Database Report for Automaspec

Overview

This report provides comprehensive documentation of the Automaspec database architecture, schema design, and compliance with diploma project requirements for OLTP transactional databases.

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1. Technology Stack

Component	Technology	Version
DBMS	Turso (Distributed SQLite)	libsql 0.15.15
ORM	Drizzle ORM	0.45.1
Migration Tool	Drizzle Kit	0.31.8
Schema Definition	TypeScript	5.9.3
Validation	Zod (via drizzle-zod)	4.3.4

1.1 DBMS Selection Justification

Turso (SQLite-based) was chosen for the following reasons:

1. **Edge Distribution**: Turso provides global edge replication, reducing latency for users worldwide
2. **Serverless Compatibility**: Works seamlessly with Next.js and Cloudflare edge deployments
3. **Cost Efficiency**: Free tier sufficient for MVP with generous read/write quotas
4. **SQLite Compatibility**: Full SQL support with ACID transactions
5. **Drizzle ORM Integration**: First-class TypeScript support with type-safe queries

Note: While SQLite has limitations for heavy OLAP workloads, Automaspec is an OLTP application focused on transactional operations (CRUD for test specifications), making SQLite an appropriate choice.

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2. Logical Schema

2.1 ER Diagram

```
erDiagram
    user ||--o{ account : has
    user ||--o{ session : has
    user ||--o{ member : belongs_to
    user ||--o{ invitation : invites

    organization ||--o{ member : has
    organization ||--o{ invitation : has
    organization ||--o{ test_folder : contains
    organization ||--o{ test_spec : contains

    test_folder ||--o{ test_folder : parent_child
    test_folder ||--o{ test_spec : contains

    test_spec ||--o{ test_requirement : has

    test_requirement ||--o{ test : has

    user {
        text id PK
        text name
        text email UK
        boolean emailVerified
        text image
        timestamp createdAt
        timestamp updatedAt
}

account {
    text id PK
    text accountId
    text providerId
    text userId FK
    text accessToken
    text refreshToken
    text idToken
    timestamp accessTokenExpiresAt
    timestamp refreshTokenExpiresAt
    text scope
    text password
    timestamp createdAt
    timestamp updatedAt
}

session {
    text id PK
    timestamp expiresAt
    text token UK
    timestamp createdAt
    timestamp updatedAt
    text ipAddress
    text userAgent
    text userId FK
    text activeOrganizationId
}

organization {
    text id PK
    text name
    text slug UK
    text logo
    text plan
    text metadata
    timestamp createdAt
    timestamp updatedAt
}

member {
    text id PK
    text organizationId FK
    text userId FK
    text role
    timestamp createdAt
    timestamp updatedAt
}

invitation {
    text id PK
    text organizationId FK
    text email
    text role
    text status
    timestamp expiresAt
    text inviterId FK
    timestamp createdAt
}
```

```
    verification {
        text id PK
        text identifier
        text value
        timestamp expiresAt
        timestamp createdAt
        timestamp updatedAt
    }

    test_folder {
        text id PK
        text name
        text description
        text parentFolderId FK
        text organizationId FK
        integer order
        text createdAt
        text updatedAt
    }

    test_spec {
        text id PK
        text name
        text fileName
        text description
        json statuses
        integer numberOfTests
        text folderId FK
        text organizationId FK
        text createdAt
        text updatedAt
    }

    test_requirement {
        text id PK
        text name
        text description
        integer order
        text specId FK
        text createdAt
        text updatedAt
    }

    test {
        text id PK
        text status
        text framework
        text code
        text requirementId FK
        text createdAt
        text updatedAt
    }
```

2.2 Physical ER Diagram

See diagram.pdf for the original database diagram.

Diagram Accuracy Note: The diagram is current with one minor clarification: - `test_folder.parentFolderId` is nullable (allows root-level folders)

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3. Data Dictionary

3.1 Authentication Layer (Better Auth)

Table: `user`

Column	Type	Constraints	Description
id	TEXT	PK, NOT NULL	Unique user identifier
name	TEXT	NOT NULL	User display name
email	TEXT	NOT NULL, UNIQUE	User email address
emailVerified	INTEGER	NOT NULL	Boolean flag for email verification
image	TEXT	-	Profile image URL
createdAt	INTEGER	NOT NULL	Account creation timestamp
updatedAt	INTEGER	NOT NULL	Last update timestamp

