DISTRIBUTED AUDIO

USING **BEAM**, **GLEAM**, AND THE **WEB AUDIO API**

FOSDEM '23

WHOAMI

WHOAMI

- 🏷️ hayleigh
- 👩‍💻 frontend elm developer

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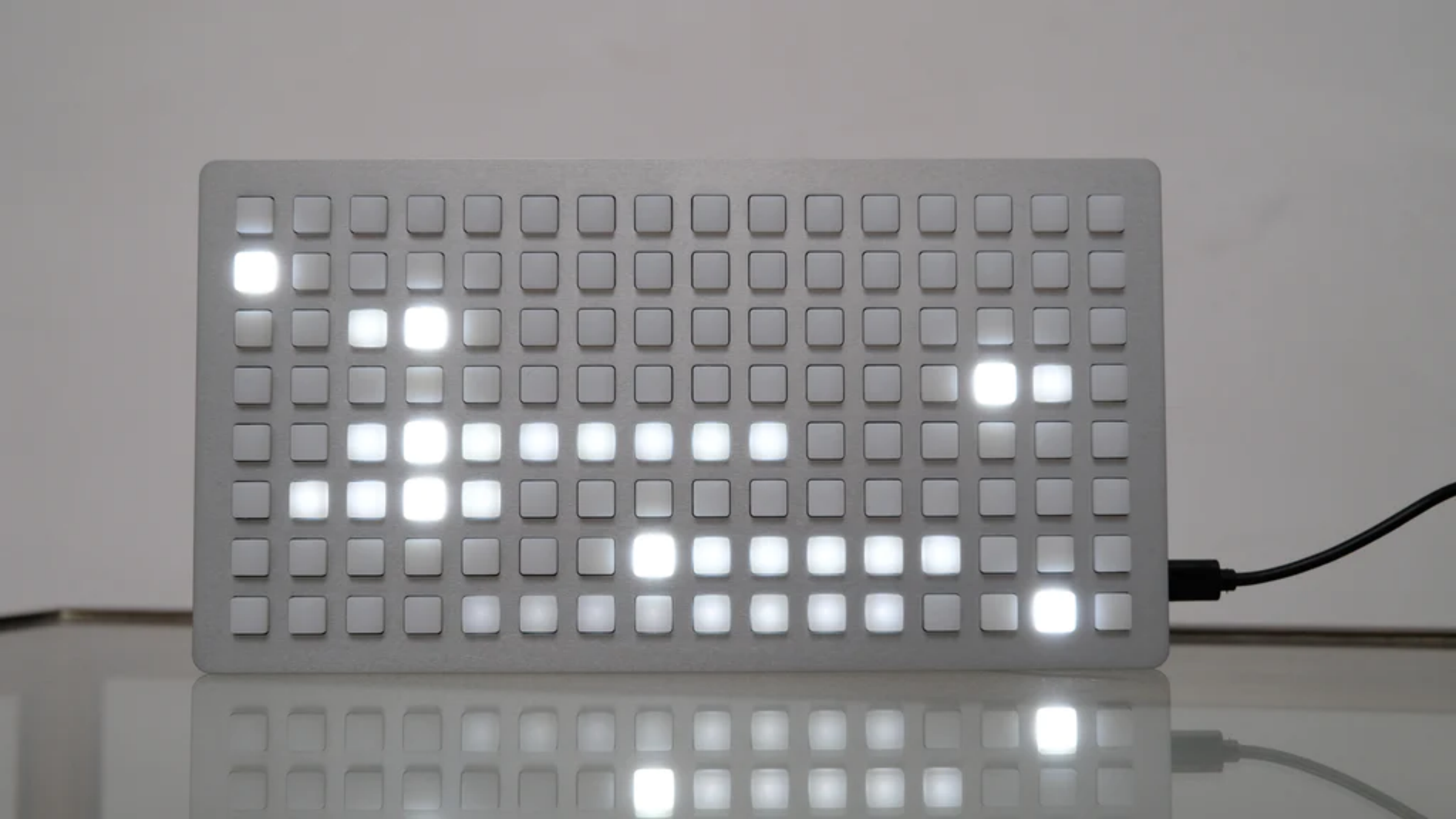
- 👩‍🎓 phd student
- 📣 gleam community person

DISTRIBUTED AUDIO

WHAT ARE WE MAKING?



