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PROJECT: SKILL-SHARING WEBSITE

A *skill-sharing* meeting is an event where people with a shared interest come together and give small, informal presentations about things they know. At a gardening skill-sharing meeting, someone might explain how to cultivate celery. Or in a programming skill-sharing group, you could drop by and tell people about Node.js.

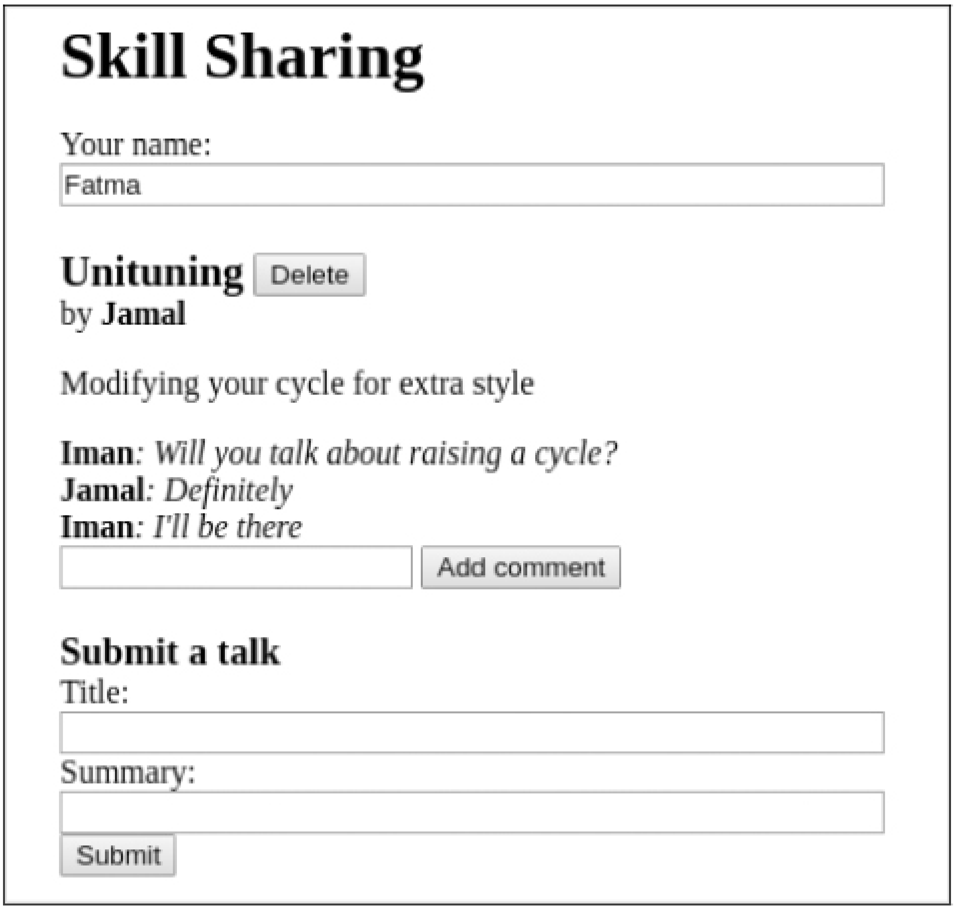
In this final project chapter, our goal is to set up a website for managing talks given at a skill-sharing meeting. Imagine a small group of people meeting up regularly in the office of one of the members to talk about unicycling. The previous organizer of the meetings moved to another town, and nobody stepped forward to take over this task. We want a system that will let the participants propose and discuss talks among themselves without an active organizer.

The full code for the project can be downloaded from *https://eloquentjavascript.net/code/skillsharing.zip*.

Design

There is a *server* part to this project, written for Node.js, and a *client* part, written for the browser. The server stores the system's data and provides it to the client. It also serves the files that implement the client-side system.

The server keeps the list of talks proposed for the next meeting, and the client shows this list. Each talk has a presenter name, a title, a summary, and an array of comments associated with it. The client allows users to propose new talks (adding them to the list), delete talks, and comment on existing talks. Whenever the user makes such a change, the client makes an HTTP request to tell the server about it.