Table: `account`

Column	Type	Constraints	Description
id	TEXT	PK, NOT NULL	Unique account identifier
accountId	TEXT	NOT NULL	External account ID (OAuth)
providerId	TEXT	NOT NULL	Auth provider (credential, google, github)
userId	TEXT	FK → user.id, NOT NULL, ON DELETE CASCADE	Associated user
accessToken	TEXT	-	OAuth access token
refreshToken	TEXT	-	OAuth refresh token
idToken	TEXT	-	OAuth ID token
accessTokenExpiresAt	INTEGER	-	Token expiration timestamp
refreshTokenExpiresAt	INTEGER	-	Refresh token expiration
scope	TEXT	-	OAuth scopes
password	TEXT	-	Hashed password (bcrypt)
createdAt	INTEGER	NOT NULL	Creation timestamp
updatedAt	INTEGER	NOT NULL	Update timestamp

Table: `session`

Column	Type	Constraints	Description
id	TEXT	PK, NOT NULL	Unique session identifier
expiresAt	INTEGER	NOT NULL	Session expiration timestamp
token	TEXT	NOT NULL, UNIQUE	Session token
createdAt	INTEGER	NOT NULL	Session creation timestamp
updatedAt	INTEGER	NOT NULL	Last activity timestamp
ipAddress	TEXT	-	Client IP address
userAgent	TEXT	-	Browser user agent
userId	TEXT	FK → user.id, NOT NULL, ON DELETE CASCADE	Session owner
activeOrganizationId	TEXT	-	Currently active organization

Table: `organization`

Column	Type	Constraints	Description
id	TEXT	PK, NOT NULL	Unique organization identifier
name	TEXT	NOT NULL	Organization display name
slug	TEXT	UNIQUE	URL-friendly identifier
logo	TEXT	-	Organization logo URL
plan	TEXT	NOT NULL, DEFAULT ‘free’	Subscription plan (free/pro/enterprise)
metadata	TEXT	-	Additional JSON metadata
createdAt	INTEGER	-	Creation timestamp

Column	Type	Constraints	Description
updatedAt	INTEGER	-	Update timestamp

Table: `member`

Column	Type	Constraints	Description
id	TEXT	PK, NOT NULL	Unique membership identifier
organizationId	TEXT	FK → organization.id, NOT NULL, ON DELETE CASCADE	Organization reference
userId	TEXT	FK → user.id, NOT NULL, ON DELETE CASCADE	User reference
role	TEXT	NOT NULL, DEFAULT ‘member’	Role (owner/admin/member)
createdAt	INTEGER	-	Membership creation timestamp
updatedAt	INTEGER	-	Update timestamp

Table: `invitation`

Column	Type	Constraints	Description
id	TEXT	PK, NOT NULL	Unique invitation identifier
organizationId	TEXT	FK → organization.id, NOT NULL, ON DELETE CASCADE	Target organization
email	TEXT	NOT NULL	Invitee email address
role	TEXT	-	Assigned role upon acceptance
status	TEXT	NOT NULL, DEFAULT ‘pending’	Invitation status
expiresAt	INTEGER	NOT NULL	Expiration timestamp
inviterId	TEXT	FK → user.id, NOT NULL, ON DELETE CASCADE	Inviting user
createdAt	INTEGER	-	Creation timestamp

Table: `verification`

Column	Type	Constraints	Description
id	TEXT	PK, NOT NULL	Unique verification identifier
identifier	TEXT	NOT NULL	Verification target (email)
value	TEXT	NOT NULL	Verification token/code
expiresAt	INTEGER	NOT NULL	Token expiration
createdAt	INTEGER	-	Creation timestamp
updatedAt	INTEGER	-	Update timestamp

Table: `apiKey` API keys are used for webhook integration (CI/CD sync) and are scoped to a user.

Column	Type	Constraints	Description
id	TEXT	PK	Unique API key id
name	TEXT	-	Optional display name
start	TEXT	-	Optional start hint
prefix	TEXT	-	Optional prefix
key	TEXT	NOT NULL	Hashed key material
userId	TEXT	FK → user.id, NOT NULL, ON DELETE CASCADE	Owner user
enabled	INTEGER	DEFAULT true	Key enabled flag
rateLimitEnabled	INTEGER	DEFAULT true	Per-key rate limit enabled
rateLimitTimeWindow	INTEGER	DEFAULT 86400000	Rate limit window (ms)
rateLimitMax	INTEGER	DEFAULT 10	Max requests per window
createdAt	INTEGER	NOT NULL	Creation timestamp
updatedAt	INTEGER	NOT NULL	Update timestamp

