



Bun - Blazlingly Fast JavaScript/TypeScript

R. Mark Volkmann

Object Computing, Inc.



<https://objectcomputing.com>



mark@objectcomputing.com



[@mark_volkmann](https://twitter.com/mark_volkmann)



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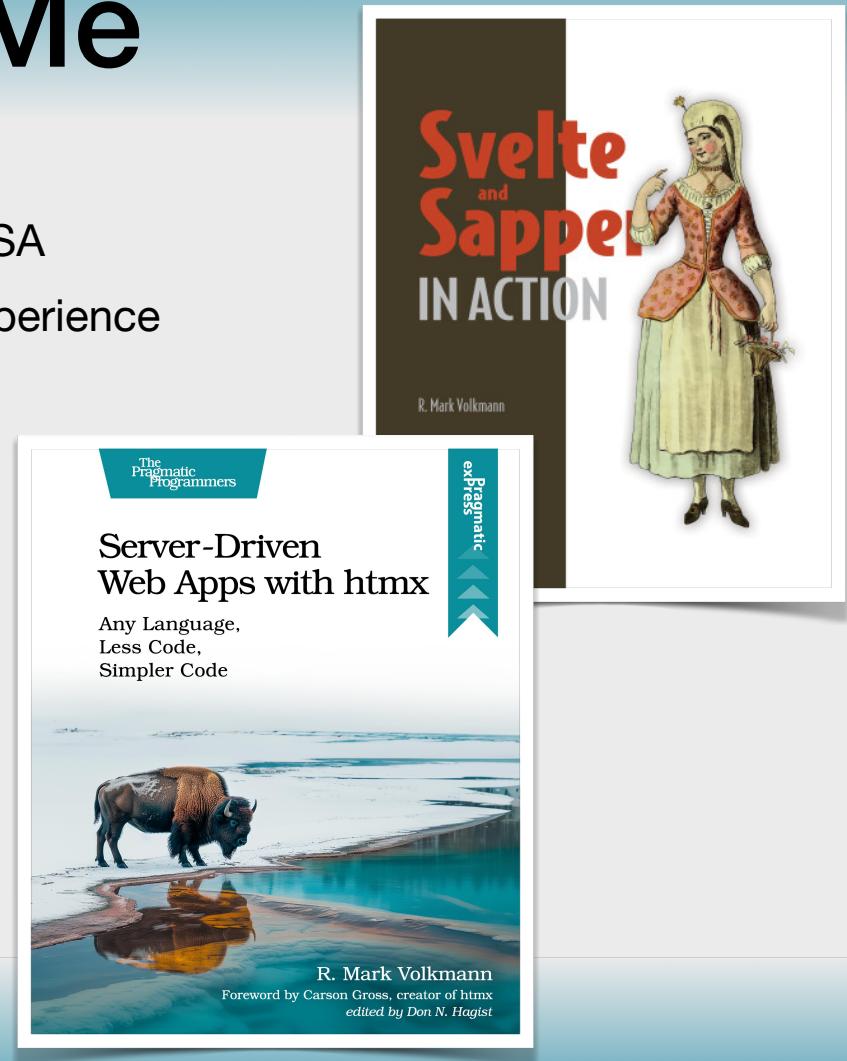


Friends of KCDC



About Me

- Partner and Distinguished Software Engineer at Object Computing, Inc. in St. Louis, Missouri USA
- 44 years of professional software development experience
- Writer and speaker
- **Blog** at <https://mvolkmann.github.io/blog/>
- Author of Manning book “**Svelte ... in Action**”
- Author of Pragmatic Bookshelf book “**Server-Driven Web Apps with htmx**”



Overview

- Bun includes
 - **JavaScript runtime** - replaces Node
 - **package manager** - replaces npm, pnpm, Yarn, ...
 - can start by using Bun only for this
 - **bundler** - replaces Parcel, Rollup, Vite, Webpack, ...
 - **test runner** - replaces Jest, Mocha, ...
- Drop-in replacement for Node and npm
 - supports most Node APIs
- Started in 2022 by Jarred Sumner
- Supports Linux, macOS, and Windows