The application will be set up to show a *live* view of the current proposed talks and their comments. Whenever someone, somewhere, submits a new talk or adds a comment, all people who have the page open in their browsers should immediately see the change. This poses a bit of a challenge—there is no way for a web server to open a connection to a client, nor is there a good way to know which clients are currently looking at a given website.

A common solution to this problem is called *long polling*, which happens to be one of the motivations for Node's design.

Long Polling

To be able to immediately notify a client that something changed, we need a connection to that client. Since web browsers do not traditionally accept connections and clients are often behind routers that would block such connections anyway, having the server initiate this connection is not practical.

We can arrange for the client to open the connection and keep it around so that the server can use it to send information when it needs to do so. But an HTTP request allows only a simple flow of information: the client sends a request, the server comes back with a single response, and that's it. A technology called *WebSockets* makes it possible to open connections for arbitrary data exchange, but using such sockets properly is somewhat tricky.

In this chapter, we use a simpler technique, *long polling*, where clients continuously ask the server for new information using regular HTTP requests and the server stalls its answer when it has nothing new to report.

As long as the client makes sure it constantly has a polling request open, it will receive information from the server quickly after it becomes available. For example, if Fatma has our skill-sharing application open in her browser, that browser will have made a request for updates and will be waiting for a response to that request. When Iman submits a talk on Extreme Downhill Unicycling, the server will notice that Fatma is waiting for updates and send a response containing the new talk to her pending request. Fatma's browser will receive the data and update the screen to show the talk.

To prevent connections from timing out (being aborted because of a lack of activity), long polling techniques usually set a maximum time for each request, after which the server will respond anyway, even though it has nothing to report. The client can then start a new request. Periodically restarting the request also makes the technique more robust, allowing clients to recover from temporary connection failures or server problems.

A busy server that is using long polling may have thousands of waiting requests, and thus TCP connections, open. Node, which makes it easy to manage many connections without creating a separate thread of control for each one, is a good fit for such a system.

HTTP Interface

Before we start designing either the server or the client, let's think about the point where they touch: the HTTP interface over which they communicate.

We will use JSON as the format of our request and response body. Like in the file server from Chapter 20, we'll try to make good use of HTTP methods and headers. The interface is centered around the */talks* path. Paths that do not start with */talks* will be used for serving static files—the HTML and JavaScript code for the client-side system.

A `GET` request to */talks* returns a JSON document like this:

```
[{"title": "Unituning",
  "presenter": "Jamal",
  "summary": "Modifying your cycle for extra style",
  "comments": []}]
```

Creating a new talk is done by making a `PUT` request to a URL like */talks/Unituning*, where the part after the second slash is the title of the talk. The `PUT` request's body should contain a JSON object that has `presenter` and `summary` properties.

Since talk titles may contain spaces and other characters that may not appear normally in a URL, title strings must be encoded with the `encodeURI Component` function when building up such a URL.

```
console.log("/talks/" + encodeURIComponent("How to Idle
// → /talks/How%20to%20Idle
```

A request to create a talk about idling might look something like this:

```
PUT /talks/How%20to%20Idle HTTP/1.1
Content-Type: application/json
Content-Length: 92

{"presenter": "Maureen",
 "summary": "Standing still on a unicycle"}
```

Such URLs also support `GET` requests to retrieve the JSON representation of a talk and `DELETE` requests to delete a talk.

Adding a comment to a talk is done with a `POST` request to a URL like */talks/Unituning/comments*, with a JSON body that has `author` and `message` properties.

```
POST /talks/Unituning/comments HTTP/1.1
Content-Type: application/json
```

```
Content-Length: 72

{"author": "Iman",
 "message": "Will you talk about raising a cycle?"}
```

To support long polling, `GET` requests to */talks* may include extra headers that inform the server to delay the response if no new information is available. We'll use a pair of headers normally intended to manage caching: `ETag` and `If-None-Match`.