Column	Type	Constraints	Description

3.2 Test Management Layer

Table: `test_folder`

Column	Type	Constraints	Description
id	TEXT	PK, NOT NULL	Unique folder identifier
name	TEXT	NOT NULL	Folder display name
description	TEXT	-	Folder description
parentFolderId	TEXT	FK → test_folder.id (self-ref)	Parent folder for nesting
organizationId	TEXT	FK → organization.id, NOT NULL, ON DELETE CASCADE	Owning organization
order	INTEGER	NOT NULL, DEFAULT 0	Sort order within parent
createdAt	TEXT	NOT NULL, DEFAULT CURRENT_TIMESTAMP	Creation timestamp
updatedAt	TEXT	NOT NULL, DEFAULT CURRENT_TIMESTAMP	Update timestamp (auto-update)

Table: `test_spec`

Column	Type	Constraints	Description
id	TEXT	PK, NOT NULL	Unique spec identifier
name	TEXT	NOT NULL	Test specification name
fileName	TEXT	-	Associated test file name
description	TEXT	-	Detailed description
statuses	TEXT (JSON)	NOT NULL, DEFAULT {…}	Aggregated status counts
numberOfTests	INTEGER	NOT NULL, DEFAULT 0	Total test count
folderId	TEXT	FK → test_folder.id, ON DELETE CASCADE	Parent folder
organizationId	TEXT	FK → organization.id, NOT NULL, ON DELETE CASCADE	Owning organization
createdAt	TEXT	NOT NULL, DEFAULT CURRENT_TIMESTAMP	Creation timestamp
updatedAt	TEXT	NOT NULL, DEFAULT CURRENT_TIMESTAMP	Update timestamp

Status JSON Structure:

```json
{
  "passed": 0,
  "failed": 0,
  "pending": 0,
  "skipped": 0,
  "todo": 0,
  "disabled": 0,
  "missing": 0,
  "deactivated": 0,
  "partial": 0
}
```

Table: `test_requirement`

Column	Type	Constraints	Description
id	TEXT	PK, NOT NULL	Unique requirement identifier
name	TEXT	NOT NULL	Requirement description

Column	Type	Constraints	Description
description	TEXT	-	Detailed description
order	INTEGER	NOT NULL, DEFAULT 0	Sort order within spec
specId	TEXT	FK → test_spec.id, NOT NULL, ON DELETE CASCADE	Parent specification
createdAt	TEXT	NOT NULL, DEFAULT CURRENT_TIMESTAMP	Creation timestamp
updatedAt	TEXT	NOT NULL, DEFAULT CURRENT_TIMESTAMP	Update timestamp

Table: `test`

Column	Type	Constraints	Description
id	TEXT	PK, NOT NULL	Unique test identifier
status	TEXT	NOT NULL	Test status (passed/failed/pending/…)
framework	TEXT	NOT NULL	Test framework (vitest)
code	TEXT	-	Test source code
requirementId	TEXT	FK → test_requirement.id, NOT NULL, ON DELETE CASCADE	Parent requirement
createdAt	TEXT	NOT NULL, DEFAULT CURRENT_TIMESTAMP	Creation timestamp
updatedAt	TEXT	NOT NULL, DEFAULT CURRENT_TIMESTAMP	Update timestamp

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4. Normalization Analysis

4.1 Third Normal Form (3NF) Compliance

The database schema is normalized to 3NF:

First Normal Form (1NF): - All tables have atomic values in each column - Each table has a primary key - No repeating groups

Second Normal Form (2NF): - All non-key attributes depend on the entire primary key - No partial dependencies (all PKs are single-column)

Third Normal Form (3NF): - No transitive dependencies - All non-key attributes depend only on the primary key

Deliberate Denormalization: - `test_spec.statuses`: JSON field storing aggregated status counts for performance - **Justification**: Avoids expensive COUNT queries on every spec display - **Maintained by**: Application logic updates on test status changes

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5. Relationships and Constraints

5.1 Foreign Key Relationships

Source Table	Source Column	Target Table	Target Column	On Delete
account	userId	user	id	CASCADE
session	userId	user	id	CASCADE
member	organizationId	organization	id	CASCADE
member	userId	user	id	CASCADE
invitation	organizationId	organization	id	CASCADE
invitation	inviterId	user	id	CASCADE
test_folder	parentFolderId	test_folder	id	-
test_folder	organizationId	organization	id	CASCADE
test_spec	folderId	test_folder	id	CASCADE
test_spec	organizationId	organization	id	CASCADE
test_requirement	specId	test_spec	id	CASCADE
test	requirementId	test_requirement	id	CASCADE