DISTRIBUTED AUDIO

WHAT ARE WE MAKING?

- collaborative step sequencer
- grid of notes/steps
- some sound controls
- all clients in sync

OVERVIEW

- why not x?
- why gleam?
- making sounds
- rendering web apps
- serving static files
- client <-> server communication

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WHY NOT **JAVASCRIPT**?

- mutable
- dynamically typed
- error prone
- can’t decide whether or not to use semi colons

WHY NOT **ELM**?

- restrictive FFI
- what to choose for the backend?
- unfamiliar syntax (not for me, but)

WHY NOT **ELIXIR**?

- still needs a lot of js for the audio
- i’m a type nerd
- i don’t know elixir...

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WHY GLEAM?

- same language for the front end and back end
- sharable types
- functional but familiar
- amazing interoperability
- leverage existing libraries
- otp makes multiplayer easy
- #1 bdfl
  - consortium? how about one dude. (idk maybe bad joke)

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A PRIMER ON THE **WEB AUDIO API**

- low-ish level API for making sounds
- audio nodes are connected in a graph
- signal processing is handled by native code

web-audio-api.js

```
const audioContext = new AudioContext()

const osc = audioContext.createOscillator()
const amp = audioContext.createGain()
const dac = audioContext.destination

osc.frequency.value = 880
osc.type = 'square'
amp.gain.value = 0.5

osc.connect(amp)
amp.connect(dac)

osc.start()
```

web-audio.gleam

```gleam
pub type Node {
  Node(
    t: String,
    params: List(Param),
    connections: List(Node)
  )
}

pub type Param {
  Param(name: String, value: Float)
  Property(name: String, value: Dynamic)
}
```

web-audio.gleam

```
osc([ freq(880.0), waveform("square") ], [
  amp([ gain(0.5) ], [
    dac
  ])
])
```

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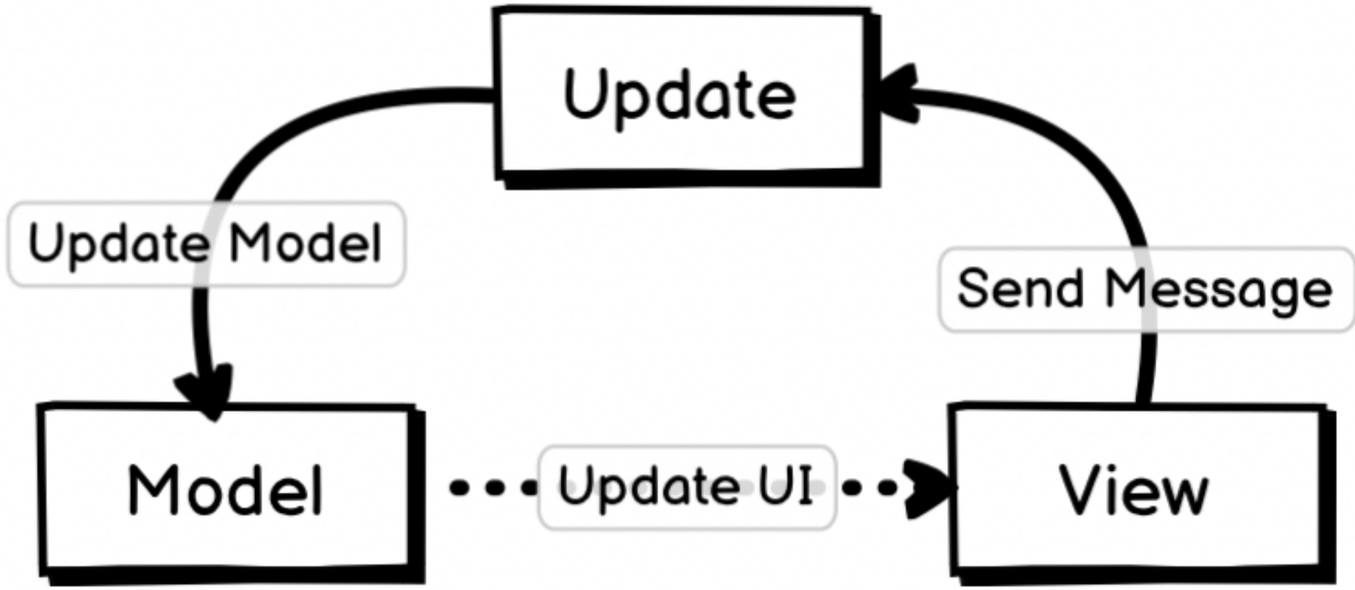
LUSTRE