Servers may include an `ETag` ("entity tag") header in a response. Its value is a string that identifies the current version of the resource. Clients, when they later request that resource again, may make a *conditional request* by including an `If-None-Match` header whose value holds that same string. If the resource hasn't changed, the server will respond with status code 304, which means "not modified," telling the client that its cached version is still current. When the tag does not match, the server responds as normal.

We need something like this, where the client can tell the server which version of the list of talks it has, and the server responds only when that list has changed. But instead of immediately returning a 304 response, the server should stall the response and return only when something new is available or a given amount of time has elapsed. To distinguish long polling requests from normal conditional requests, we give them another header, `Prefer: wait=90`, which tells the server that the client is willing to wait up to 90 seconds for the response.

The server will keep a version number that it updates every time the talks change and will use that as the `ETag` value. Clients can make requests like this to be notified when the talks change:

```
GET /talks HTTP/1.1
If-None-Match: "4"
Prefer: wait=90

(time passes)

HTTP/1.1 200 OK
Content-Type: application/json
ETag: "5"
Content-Length: 295
```

```
--snip--
```

The protocol described here doesn't do any access control. Everybody can comment, modify talks, and even delete them. (Since the internet is full of hooligans, putting such a system online without further protection probably wouldn't end well.)

The Server

Let's start by building the server-side part of the program. The code in this section runs on Node.js.

Routing

Our server will use Node's `createServer` to start an HTTP server. In the function that handles a new request, we must distinguish between the various kinds of requests (as determined by the method and the path) that we support. This can be done with a long chain of `if` statements, but there's a nicer way.

A *router* is a component that helps dispatch a request to the function that can handle it. You can tell the router, for example, that `PUT` requests with a path that matches the regular expression `/^\/talks\/([^\/]+)$/` (*/talks/* followed by a talk title) can be handled by a given function. In addition, it can help extract the meaningful parts of the path (in this case the talk title), wrapped in parentheses in the regular expression, and pass them to the handler function.

There are a number of good router packages on NPM, but here we'll write one ourselves to illustrate the principle.

This is *router.mjs*, which we will later `import` from our server module:

```
export class Router {
  constructor() {
    this.routes = [];
  }
  add(method, url, handler) {
    this.routes.push({method, url, handler});
  }
  async resolve(request, context) {
    let {pathname} = new URL(request.url, "http://d");
```

```
      for (let {method, url, handler} of this.routes) {
        let match = url.exec(pathname);
        if (!match || request.method != method) continue;
        let parts = match.slice(1).map(decodeURIComponent
        return handler(context, ...parts, request);
      }
    }
  }
```

The module exports the `Router` class. A router object allows you to register handlers for specific methods and URL patterns with its `add` method. When a request is resolved with the `resolve` method, the router calls the handler whose method and URL match the request and return its result.

Handler functions are called with the `context` value given to `resolve`. We will use this to give them access to our server state. Additionally, they receive the match strings for any groups they defined in their regular expression, and the request object. The strings have to be URL-decoded, since the raw URL may contain `%20`-style codes.

Serving Files

When a request matches none of the request types defined in our router, the server must interpret it as a request for a file in the *public* directory. It would be possible to use the file server defined in Chapter 20 to serve such files, but we neither need nor want to support `PUT` and `DELETE` requests on files, and we would like to have advanced features such as support for caching. Let's use a solid, well-tested static file server from NPM instead.

I opted for `serve-static`. This isn't the only such server on NPM, but it works well and fits our purposes. The `serve-static` package exports a function that can be called with a root directory to produce a request handler function. The handler function accepts the `request` and `response` arguments provided by the server from "`node:http`", and a third argument, a function that it will call if no file matches the request. We want our server to first check for requests we should handle specially, as defined in the router, so we wrap it in another function.

```
import {createServer} from "node:http";
import serveStatic from "serve-static";
```

```
function notFound(request, response) {
  response.writeHead(404, "Not found");
  response.end("<h1>Not found</h1>");
}
class SkillShareServer {
  constructor(talks) {
    this.talks = talks;
    this.version = 0;
    this.waiting = [];

    let fileServer = serveStatic("./public");
    this.server = createServer((request, response) => {
      serveFromRouter(this, request, response, () => {
        fileServer(request, response,
                   () => notFound(request, response));
      });
    });
  }
  start(port) {
    this.server.listen(port);
  }
  stop() {
    this.server.close();
  }
}
```

The `serveFromRouter` function has the same interface as `fileServer`, taking `(request, response, next)` arguments. We can use this to "chain" several request handlers, allowing each to either handle the request or pass responsibility for that on to the next handler. The final handler, `notFound`, simply responds with a "not found" error.