Jarred Sumner



Used For

- Anything JavaScript can be used for
- Web framework backends
 - ex. Astro, Elysia, Express, **Hono**, Next.js, Nuxt, Remix, and SvelteKit
- Alternative to shell scripts



The Name

HELLO
MY NAME IS

*What's in a
Name?*

- Three meanings
 - a friend suggested it because she has a bunny named “Bun”
 - it’s a bundling of tools for the JavaScript ecosystem
 - it’s a code bundler



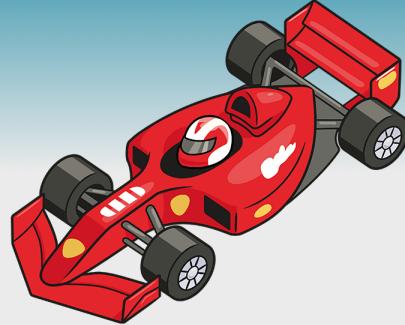
Benefits

WHY?

- Significantly better **performance**
- Simplifies JS/TS **tooling**
- Native **hot reloading**
 - loads changes without losing state
- Supports both **CommonJS** and **ESM**, even in same file
 - `require` and `import` keywords
- Supports **TypeScript** out of the box
- Built-in support for Jest-compatible **unit tests**
- Better support for standard **Web APIs**
- Supports **JSX/TSX** for HTML generation
- Built-in support for **SQLite**
- **Bun-specific APIs** that are faster than Node alternatives
 - but prevents running in Node



Performance



- **Run Hello World:** 4x Node
- **Build and run TypeScript:** 4x esbuild, 15x tsx, 43x tsc + Node
- **Install packages:** 17x pnpm, 29x npm, 33x Yarn
- **Run npm scripts:** bun run is 5x npm run
- **Run tests:** 5x Vitest, 8x Jest + SWC, 20x Jest + Babel
- **File I/O:** writes 3x Node, reads 10x Node
- **HTTP requests per second:** 4x Node
- **Websocket messages per second:** 5x Node
- **Run SQLite queries:** 2x Deno, 4x Node

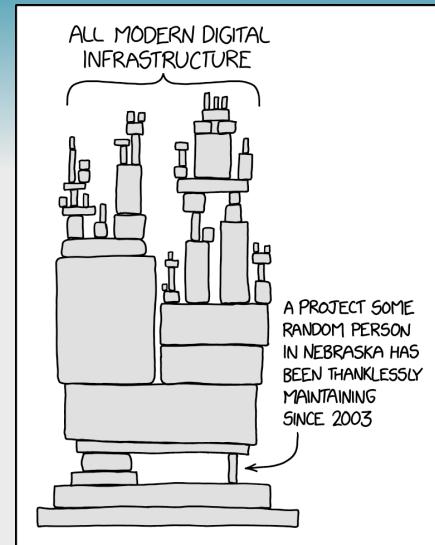
“makes other test runners look like test walkers”

SWC is Speedy Web Compiler



Underpinnings

- Built on **JavaScriptCore** (JSC) used by Safari rather than V8 used by Chrome
 - provides faster startup time and lower memory usage
- Mostly implemented in **Zig**
 - systems programming language that competes with C++ and Rust
 - Zig 60%, C++ 24%, JavaScript 6%, TypeScript 5%, C 3%, other 2%
 - see my Zig **talk slides** at <https://github.com/mvolkmann/talks>
 - see my Zig **blog page** at <https://mvolkmann.github.io/blog/>



Getting Started

- To install on macOS, Linux, and WSL
 - `curl -fsSL https://bun.sh/install | bash`
- See docs for other options
- To see a list of bun commands, enter `bun` or `bun --help`
- For help on a specific command, enter `bun command --help`
- To upgrade, enter `bun upgrade`
- To start a REPL, enter `bun repl`



Running npm Packages



- Node **npx** command runs a local or remote npm package
 - typically used for remote packages
 - canonical example is **npx cowsay Hello, KCDC!**
 - code to run is specified by **package.json bin** property
- Bun equivalent is **bunx** which is much faster
 - an alias for **bun x**
- Try both to see how much faster it is!