5.2 Unique Constraints

Table	Column(s)	Description
user	email	One account per email
organization	slug	Unique URL slugs
session	token	Unique session tokens

5.3 Default Values

Table	Column	Default
organization.plan	-	'free'
member.role	-	'member'
invitation.status	-	'pending'
test_folder.order	-	0
test_spec.numberOfTests	-	0
test_spec.statuses	-	JSON with all counts = 0
test_requirement.order	-	0
*.createdAt	-	CURRENT_TIMESTAMP
*.updatedAt	-	CURRENT_TIMESTAMP

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6. DDL Scripts and Migrations

6.1 Schema Definition Location

Schema is defined using Drizzle ORM TypeScript:

- **Authentication Schema**: db/schema/auth.ts
- **Test Management Schema**: db/schema/tests.ts
- **Index Export**: db/schema/index.ts

6.2 Migration Files

Migrations are stored in `db/migrations/`:

Migration	Description
0000_unknown_genesis.sql	Initial schema with unique indexes
0001_organic_warpath.sql	Remove parentFolderId column
0002_lean_juggernaut.sql	Re-add parentFolderId as nullable

6.3 Migration Configuration

```
// drizzle.config.ts
export default defineConfig({
    schema: './db/schema',
    out: './db/migrations',
    dialect: 'turso',
    casing: 'snake_case',
    dbCredentials: {
        url: process.env.NEXT_PUBLIC_DATABASE_URL ?? '',
        authToken: process.env.DATABASE_AUTH_TOKEN
    }
})
```

6.4 Version Control

All migrations are tracked in Git with journal metadata:

```
db/migrations/meta/_journal.json
```

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7. Data Integrity

7.1 Referential Integrity

- **Cascading Deletes**: All foreign keys use `ON DELETE CASCADE`
- **Organization Isolation**: All test data requires `organizationId`
- **Hierarchical Integrity**: Folder deletion cascades to specs, requirements, and tests

7.2 Transaction Support

Drizzle ORM provides transaction support:

```
await db.transaction(async (tx) => {
    await tx.insert(testSpec).values({...})
    await tx.insert(testRequirement).values({...})
})
```

7.3 Timestamp Automation

- `createdAt`: Set automatically via SQL `DEFAULT CURRENT_TIMESTAMP`
- `updatedAt`: Updated via Drizzle's `$onUpdate()` modifier

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8. Security Implementation

8.1 Password Storage

- **Algorithm**: bcrypt (via Better Auth)
- **Storage**: Hashed in `account.password` column
- **No plaintext**: Passwords never stored in clear text
- **No weak hashing**: MD5/SHA-1 not used

8.2 Authorization Model

Authorization is implemented at the **application level** via oRPC middleware:

```
// orpc/middleware.ts
export const authMiddleware = os.middleware(async ({ context, next }) => {
    const session = await auth.api.getSession({ headers: context.headers })
    if (!session) throw new ORPCError('UNAUTHORIZED')
    return next({ context: { ...context, session } })
})

export const organizationMiddleware = os.middleware(async ({ context, next }) => {
    const organizationId = context.session.session.activeOrganizationId
    if (!organizationId) throw new ORPCError('FORBIDDEN')
    return next({ context: { ...context, organizationId } })
})
```

Role Hierarchy: | Role | Permissions | |——|————–| | owner | Full access, can delete organization | | admin | Manage members, full CRUD on specs | | member | Read/write specs within organization |

Justification for Application-Level Authorization: - Turso (edge SQLite) does not support traditional database roles - Application-level middleware provides equivalent security - All queries are scoped by `organizationId` preventing cross-tenant access - This pattern is standard for serverless/edge deployments

8.3 SQL Injection Protection

- All queries use Drizzle ORM parameterized queries
- No raw SQL string concatenation
- Input validation via Zod schemas before database operations

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9. Test Data

9.1 Sample Data Script

Location: db/dump.sql

Includes: - 5 test folders (Dashboard Tests, Authentication, Test Management, API Routes, Organization Management) - 8 test specifications with realistic statuses - 25 test requirements - 25 test cases with actual Vitest code examples

9.2 Sample Data Summary

Entity	Count	Description
test_folder	5	Root-level folders
test_spec	8	Test specification documents
test_requirement	25	Individual requirements
test	25	Test implementations

