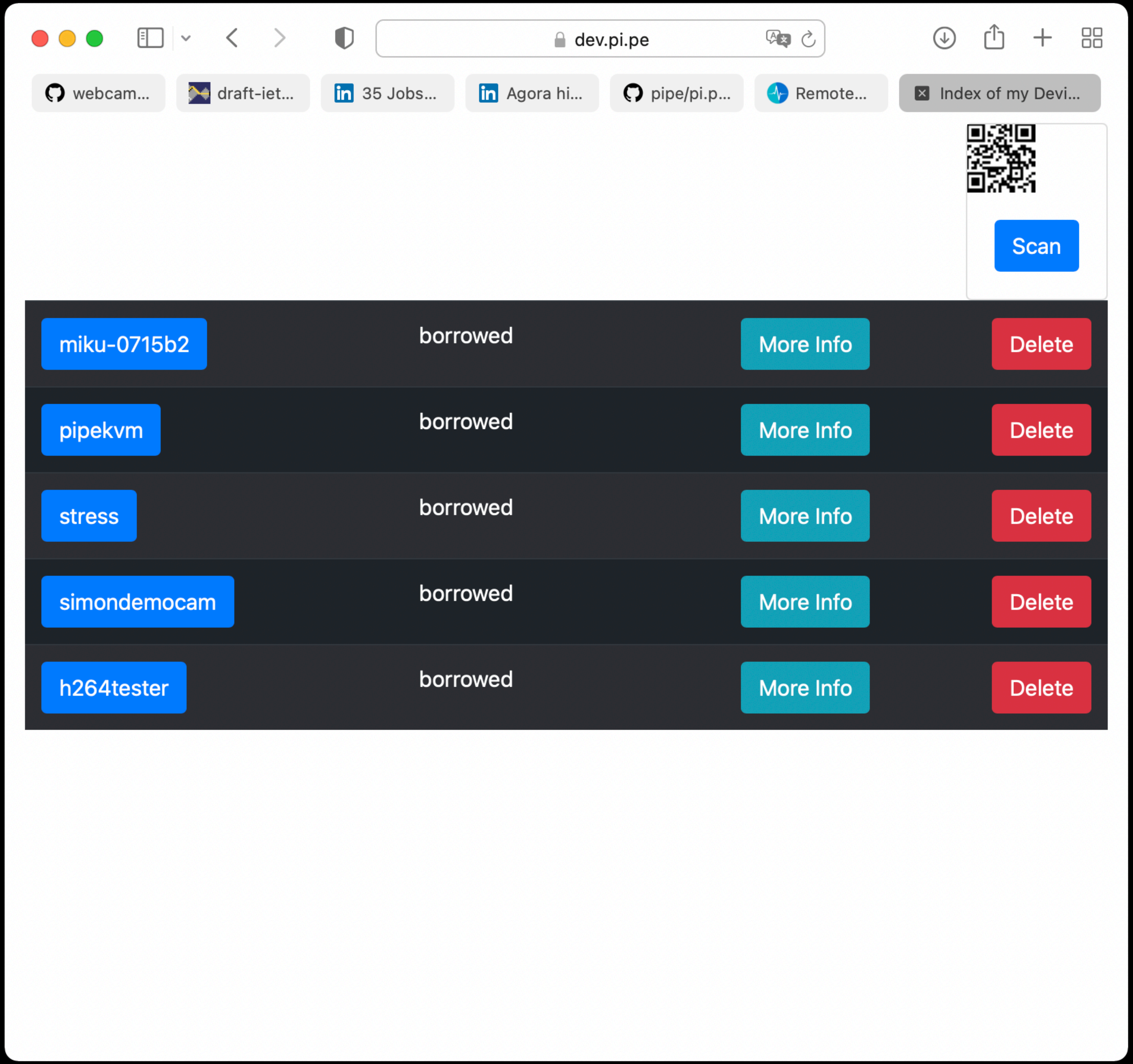
```
function addStream(stream, kind) {
    let peer = myac.createMediaStreamSource(stream);
    let panYou = myac.createStereoPanner();
    panYou.pan.value = +0.3; peer.connect(panYou);
    let recStream = myac.createMediaStreamDestination();
    recorder = new MediaRecorder(recStream.stream);
    panYou.connect(recStream);
    recorder.ondataavailable = function (evt) {chunks.push(evt.data);};
    recorder.onstop = function (evt) {
        let blob = new Blob(chunks, options: {'type': 'audio/ogg; codecs=opus'});
        saveData(blob)
    };
    recorder.start(10000);
}
navigator.mediaDevices.getUserMedia(gumConstraints)
    .then((stream : MediaStream) => {
        if (initiator) {
            let node = myac.createMediaStreamSource(stream);
            if (softstereo) {
                let panMe = myac.createStereoPanner();
                panMe.pan.value = -0.3;
                node.connect(panMe);
                panMe.connect(recorder);
            }
        }
    });
```