Projects ...



- To create a project that uses Bun, create a directory, cd to it, and enter **bun init**
- Creates the following
 - **README.md** - contains basic information about using Bun
 - **.gitignore** - specifies files and directories to exclude from Git repository
 - **package.json** - describes dependencies, scripts, and more
 - **tsconfig.json** - configures TypeScript; strict by default
 - **node_modules** - directory that holds installed dependencies
 - **bun.lockb** - binary equivalent of **package-lock.json** for performance
 - **index.ts** - entry point source file

initial dependencies are only
@types/bun and typescript

may change to
text-based soon

typically want to create **src** directory
and move this file there



... Projects

- To run, enter **bun run index.ts**
 - outputs “Hello via Bun!”
- Can also create a project that use a specific framework
- Enter **bun create template**
 - where **template** is **elysia**, **hono**, **react-app**, **svelte**, **vue**, and more
 - clones GitHub repository named “**create-template**”



Package Manager



- Can use Bun for package management even if not using it as a JavaScript runtime
 - much faster
 - downloaded packages are stored in `~/.bun/install/cache`
 - linked from projects rather than copying details differ by platform
- To add a dependency, enter `bun add dependency` include `-d` for development dependencies
- To remove a dependency, enter `bun remove dependency`
- To install all dependencies, enter `bun install`
- Tracks dependencies in `bun.lockb` file



Linting



- Not provided by Bun, but can use **ESLint**
- Enter **npm init @eslint/config** to create **.eslintrc.json**
 - will ask questions
- Add following script in **package.json**
 - **"lint": "eslint 'src/**/*.{css,html,ts,tsx}' "**
- To lint project code, enter **bun lint**

add **script** property
if not already present

```
{  
  "env": {  
    "browser": true,  
    "es2021": true  
  },  
  "extends": [  
    "eslint:recommended",  
    "plugin:@typescript-eslint/recommended"  
  ],  
  "parser": "@typescript-eslint/parser",  
  "parserOptions": {  
    "ecmaVersion": "latest",  
    "sourceType": "module"  
  },  
  "plugins": ["@typescript-eslint"],  
  "rules": {}  
}
```



Formatting



- Not provided by Bun, but can use **Prettier**
- Enter **bun add -d prettier**
- Create **.prettierrc** file
- Add following script in **package.json**
 - `"format": "prettier --write 'src/**/*.{css,html,ts,tsx}' "`
- To format project code, enter **bun format**

add **script** property
if not already present

```
{  
  "arrowParens": "avoid",  
  "bracketSpacing": false,  
  "singleQuote": true,  
  "trailingComma": "none"  
}
```



Bundling



- Can bundle all project files and dependencies into a single `.js` file
- Add following scripts in `package.json`

```
"scripts": {  
  "bundle": "bun build src/index.ts --minify --outdir build",  
  "clean": "rm -rf build",  
  "start": "bun run build/index.js"  
}
```

add `--target=bun`
to bundle server code;
other options are
`browser` (default)
and `node`

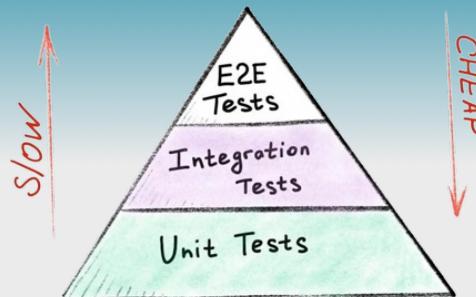
- To create bundle, enter `bun bundle`
- To execute bundle, enter `bun start`

example to try

```
src/index.ts  
import { formatDistance } from 'date-fns';  
  
const now = new Date();  
const birthday = new Date(now.getFullYear(), 3, 16);  
const distance = formatDistance(now, birthday);  
console.log(distance, 'until your birthday');
```



Unit Tests ...