frontend.gleam

```
type Model {
  Model(
    ctx: AudioContext,
    nodes: List(Node),
    rows: List(Row),
    step: Int,
    step_count: Int,
    waveform: Waveform,
    delay_time: DelayTime,
    gain: Float,
  )
}
```

frontend.gleam

```
fn render_step(step, name, active_column) {
  let #(idx, is_active) = step
  let msg = UpdateStep(name, idx, !is_active)
  let bg = case idx == active_column, is_active {
    True, True -> "bg-faff-200 animate-bloop"
    True, False -> "bg-charcoal-200 scale-[0.8]"
    False, True -> "bg-faff-300"
    False, False -> "bg-charcoal-700 scale-[0.8]"
  }

  element.div(
    [class("p-2")],
    [button.box(bg <> " hover:bg-faff-100", msg)]
  )
}
```

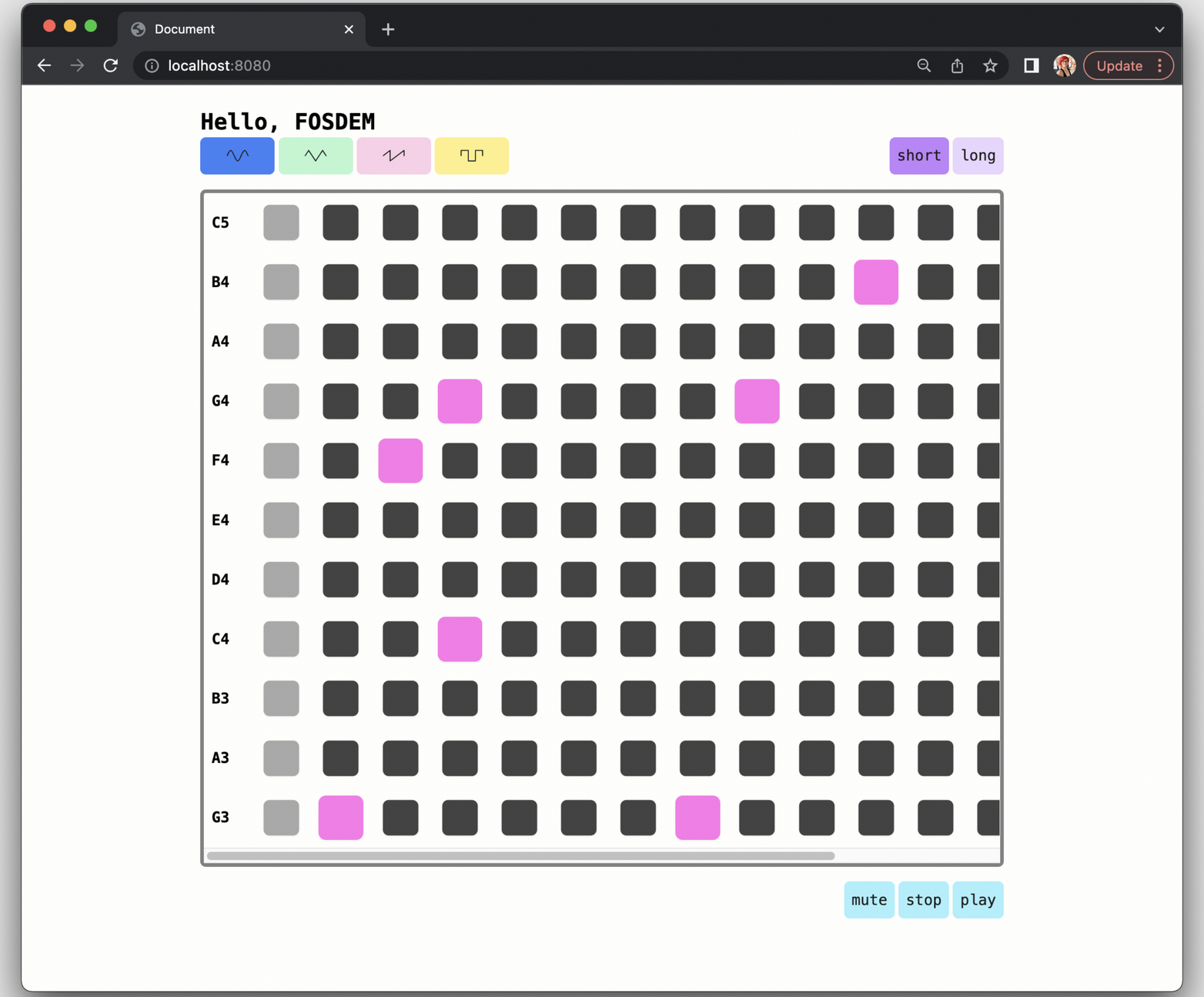
frontend.gleam

```
fn update(model, msg) {
  case msg {
    UpdateStep(name, idx, is_active) -> {
      let rows = list.map(model.rows, fn(row) {
        let steps = case row.name == name {
          True -> map.insert(row.steps, idx, is_active)
          False -> row.steps
        }

        Row(..row, steps: steps)
      }

      Model(..model, rows: rows)
    }

    ...
  }
}
```