9: Phone a Friend

Sites need to limit access to video sources
Usernames and passwords+cookies are clumsy

Trick: Trust on first Use

- Verify user on first use
- Persist the token
- Next time: fewer checks
- Confirm peer to peer
- Detect MITM

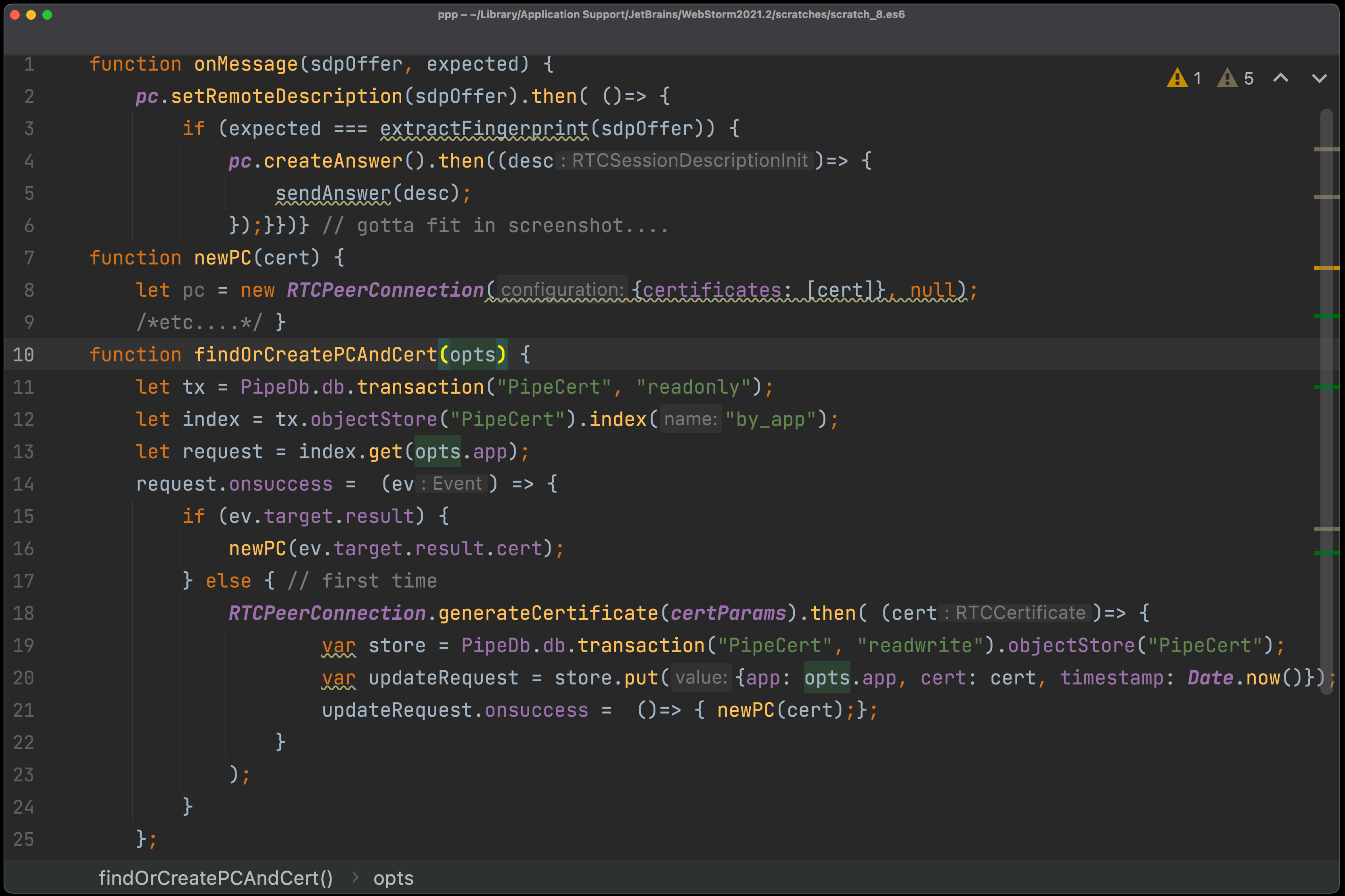


miku-0715b2	borrowed	More Info	Delete
pipekvm	borrowed	More Info	Delete
stress	borrowed	More Info	Delete
simondemocam	borrowed	More Info	Delete
h264tester	borrowed	More Info	Delete

Code:

createCertificate and IndexDb

- Create your peer connections with persistent certificates
- When you get an SDP offer, check the fingerprint is expected
- First time, save the certificate in IndexDb
- Subsequent times, retrieve it and use it



ppp – ~/Library/Application Support/JetBrains/WebStorm2021.2/scratches/scratch_8.es6
1 5

```
function onMessage(sdpOffer, expected) {
    pc.setRemoteDescription(sdpOffer).then( ()=> {
        if (expected === extractFingerprint(sdpOffer)) {
            pc.createAnswer().then((desc : RTCSessionDescriptionInit )=> {
                sendAnswer(desc);
            });}})} // gotta fit in screenshot....
function newPC(cert) {
    let pc = new RTCPeerConnection( configuration: {certificates: [cert]}, null);
    /*etc....*/ }
function findOrCreatePCAndCert(opts) {
    let tx = PipeDb.db.transaction("PipeCert", "readonly");
    let index = tx.objectStore("PipeCert").index( name: "by_app");