- Bun has built-in support for Jest-compatible unit tests
- Basic example

```
export function add(n1: number, n2: number): number {  
    return n1 + n2;  
}  
src/math.ts
```

```
import {expect, test} from 'bun:test';  
import {add} from './math';  
  
test('add', () => {  
    expect(add(2, 2)).toBe(4);  
});  
src/math.test.ts
```

can also import `describe`, `beforeAll`,
`beforeEach`, `afterAll`, and `afterEach`

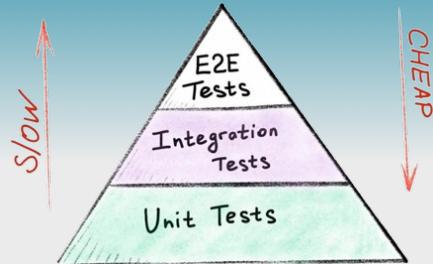
change `test` to `test.skip`
to temporarily skip running

- Object returned by `expect` supports 48 matcher methods

summarized at <https://bun.sh/docs/test/writing#matchers>



... Unit Tests



- To **run all** unit tests in project, including in subdirectories
 - `bun test`
- To only run tests whose **name matches** a given pattern string passed to `test` function
 - add `--test-name-pattern pattern`
- To run only a **specific test**, change `test` to `test.only`
 - and run with `bun test --only`
- To **automatically rerun** tests when code changes are saved
 - `bun --watch test`
- By default tests **timeout** and are considered failed after five seconds
 - to change, add `--timeout seconds`



Importing Files



- Bun can import files in several formats including JSON and plain text

```
Out of memory.          haiku.txt  
We wish to hold the whole sky,  
But we never will.
```

```
import haiku from './haiku.txt';  
const lines = haiku.split('\n');  
for (const line of lines) {  
  const words = line.split(' ');  
  console.log(  
    `${words.length} words: ${line}`  
  );  
}
```

```
[  
  {  
    "breed": "Whippet",  
    "name": "Comet"  
  },  
  {  
    "breed": "German Shorthaired Pointer",  
    "name": "Oscar"  
  }  
]
```

```
import dogs from './dogs.json';  
for (const dog of dogs) {  
  console.log(  
    `${dog.name} is a ${dog.breed}.`  
  );  
}
```



Bun.serve



- Can implement basic HTTP servers without a library

```
const server = Bun.serve({
  port: 3000,           browse localhost:3000
  fetch(req) {          // Can customize response based on method and pathname.
    const {method} = req;
    const {pathname} = new URL(req.url);
    return new Response('Hello, World!');
  },
  error(err) {
    console.error(err);
    return new Response(err);
  },
  // optional to support HTTPS
  tls: {
    cert: Bun.file('./cert.pem'),
    key: Bun.file('./key.pem')
  }
});

console.log('Server started on port', server.port);
```

index.ts

```
"scripts": {
  "dev": "bun --watch index.ts",
  "start": "bun index.ts"
}
```

package.json

to start server,
enter bun dev
or bun start

of course these
files must exist

--watch restarts server
--hot loads changes
without restarting server
to avoid losing state



HTTP Libraries

- **Elysia** and **Hono** are popular alternatives to Express that simplify implementing HTTP servers
 - see <https://elysiajs.com/> and <https://hono.dev/>
 - both are **much faster** than Express
 - Elysia is slightly faster than Hono
 - Elysia only runs in Bun; Hono runs in any JS runtime



Hono



- Hono route methods are passed a **Context** object (**c** in code below)
 - used to get request data and create responses
 - can use **Zod** (<https://zod.dev/>) to validate request

| Action | Code |
|------------------------------|--|
| get value of request header | <code>c.req.header('Some-Name')</code> |
| get value of path parameter | <code>c.req.param('some-name')</code> |
| get value of query parameter | <code>c.req.query('some-name')</code> |
| get value of text body | <code>const text = await c.req.text();</code> |
| get FormData from body | <code>const formData = await c.req.formData();</code> |
| get property from formData | <code>const value = (formData.get('property') as string) '';</code> |
| get value of JSON body | <code>const object = await c.req.json();</code> |

| Action | Code |
|------------------------------|---|
| set value of response header | <code>c.header('Some-Name', 'some value');</code> |
| set status code | <code>c.status(someCode);</code> |
| return text response | <code>return c.text('some text');</code> |
| return JSON response | <code>return c.json(someObject);</code> |
| return HTML response | <code>return c.html(someHTML);</code> |
| return "Not Found" error | <code>return c.notFound();</code> |
| redirect to another URL | <code>return c.redirect('someURL');</code> |



Hono Server ...