Our `serveFromRouter` function uses a similar convention to the file server from the previous chapter for responses—handlers in the router return promises that resolve to objects describing the response.

```
import {Router} from "./router.mjs";

const router = new Router();
const defaultHeaders = {"Content-Type": "text/plain"};

async function serveFromRouter(server, request,
                               response, next) {
```

```
    let resolved = await router.resolve(request, server)
      .catch(error => {
        if (error.status != null) return error;
        return {body: String(err), status: 500};
      });
    if (!resolved) return next();
    let {body, status = 200, headers = defaultHeaders} =
      await resolved;
    response.writeHead(status, headers);
    response.end(body);
  }
```

Talks as Resources

The talks that have been proposed are stored in the `talks` property of the server, an object whose property names are the talk titles. We'll add some handlers to our router that expose these as HTTP resources under */talks/<title>*.

The handler for requests that `GET` a single talk must look up the talk and respond either with the talk's JSON data or with a 404 error response.

```
const talkPath = /^\/talks\/([^\/]+)$/;

router.add("GET", talkPath, async (server, title) => {
  if (Object.hasOwn(server.talks, title)) {
    return {body: JSON.stringify(server.talks[title]),
            headers: {"Content-Type": "application/jsor
  } else {
    return {status: 404, body: `No talk '${title}' four
  }
});
```

Deleting a talk is done by removing it from the `talks` object.

```
router.add("DELETE", talkPath, async (server, title) =>
  if (Object.hasOwn(server.talks, title)) {
    delete server.talks[title];
    server.updated();
  }
```

```
    return {status: 204};
  });
```

The `updated` method, which we will define later, notifies waiting long polling requests about the change.

One handler that needs to read request bodies is the `PUT` handler, which is used to create new talks. It has to check whether the data it was given has `presenter` and `summary` properties, which are strings. Any data coming from outside the system might be nonsense, and we don't want to corrupt our internal data model or crash when bad requests come in.

If the data looks valid, the handler stores an object that represents the new talk in the `talks` object, possibly overwriting an existing talk with this title, and again calls `updated`.

To read the body from the request stream, we will use the `json` function from "`node:stream/consumers`", which collects the data in the stream and then parses it as JSON. There are similar exports called `text` (to read the content as a string) and `buffer` (to read it as binary data) in this package. Since `json` is a very generic name, the import renames it to `readJSON` to avoid confusion.

```
import {json as readJSON} from "node:stream/consumers";

router.add("PUT", talkPath,
           async (server, title, request) => {
  let talk = await readJSON(request);
  if (!talk ||
      typeof talk.presenter != "string" ||
      typeof talk.summary != "string") {
    return {status: 400, body: "Bad talk data"};
  }
  server.talks[title] = {
    title,
    presenter: talk.presenter,
    summary: talk.summary,
    comments: []
  };
  server.updated();
  return {status: 204};
});
```

Adding a comment to a talk works similarly. We use `readJSON` to get the content of the request, validate the resulting data, and store it as a comment when it looks valid.

```
router.add("POST", /^\/talks\/([^\/]+)\/comments$/,
           async (server, title, request) => {
  let comment = await readJSON(request);
  if (!comment ||
      typeof comment.author != "string" ||
      typeof comment.message != "string") {
    return {status: 400, body: "Bad comment data"};
  } else if (Object.hasOwn(server.talks, title)) {
    server.talks[title].comments.push(comment);
    server.updated();
    return {status: 204};
  } else {
    return {status: 404, body: `No talk '${title}' four
  }
});
```

Trying to add a comment to a nonexistent talk returns a 404 error.