Document
localhost:8080
Update
Hello, FOSDEM
short
long
C5
B4
A4
G4
F4
E4
D4
C4
B3
A3
G3
mute
stop
play

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GLISTEN & MIST

`glisten` provides a supervisor which manages a pool of acceptors. Each acceptor will block on accept until a connection is opened. The acceptor will then spawn a handler process and then block again on accept.

GLISTEN & MIST

`mist` is a pure Gleam web server. It provides a simple HTTP server that can be configured to support WebSockets and SSL connections.

backend.gleam

```gleam
fn serve(app: App) -> Result(Nil, glisten.StartError) {
  let port = 8080
  let handler = {
    use req <- mist_handler.with_func

    case req.method, request.path_segments(req) {
      Get, [] -> {
        let res = serve_static_asset("index.html")
        mist_handler.Response(res)
      }

      Get, _ -> {
        let res = serve_static_asset(req.path)
        mist_handler.Response(res)
      }
    }
  }

  mist.serve(port, handler)
}
```

backend.gleam

```gleam
fn serve_static_asset(path: String) -> Response(HttpResponseBody) {
  let path = static <> "/" <> path
  let file =
    path
    |> file.read_bits
    |> result.map(bit_builder.from_bit_string)

  let res = case file {
    Ok(bits) -> Response(200, [], BitBuilderBody(bits))
    Error(_) -> Response(404, [], not_found)
  }

  case list.last(string.split(path, ".")) {
    Ok("html") -> response.set_header(res, "content-type", "text/html")
    Ok("svg") -> response.set_header(res, "content-type", "image/svg+xml")
    Ok("css") -> response.set_header(res, "content-type", "text/css")
    Ok("js") -> response.set_header(res, "content-type", "application/javascript")
    _ -> response.set_header(res, "content-type", "text/plain")
  }
}
```

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backend.gleam

```
fn serve(app: App) -> Result(Nil, glisten.StartError) {
  ...

    case req.method, request.path_segments(req) {
      Get, ["ws"] -> upgrade_websocket(app)

      ...
    }
  }

  mist.serve(port, handler)
}
```

frontend.gleam

```gleam
fn upgrade_websocket(app) {
  let handler =
    WebsocketHandler(
      on_init: Some(on_ws_open(_, app)),
      on_close: Some(on_ws_close(_, app)),
      handler: fn(message, client) {
        case message {
          TextMessage(json) ->
            Ok(on_ws_message(client, json, app))
          _ ->
            Error(Nil)
        }
      },
    )

  mist_handler.Upgrade(handler)
}
```

LUSTRE_WEBSOCKET

`lustre_websocket` is a package that makes it trivial to set up websockets on the client. We just need to call `ws.init` and let it handle everything for us.

frontend.gleam

```gleam
fn init() {
  #(Model(..), ws.init("/ws", WebSocket))
}

fn update(model, msg) {
  case msg {
    WebSocket(OnOpen(conn)) ->
      #(Model(..model, ws: Some(conn)), cmd.none())
    WebSocket(OnClose(_)) ->
      #(Model(..model, ws: Some(conn)), cmd.none())
    WebSocket(OnMessage(msg)) -> {
      // Handle messages from the backend here
      ...
    }

    ...
  }
```