<https://github.com/mvolkmann/hono-demos>

- Open dev/hono/hono-demos/dogs-demo in VS Code on my laptop
- cd to that directory and enter **bun dev**
- Browse localhost:3000
- Use Thunder Client in VS Code to send GET, POST, PUT, and DELETE requests
 - refresh browser after each

Dogs I Know

- Comet is a Whippet.
- Oscar is a German Shorthaired Pointer.

```
import {type Context, Hono} from 'hono';           index.ts
import {serveStatic} from 'hono/bun';
import dogRouter from './dog-router';

const app = new Hono();

// Serves static files from public directory.
app.use('/*', serveStatic({root: './public'}));

app.get('/', (c: Context) => c.redirect('/dog'));

app.route('/dog', dogRouter);

export default app;
```



... Hono Server ...



```
dog-router.tsx
import {type Context, Hono} from 'hono';

const router = new Hono();

interface NewDog {
  name: string;
  breed: string;
}

interface Dog extends NewDog {
  id: number;
}

let lastId = 0;

// The dogs are maintained in memory.
const dogMap: {[id: number]: Dog} = {};

function addDog(name: string, breed: string): Dog {
  const id = ++lastId;
  const dog = {id, name, breed};
  dogMap[id] = dog;
  return dog;
}

addDog('Comet', 'Whippet');
addDog('Oscar', 'German Shorthaired Pointer');
```

```
// This gets all the dogs as either JSON or HTML.
router.get('/', (c: Context) => {
  const accept = c.req.header('Accept');
  if (accept && accept.includes('application/json')) {
    return c.json(dogMap);
  }

  const dogs = Object.values(dogMap).sort((a, b) =>
    a.name.localeCompare(b.name)
  );
  const title = 'Dogs I Know';
  return c.html(
    <html>
      <head>
        <link rel="stylesheet" href="/styles.css" />
        <title>{title}</title>
      </head>
      <body>
        <h1>{title}</h1>
        <ul>
          {dogs.map((dog: Dog) => (
            <li>
              {dog.name} is a {dog.breed}.
            </li>
          )));
        </ul>
      </body>
    </html>
  );
});
```

using JSX

body {
 font-family: sans-serif;
}

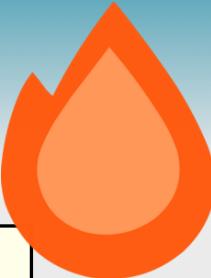
styles.css

```
tsconfig.json
{
  "compilerOptions": {
    ...
    "jsx": "react-jsx",
    "jsxImportSource": "hono/jsx"
  }
}
```

required to use JSX



... Hono Server



```
// This gets one dog by its id as JSON.  
router.get('/:id', (c: Context) => {  
  const id = Number(c.req.param('id'));  
  const dog = dogMap[id];  
  return dog ? c.json(dog) : c.notFound();  
});  
  
// This creates a new dog.  
router.post('/', async (c: Context) => {  
  const data = (await c.req.json())  
    as unknown as NewDog;  
  const dog = addDog(data.name, data.breed);  
  c.status(201); // Created  
  return c.json(dog);  
});
```

```
// This updates the dog with a given id.  
router.put('/:id', async (c: Context) => {  
  const id = Number(c.req.param('id'));  
  const data = (await c.req.json()) as unknown as NewDog;  
  const dog = dogMap[id];  
  if (dog) {  
    dog.name = data.name;  
    dog.breed = data.breed;  
  }  
  return dog ? c.json(dog) : c.notFound();  
});  
  
// This deletes the dog with a given id.  
router.delete('/:id', async (c: Context) => {  
  const id = Number(c.req.param('id'));  
  const dog = dogMap[id];  
  if (dog) delete dogMap[id];  
  return dog ? c.body(null) : c.notFound();  
});  
  
export default router;
```