Long Polling Support

The most interesting aspect of the server is the part that handles long polling. When a `GET` request comes in for */talks*, it may be either a regular request or a long polling request.

There will be multiple places in which we have to send an array of talks to the client, so we first define a helper method that builds up such an array and includes an `ETag` header in the response.

```
SkillShareServer.prototype.talkResponse = function() {
  let talks = Object.keys(this.talks)
    .map(title => this.talks[title]);
  return {
    body: JSON.stringify(talks),
    headers: {"Content-Type": "application/json",
              "ETag": `"${this.version}"`,
              "Cache-Control": "no-store"}
```

```
  };
};
```

The handler itself needs to look at the request headers to see whether `If-None-Match` and `Prefer` headers are present. Node stores headers, whose names are specified to be case insensitive, under their lowercase names.

```
router.add("GET", /^\/talks$/, async (server, request)
  let tag = /"(.*)"/.exec(request.headers["if-none-matc
  let wait = /\bwait=(\d+)/.exec(request.headers["prefe
  if (!tag || tag[1] != server.version) {
    return server.talkResponse();
  } else if (!wait) {
    return {status: 304};
  } else {
    return server.waitForChanges(Number(wait[1]));
  }
});
```

If no tag was given or a tag was given that doesn't match the server's current version, the handler responds with the list of talks. If the request is conditional and the talks did not change, we consult the `Prefer` header to see whether we should delay the response or respond right away.

Callback functions for delayed requests are stored in the server's `waiting` array so that they can be notified when something happens. The `waitFor Changes` method also immediately sets a timer to respond with a 304 status when the request has waited long enough.

```
SkillShareServer.prototype.waitForChanges = function(ti
  return new Promise(resolve => {
    this.waiting.push(resolve);
    setTimeout(() => {
      if (!this.waiting.includes(resolve)) return;
      this.waiting = this.waiting.filter(r => r != resc
      resolve({status: 304});
    }, time * 1000);
  });
};
```

Registering a change with `updated` increases the `version` property and wakes up all waiting requests.

```
SkillShareServer.prototype.updated = function() {
  this.version++;
  let response = this.talkResponse();
  this.waiting.forEach(resolve => resolve(response));
  this.waiting = [];
};
```

That concludes the server code. If we create an instance of `SkillShare Server` and start it on port 8000, the resulting HTTP server serves files from the *public* subdirectory alongside a talk-managing interface under the */talks* URL.

```
new SkillShareServer({}).start(8000);
```

The Client

The client-side part of the skill-sharing website consists of three files: a tiny HTML page, a style sheet, and a JavaScript file.

HTML

It is a widely used convention for web servers to try to serve a file named *index.html* when a request is made directly to a path that corresponds to a directory. The file server module we use, `serve-static`, supports this convention. When a request is made to the path */*, the server looks for the file *./public/index.html* (*./public* being the root we gave it) and returns that file if found.

Thus, if we want a page to show up when a browser is pointed at our server, we should put it in *public/index.html*. This is our index file:

```
<!doctype html>
<meta charset="utf-8">
<title>Skill Sharing</title>
<link rel="stylesheet" href="skillsharing.css">

<h1>Skill Sharing</h1>
```

```
<script src="skillsharing_client.js"></script>
```

It defines the document title and includes a style sheet, which defines a few styles to, among other things, make sure there is some space between talks. It then adds a heading at the top of the page and loads the script that contains the client-side application.

Actions

The application state consists of the list of talks and the name of the user, and we'll store it in a `{talks, user}` object. We don't allow the user interface to directly manipulate the state or send off HTTP requests. Rather, it may emit *actions* that describe what the user is trying to do.