TYPED MESSAGES

`lustre_websocket` is a package that makes it trivial to set up websockets on the client. We just need to call `ws.init` and let it handle everything for us.

frontend.gleam

```gleam
pub type ToBackend {
  Play
  Stop
  UpdateDelayTime(DelayTime)
  UpdateStep(#(String, Int, Bool))
  UpdateWaveform(Waveform)
}
```

backend.gleam

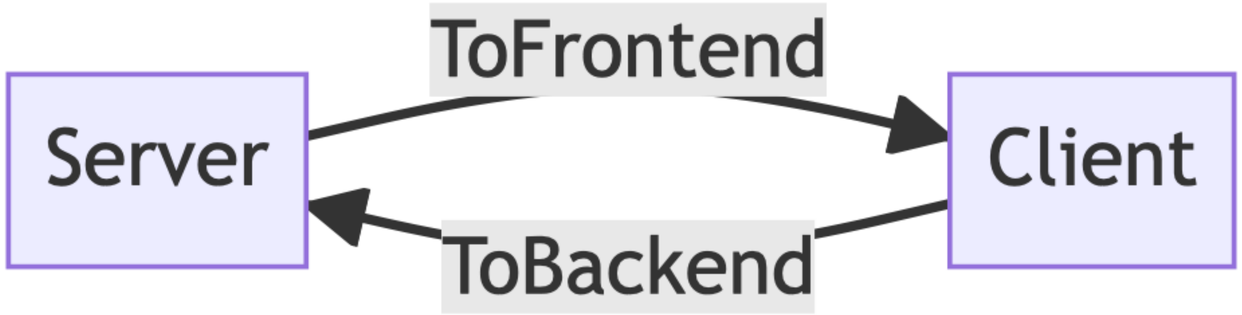
```
OnMessage(_, _, UpdateWaveform(waveform)) -> {
  let shared = shared.State(..state.shared, waveform: waveform)
  broadcast(state.clients, SetWaveform(waveform))

  State(..state, shared: shared)
}

OnMessage(_, _, UpdateStep(#(name, idx, is_active))) -> {
  let rows = {
    use row <- list.map(state.shared.rows)
    let steps = case row.name == name {
      True -> map.insert(row.steps, idx, is_active)
      False -> row.steps
    }

    Row(..row, steps: steps)
  }
  let shared = shared.State(..state.shared, rows: rows)

  broadcast(state.clients, SetRows(rows))
  State(..state, shared: shared)
}

...
```

frontend.gleam

```gleam
pub type ToFrontend {
  SetDelayTime(DelayTime)
  SetGain(Float)
  SetRows(List(Row))
  SetState(State)
  SetStep(Int)
  SetStepCount(Int)
  SetWaveform(Waveform)
}
```

frontend.gleam

```
fn on_message(state, message) {
  let shared = state.shared

  case json.decode(message, to_frontend.decoder) {
    Ok(SetState(shared)) ->
      State(..state, shared: shared)

    Ok(SetRows(rows)) ->  {
      let shared = shared.State(..shared, rows: rows)
      State(..state, shared: shared)
    }

    Ok(SetStep(step)) -> {
      let shared = shared.State(..shared, step: step)
      State(..state, shared: shared)
    }

    ...

    Error(_) -> state
  }
}
```


ToFrontend
Server
Client
ToBackend

DEMO

RECAP

- fullstack gleam app
- otp server on the backend
- react app on the frontend
- liveview style communication

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cloc

```
$ cloc src
      15 text files.
      15 unique files.
       0 files ignored.

github.com/AlDanial/cloc v 1.90  T=0.02 s (920.4 files/s, 106209.0 lines/s)
-------------------------------------------------------------------------------
Language                     files          blank        comment           code
-------------------------------------------------------------------------------
Gleam                           13            265            134           1219
JavaScript                       1             17              9             84
CSS                              1              0              0              3
-------------------------------------------------------------------------------
SUM:                            15            282            143           1306
-------------------------------------------------------------------------------
```

THANKS FOR LISTENING!