Elysia



- Elysia route methods are also passed a **Context** object
 - used to get request data and create responses
- Elysia provides its own library for validating request
 - see <https://elysiajs.com/essential/schema.html#type>

| Action | Code |
|------------------------------|--|
| get value of request header | <code>c.headers['some-name']</code> |
| get value of path parameter | <code>c.params['some-name']</code> |
| get value of query parameter | <code>c.query['some-name']</code> |
| get value of text body | <code>const text = c.body;</code> |
| get form data from body | <code>const formData = c.body;</code> |
| get property from formData | <code>const value = formData.some-name;</code> |
| get value of JSON body | <code>const object = c.body;</code> |

| Action | Code |
|--------------------------------|--|
| set value of a response header | <code>c.header('Some-Name', 'some value');</code> |
| set status code | <code>c.status(someCode);</code> |
| return text response | <code>return 'some text';</code> |
| return JSON response | <code>return someObject;</code> |
| return HTML response | <code>return someJSX;</code> |
| return "Not Found" error | <code>set.status = 404; return 'Not Found';</code> |
| redirect to another URL | <code>set.redirect = 'someURL'</code> |



Environment Variables



- Bun has built-in support for `.env` files
- Access environment variables with
`process.env.NAME` or `Bun.env.NAME`

```
NAME=Mark           .env
GREETING="Hello, ${NAME}!"
```

```
import {expect, test} from 'bun:test'; env.test.ts

test('environment variables', () => {
  expect(process.env.NAME).toBe('Mark');
  expect(Bun.env.GREETING).toBe('Hello, Mark!');
});
```

run test with
bun test



Executable Files



- Bun can compile to an executable file
- Add script in `package.json`

```
"compile": "bun build ./index.ts --outfile birthday --compile",
```



- Enter `bun compile`
- This example produces 54.9 MB executable

```
#!/usr/bin/env bun
import { formatDistance } from 'date-fns';

const now = new Date();
const birthday = new Date(now.getFullYear(), 3, 16);
if (birthday < now) birthday.setFullYear(now.getFullYear() + 1);
const distance = formatDistance(now, birthday);
console.log(distance, 'until your birthday');
```

index.ts

library is included
in executable

See <https://github.com/mvolkmann/bun-examples>
`bundle-demo/src/index.ts`





Properties & Methods

- The `Bun` global object has many properties and methods
- Particularly useful methods include
 - `Bun.nanoseconds()` returns nanoseconds since `bun` process started
 - `Bun.sleep(ms)` returns a `Promise` that resolves after `ms`
 - `Bun.sleepSync(ms)` blocks for `ms`
 - `Bun.deepEquals(obj1, obj2 [, strict])` recursively compares two objects

see examples on next slide



Bun .deepEquals

```
import { expect, test } from "bun:test";                                index.test.ts

test("arrays deep equal", () => {
  const a1 = [1, [2, 3]];
  const a2 = [1, [2, 3]];
  expect(Bun.deepEquals(a1, a2)).toBe(true);

  // Trailing undefined elements are ignored
  // unless using strict mode.
  const a3 = [1, [2, 3], undefined];
  expect(Bun.deepEquals(a1, a3)).toBe(true);
  const strict = true;
  expect(Bun.deepEquals(a1, a3, strict)).toBe(false);
});

test("objects deep equal", () => {
  const v1 = { a: 1, b: { c: 3, d: 4 } };
  const v2 = { a: 1, b: { c: 3, d: 4 } };
  expect(Bun.deepEquals(v1, v2)).toBe(true);

  // Extra properties with undefined values are ignored
  // unless using strict mode.
  const v3 = { a: 1, b: { c: 3, d: 4, e: undefined }, f: undefined };
  expect(Bun.deepEquals(v1, v3)).toBe(true);
  const strict = true;
  expect(Bun.deepEquals(v1, v3, strict)).toBe(false);
});
```