The `handleAction` function takes such an action and makes it happen. Because our state updates are so simple, state changes are handled in the same function.

```
function handleAction(state, action) {
  if (action.type == "setUser") {
    localStorage.setItem("userName", action.user);
    return {...state, user: action.user};
  } else if (action.type == "setTalks") {
    return {...state, talks: action.talks};
  } else if (action.type == "newTalk") {
    fetchOK(talkURL(action.title), {
      method: "PUT",
      headers: {"Content-Type": "application/json"},
      body: JSON.stringify({
        presenter: state.user,
        summary: action.summary
      })
    }).catch(reportError);
  } else if (action.type == "deleteTalk") {
    fetchOK(talkURL(action.talk), {method: "DELETE"})
      .catch(reportError);
  } else if (action.type == "newComment") {
    fetchOK(talkURL(action.talk) + "/comments", {
      method: "POST",
      headers: {"Content-Type": "application/json"},
      body: JSON.stringify({
        author: state.user,
```

```
        message: action.message
      })
    }).catch(reportError);
  }
  return state;
}
```

We’ll store the user’s name in `localStorage` so that it can be restored when the page is loaded.

The actions that need to involve the server make network requests, using `fetch`, to the HTTP interface described earlier. We use a wrapper function, `fetchOK`, which makes sure the returned promise is rejected when the server returns an error code.

```
function fetchOK(url, options) {
  return fetch(url, options).then(response => {
    if (response.status < 400) return response;
    else throw new Error(response.statusText);
  });
}
```

This helper function is used to build up a URL for a talk with a given title.

```
function talkURL(title) {
  return "talks/" + encodeURIComponent(title);
}
```

When the request fails, we don’t want our page to just sit there doing nothing without explanation. The function called `reportError`, which we used as the `catch` handler, shows the user a crude dialog to tell them something went wrong.

```
function reportError(error) {
  alert(String(error));
}
```

Rendering Components

We'll use an approach similar to the one we saw in Chapter 19, splitting the application into components. However, since some of the components either never need to update or are always fully redrawn when updated, we'll define those not as classes but as functions that directly return a DOM node. For example, here is a component that shows the field where the user can enter their name:

```
function renderUserField(name, dispatch) {
  return elt("label", {}, "Your name: ", elt("input", {
    type: "text",
    value: name,
    onchange(event) {
      dispatch({type: "setUser", user: event.target.val
    }
  }));
}
```

The `elt` function used to construct DOM elements is the one we used in Chapter 19.

A similar function is used to render talks, which include a list of comments and a form for adding a new comment.

```
function renderTalk(talk, dispatch) {
  return elt(
    "section", {className: "talk"},
    elt("h2", null, talk.title, " ", elt("button", {
      type: "button",
      onclick() {
        dispatch({type: "deleteTalk", talk: talk.title}
      }
    }, "Delete")),
    elt("div", null, "by ",
        elt("strong", null, talk.presenter)),
    elt("p", null, talk.summary),
    ...talk.comments.map(renderComment),
    elt("form", {
      onsubmit(event) {
        event.preventDefault();
        let form = event.target;
        dispatch({type: "newComment",
```

```
                  talk: talk.title,
                  message: form.elements.comment.value}
        form.reset();
      }
    }, elt("input", {type: "text", name: "comment"}), "
       elt("button", {type: "submit"}, "Add comment")))
}
```

The “submit” event handler calls form.reset to clear the form’s content after creating a “newComment” action.

When creating moderately complex pieces of DOM, this style of programming starts to look rather messy. To avoid this, people often use a *templating language*, which allows you to write your interface as an HTML file with some special markers to indicate where dynamic elements go. Or they use *JSX*, a nonstandard JavaScript dialect that allows you to write something very close to HTML tags in your program as if they are JavaScript expressions. Both of these approaches use additional tools to preprocess the code before it can be run, which we will avoid in this chapter.