    let request = index.get(opts.app);
    request.onsuccess =  (ev : Event ) => {
        if (ev.target.result) {
            newPC(ev.target.result.cert);
        } else { // first time
            RTCPeerConnection.generateCertificate(certParams).then( (cert : RTCCertificate )=> {
                    var store = PipeDb.db.transaction("PipeCert", "readwrite").objectStore("PipeCert");
                    var updateRequest = store.put( value: {app: opts.app, cert: cert, timestamp: Date.now()});
                    updateRequest.onsuccess =  ()=> { newPC(cert);};
                }
            );
        }
    };
```

10: Easy onboarding

How to get people onto your (webRTC) site.
QR codes….

Demo time

1 to many video with no server

What you saw

(Hopefully)

- Live video
- To 20+ users
- From a modified IoT camera (not the stock firmware)
- Using my vDSL
- No cloud processing (on device SFU)
- No central permissions (edge-to-edge security)
- Expect to see this in webcams and perhaps routers.

Surprise!

None of those apps used central servers

- All ‘edge’ apps
- Own bandwidth (no AWS costs)
- Lower latency
- Better Privacy
- Customisable for niches

- The tricks/code all work on server based apps too!

Questions and contacts

- tim@pi.pe
- https://rendezvous.berlin
- https://pi.pe
- Twitter: @pipe_iot
- GitHub: https://github.com/pipe