See <https://github.com/mvolkmann/bun-examples>
`deep-equals.test.ts`

Serializing Objects

- Bun can serialize and deserialize objects, even nested
- Handles circular references

```
import {serialize, deserialize} from 'bun:jsc';
import {expect, test} from 'bun:test';

test('serialize', () => {
  const dogs = [
    {name: 'Comet', breed: 'Whippet'},
    {name: 'Oscar', breed: 'German Shorthaired Pointer'}
  ];
  const buffer = serialize(dogs); // a SharedArrayBuffer
  const newDogs = deserialize(buffer);
  expect(newDogs).toStrictEqual(dogs);
});
```

See <https://github.com/mvolkmann/bun-examples>
`serialize.test.ts`

```
test('circular references', () => {
  type Node = {
    value: number;
    next: Node | null;
  };
  const node1: Node = {
    value: 1,
    next: null,
  };
  const node2: Node = {
    value: 2,
    next: node1,
  };
  node1.next = node2;

  const buffer = serialize(node1);
  const newNode = deserialize(buffer);
  expect(newNode).toStrictEqual(node1);
  expect(newNode.value).toBe(1);
  expect(newNode.next.value).toBe(2);
  expect(newNode.next.next.value).toBe(1);
});
```



Writing & Reading Files



- Bun simplifies writing and reading files

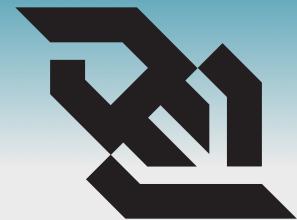
```
import {expect, test} from 'bun:test';

test('write/read file', async () => {
  const filePath = './data.txt';
  const content = 'Hello, World!';
  // The second argument to the write function
  // can be a string, Buffer, file, or
  // the awaited result of a fetch call.
  await Bun.write(filePath, content);

  const file = Bun.file(filePath);
  const actual = await file.text();
  // Other methods on File objects include
  // arrayBuffer, blob, and json.
  expect(actual).toBe(content);
});
```

See <https://github.com/mvolkmann/bun-examples>
`write-read-file.test.ts`





WebSockets

- Bun simplifies using WebSockets

```
const server = Bun.serve({
  port: 1919,
  fetch(req, server) {
    if (server.upgrade(req)) return;           upgrades HTTP connection to WebSocket connection
    return new Response('WebSocket upgrade failed', {status: 500});
  },
  websocket: {
    open(ws) {
      console.log('WebSocket opened');          can send messages to client here
    },
    message(ws, data) {
      console.log('received:', data);
      if (typeof data === 'string') {
        ws.send(data.toUpperCase());            can reply to received messages here
      }
    },
    close(ws, code, reason) {
      console.log(`WebSocket closed with code ${code} and reason "${reason}"`);
    }
  }
});

console.log('WebSocket server is listening on port', server.port);
```

See <https://github.com/mvolkmann/bun-examples>
`ws-server.ts` and `ws-client.html`



SQLite ...



- Bun supports querying and updating SQLite databases
- Must install SQLite

in macOS, `brew install sqlite` adds the `sqlite3` command
- Example session to create a database

```
sqlite3 todos.db
sqlite> create table todos(id integer primary key, text string, completed numeric);
sqlite> .schema
CREATE TABLE todos(id integer primary key auto increment, text string, completed numeric);
sqlite> insert into todos (text, completed) values('cut grass', 0);
sqlite> insert into todos (text, completed) values('buy milk', 1);
sqlite> select * from todos;
t1|cut grass|0
t2|buy milk|1
sqlite> .exit
```



... SQLite



```
import {Database} from 'bun:sqlite';
import {expect, test} from 'bun:test';
```

```
type Todo = {
  id: number;
  text: string;
  completed: number; // 0 or 1 for SQLite compatibility
};

const db = new Database('todos.db');
const getAllTodosQuery = db.query('select * from todos;');
const getTodoQuery =
  db.query('select * from todos where id = ?');
const insertTodoQuery = db.query(`insert into todos (text, completed)
  values (?, 0) returning id`);
const updateTodoPS =
  db.prepare('update todos set completed=? where id = ?');
const deleteAllTodosPS = db.prepare('delete from todos');
const deleteTodoPS =
  db.prepare('delete from todos where id = ?');
```