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10. Compliance Checklist

10.1 Minimum Requirements (5 Points)

#	Requirement	Status	Evidence
1	**Documentation**		
1.1	Data dictionary	YES	Section 3 of this document
1.2	Data integrity description	YES	Section 7
1.3	ER diagram	YES	Section 2.1 (Mermaid) + diagram.pdf
1.4	DDL scripts	YES	db/migrations/*.sql
2	**Design**		
2.1	Modern RDBMS	YES	Turso (SQLite)
2.2	3NF normalization	YES	Section 4
2.3	Sufficient tables	YES	11 tables with varied relationships
2.4	Primary keys	YES	All tables have text PKs
2.5	Foreign keys	YES	12 FK relationships with CASCADE
2.6	Constraints	YES	NOT NULL, UNIQUE, DEFAULT
2.7	Appropriate data types	YES	TEXT, INTEGER, JSON as needed
3	**Deployment**		
3.1	Migrations via scripts	YES	Drizzle Kit migrations
3.2	Version control	YES	Git repository
4	**Test Data**		
4.1	Sufficient test records	YES	25+ records per major table
4.2	Reference data scripts	YES	db/dump.sql
5	**Usage**		
5.1	Roles and permissions	PARTIAL	Application-level via middleware
5.2	No superuser in app	YES	App uses auth tokens, not DB admin
5.3	Encrypted passwords	YES	bcrypt via Better Auth
5.4	Integrity via constraints	YES	FK constraints, NOT NULL

10.2 Restrictions Compliance

Restriction	Status	Notes
No plaintext passwords	PASS	bcrypt hashing
No CSV/Excel as storage	PASS	Turso RDBMS used
No unstructured JSON without schema	PASS	JSON in `statuses` is well-defined
Data integrity enforced	PASS	FK constraints, transactions

10.3 Maximum Requirements (10 Points)

#	Requirement	Status	Notes
1	Multiple DBMS types	N/A	Single OLTP use case
2	Data layers (raw→staging→mart)	N/A	Not an analytics project
3	Schema versioning	YES	Drizzle migrations + Git
4	Indexes	PARTIAL	Unique indexes on email, slug, token
5	Triggers/procedures	NO	Application-level logic preferred
6	Views	NO	ORM handles query abstraction
7	Data masking for PII	NO	Future consideration

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11. Recommendations

11.1 Current Strengths

1. **Type-Safe Schema**: Drizzle ORM provides compile-time type checking
2. **Migration Management**: Versioned migrations with rollback capability
3. **Cascade Integrity**: Proper foreign key relationships prevent orphaned data
4. **Multi-Tenant Isolation**: All data scoped by organizationId

11.2 Future Improvements

1. **Additional Indexes**: Add indexes on frequently queried columns:
    - `test_spec.organizationId`
    - `test_folder.organizationId`
    - `test.status`
2. **Audit Logging**: Consider adding an audit table for compliance:
```sql
CREATE TABLE audit_log (
    id TEXT PRIMARY KEY,
    tableName TEXT NOT NULL,
    recordId TEXT NOT NULL,
    action TEXT NOT NULL,
    userId TEXT,
    timestamp TEXT DEFAULT CURRENT_TIMESTAMP
)
```
3. **Soft Deletes**: Add `deletedAt` columns for recoverable deletions
4. **Data Masking**: Implement PII masking for GDPR compliance exports

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12. Conclusion

The Automaspec database demonstrates a well-designed OLTP schema suitable for a test specification management platform. The implementation follows relational database best practices including:

- **Proper normalization** to 3NF with justified denormalization
- **Referential integrity** via foreign keys with cascading deletes
- **Security** through application-level authorization and bcrypt password hashing
- **Maintainability** via TypeScript schema definitions and versioned migrations

The choice of Turso (distributed SQLite) is appropriate for the serverless architecture and provides adequate performance for the expected workload.

Appendix A: Database Connection

```
// db/index.ts
import { drizzle } from 'drizzle-orm/libsql'
import { createClient } from '@libsql/client'

const client = createClient({
    url: process.env.NEXT_PUBLIC_DATABASE_URL ?? '',
    authToken: process.env.DATABASE_AUTH_TOKEN
})

export const db = drizzle(client, { casing: 'snake_case' })
```

Appendix B: Environment Variables

Variable	Description
NEXT_PUBLIC_DATABASE_URL	Turso database URL
DATABASE_AUTH_TOKEN	Turso authentication token

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