Comments are simple to render.

```
function renderComment(comment) {
  return elt("p", {className: "comment"},
             elt("strong", null, comment.author),
             ": ", comment.message);
}
```

Finally, the form that the user can use to create a new talk is rendered like this:

```
function renderTalkForm(dispatch) {
  let title = elt("input", {type: "text"});
  let summary = elt("input", {type: "text"});
  return elt("form", {
    onsubmit(event) {
      event.preventDefault();
      dispatch({type: "newTalk",
                title: title.value,
                summary: summary.value});
      event.target.reset();
    }
  }, elt("h3", null, "Submit a Talk"),
```

```
      elt("label", null, "Title: ", title),
      elt("label", null, "Summary: ", summary),
      elt("button", {type: "submit"}, "Submit"));
}
```

Polling

To start the app, we need the current list of talks. Since the initial load is closely related to the long polling process—the `ETag` from the load must be used when polling—we'll write a function that keeps polling the server for */talks* and calls a callback function when a new set of talks is available.

```
async function pollTalks(update) {
  let tag = undefined;
  for (;;) {
    let response;
    try {
      response = await fetchOK("/talks", {
        headers: tag && {"If-None-Match": tag,
                         "Prefer": "wait=90"}
      });
    } catch (e) {
      console.log("Request failed: " + e);
      await new Promise(resolve => setTimeout(resolve,
      continue;
    }
    if (response.status == 304) continue;
    tag = response.headers.get("ETag");
    update(await response.json());
  }
}
```

This is an `async` function so that looping and waiting for the request is easier. It runs an infinite loop that, on each iteration, retrieves the list of talks—either normally or, if this isn't the first request, with the headers included that make it a long polling request.

When a request fails, the function waits a moment and then tries again. This way, if your network connection goes away for a while and then comes back, the application can recover and continue updating. The promise resolved via `setTimeout` is a way to force the `async` function to wait.

When the server gives back a 304 response, that means a long polling request timed out, so the function should just immediately start the next request. If the response is a normal 200 response, its body is read as JSON and passed to the callback, and its `ETag` header value is stored for the next iteration.

The Application

The following component ties the whole user interface together:

```
class SkillShareApp {
  constructor(state, dispatch) {
    this.dispatch = dispatch;
    this.talkDOM = elt("div", {className: "talks"});
    this.dom = elt("div", null,
                   renderUserField(state.user, dispatch
                   this.talkDOM,
                   renderTalkForm(dispatch));
    this.syncState(state);
  }

  syncState(state) {
    if (state.talks != this.talks) {
      this.talkDOM.textContent = "";
      for (let talk of state.talks) {
        this.talkDOM.appendChild(
          renderTalk(talk, this.dispatch));
      }
      this.talks = state.talks;
    }
  }
}
```

When the talks change, this component redraws all of them. This is simple but also wasteful. We'll get back to that in the exercises.

We can start the application like this:

```
function runApp() {
  let user = localStorage.getItem("userName") || "Anon
  let state, app;
  function dispatch(action) {
```

```
    state = handleAction(state, action);
    app.syncState(state);
  }

  pollTalks(talks => {
    if (!app) {
      state = {user, talks};
      app = new SkillShareApp(state, dispatch);
      document.body.appendChild(app.dom);
    } else {
      dispatch({type: "setTalks", talks});
    }
  }).catch(reportError);
}

runApp();
```

If you run the server and open two browser windows for *http://localhost:8000* next to each other, you can see that the actions you perform in one window are immediately visible in the other.

Exercises

The following exercises will involve modifying the system defined in this chapter. To work on them, make sure you've downloaded the code (*https://eloquentjavascript.net/code/skillsharing.zip*), installed Node (*https://nodejs.org*), and installed the project's dependency with `npm install`.

Disk Persistence

The skill-sharing server keeps its data purely in memory. This means that when it crashes or is restarted for any reason, all talks and comments are lost.

Extend the server so that it stores the talk data to disk and automatically reloads the data when it is restarted. Don't worry about efficiency—do the simplest thing that works.

Comment Field Resets

The wholesale redrawing of talks works pretty well because you usually can't tell the difference between a DOM node and its identical replacement. But there are exceptions. If you start typing something in the comment field for a talk in one browser window and then, in another, add a comment to that talk, the field in the first window will be redrawn, removing both its content and its focus.

When multiple people are adding comments at the same time, this would be annoying. Can you come up with a way to solve it?