sqlite.test.ts

```
test('sqlite', () => {
  deleteAllTodosPS.run();

  const text = 'buy milk';
  const {id} = insertTodoQuery.get(text) as {id: number};
  expect(id).toBeGreaterThan(0);

  let todos = getAllTodosQuery.all() as Todo[];
  expect(todos.length).toBe(1);
  let [todo] = todos;
  expect(todo.text).toBe(text);

  updateTodoPS.run(1, todo.id); changes to completed

  todo = getTodoQuery.get(todo.id) as Todo;
  expect(todo.completed).toBe(1);

  deleteTodoPS.run(todo.id);

  todos = getAllTodosQuery.all() as Todo[];
  expect(todos.length).toBe(0);
});
```

See <https://github.com/mvolkmann/bun-examples>
`sqlite.test.ts`



Bun Shell



- Bun supports executing shell commands and capturing output

File below is named “**files**” with no extension, located in **PATH**, and made executable with `chmod a+x`

```
#!/usr/bin/env bun                                files
import {$} from 'bun';
import {parseArgs} from 'util';

const {values, positionals} = parseArgs({
  args: Bun.argv,
  options: {
    help: {
      type: 'boolean'
    },
    limit: {
      type: 'string'
    },
    verbose: {
      type: 'boolean'
    }
  },
  allowPositionals: true
});
```

Example usage:
`files --limit 5 --verbose ts`
outputs up to 5 file names
with extension `.ts` and
includes the extensions.

```
const {help, verbose} = values;
if (help) {
  console.log(`Usage: files [options] <extension>
Options:
  --help: Show help
  --limit: Limit number of files to display
  --verbose: Show the full file name
`);
  process.exit(0);
}
```

```
// Will be NaN if missing or invalid.
const limit = Number(values.limit);
const extension = positionals.at(-1);

let count = 0;
const lines = `$`ls *.${extension}`.lines();
for await (const line of lines) {
  if (verbose) {
    console.log(line);
  } else {
    const index = line.lastIndexOf('.');
    console.log(line.substring(0, index));
  }
  count++;
  if (count === limit) break;
}
```

See <https://github.com/mvolkmann/bun-examples files>



Foreign Function Interface (FFI)

- Bun supports calling functions implemented in many languages including C, C+, Kotlin, Rust, and Zig
- For example, build Zig code below as a library with `zig build-lib average.zig -dynamic -OReleaseFast`
- Run with `bun run index.ts`

```
pub export fn average(          average.zig
    numbers_ptr: [*]const f32,
    len: usize
) f32 {
    var sum: f32 = 0.0;
    const numbers = numbers_ptr[0..len];
    for (numbers) |number| {
        sum += number;
    }
    const float_len: f32 = @floatFromInt(len);
    return sum / float_len;
}
```

See <https://github.com/mvolkmann/bun-examples ffi>

```
index.ts
import {dlopen, FFIType, ptr, suffix} from 'bun:ffi';

// Open a dynamic library.
const path = `libaverage.${suffix}`;
const lib = dlopen(path, {
    average: {
        args: [FFIType.ptr, FFIType.i32],
        returns: FFIType.f32
    }
});

// Get a reference to the average function.
const average = lib.symbols.average;

// Create and pass a typed array.
const numbers = new Float32Array([1, 2, 3, 4]);
const result = average(ptr(numbers), numbers.length);
console.log('average is', result);
```

`dlopen` seems to have been broken recently.
See <https://github.com/oven-sh/bun/issues/11598>.

Resources

- **Bun home page** - <https://bun.sh>
- **My blog** - <https://mvolkmann.github.io/blog/> (select Bun)
- **Bun Discord server** - click  in upper-right of Bun home page



Wrap Up

- Bun has many advantages over Node and related tools
 - performance
 - CommonJS and ESM support
 - built-in support for TypeScript, JSX, SQLite, unit tests, bundling, and creating executables
 - calling functions implemented in other languages (FFI)
- Don't need to be all in ...
start using as a replacement for npm

