@serve.zone/containerarchive

backup and restore container based services

- readme.md for @serve.zone/containerarchive
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readme.md for @serve.zone/containerarchive

A high-performance, content-addressed incremental backup engine with built-in deduplication, encryption, compression, and Reed-Solomon error correction — powered by a Rust core with a clean TypeScript API.

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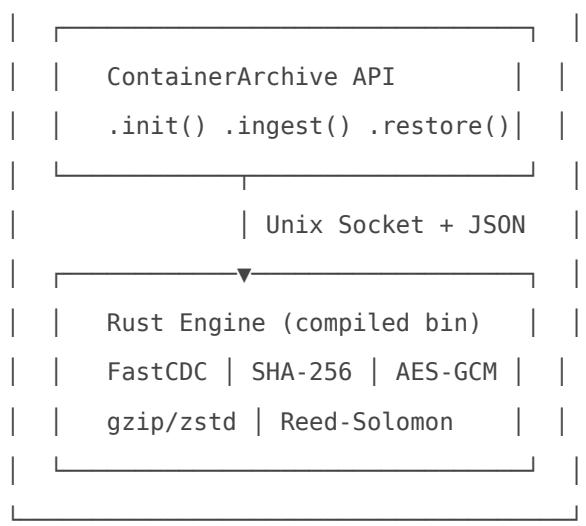
Install

```
pnpm install @serve.zone/containerarchive
```

□□ Architecture

containerarchive uses a **hybrid Rust + TypeScript architecture**. The heavy lifting — chunking, hashing, compression, encryption, pack file I/O, and parity — runs in a compiled Rust binary. The TypeScript layer provides a clean, idiomatic Node.js API and manages data streaming via Unix sockets through the `@push.rocks/smartrust` RustBridge IPC.

```
┌──────────────────────────────────────┐
│  Your Application  (TypeScript/JS)   │
```



Features

Feature	Details
Content-Defined Chunking	FastCDC with gear-based rolling hash — insertions/deletions only affect nearby boundaries
Deduplication	SHA-256 chunk addressing — identical data is stored only once across all snapshots
Compression	gzip or zstd per-chunk compression
Encryption	AES-256-GCM with Argon2id key derivation — passphrase-protected repositories
Pack Files	Chunks are batched into binary pack files with binary `.idx` indexes for fast lookup
Snapshots	Immutable point-in-time snapshots with metadata tags and multi-item support
Reed-Solomon Parity	RS(20,1) erasure coding — recover any single lost pack from a group of 20
Incremental	Only new/changed chunks are stored on each ingest
Streaming	Unix socket streaming between TypeScript and Rust for zero-copy data transfer
Multi-Item Snapshots	Bundle multiple data streams (DB dumps, config tarballs, etc.) into a single snapshot
Verification	Three-level integrity checks: quick, standard, full
Pruning	Retention policies (keep last N, days, weeks, months) with garbage collection

Feature	Details
Repair	Automatic index rebuild, stale lock removal, and parity-based pack recovery

Usage

Initialize a New Repository

```
import { ContainerArchive } from '@serve.zone/containerarchive';

// Unencrypted repository
const repo = await ContainerArchive.init('/path/to/backup-repo');

// Encrypted repository (AES-256-GCM + Argon2id)
const encryptedRepo = await ContainerArchive.init('/path/to/secure-repo', {
  passphrase: 'my-strong-passphrase',
});
```

Open an Existing Repository

```
const repo = await ContainerArchive.open('/path/to/backup-repo');

// With passphrase for encrypted repos
const repo = await ContainerArchive.open('/path/to/secure-repo', {
  passphrase: 'my-strong-passphrase',
});
```

Ingest Data (Single Stream)

```
import * as fs from 'node:fs';

const inputStream = fs.createReadStream('/path/to/database-dump.sql');
const snapshot = await repo.ingest(inputStream, {
  tags: { service: 'postgres', environment: 'production' },
```

```
  items: [{ name: 'database.sql', type: 'database-dump' }],
});

console.log(`Snapshot ${snapshot.id} created`);
console.log(`Original: ${snapshot.originalSize} bytes`);
console.log(`Stored: ${snapshot.storedSize} bytes`);
console.log(`New chunks: ${snapshot.newChunks}, Reused: ${snapshot.reusedChunks}`);
```

Multi-Item Ingest

Bundle multiple data streams into one snapshot:

```
import * as stream from 'node:stream';

const dbDump = fs.createReadStream('/tmp/pg_dump.sql');
const configTar = fs.createReadStream('/tmp/config-volumes.tar');

const snapshot = await repo.ingestMulti([
  { stream: dbDump, name: 'database.sql', type: 'database-dump' },
  { stream: configTar, name: 'config.tar', type: 'volume-tar' },
], {
  tags: { service: 'myapp', type: 'full-backup' },
});

console.log(`Items stored: ${snapshot.items.map(i => i.name).join(', ')}`);
```

Restore Data

```
// Restore an entire snapshot
const restoreStream = await repo.restore(snapshot.id);
const writeStream = fs.createWriteStream('/tmp/restored-dump.sql');
restoreStream.pipe(writeStream);

// Restore a specific item from a multi-item snapshot
const configStream = await repo.restore(snapshot.id, { item: 'config.tar' });
configStream.pipe(fs.createWriteStream('/tmp/restored-config.tar'));
```

List & Filter Snapshots

```
// List all snapshots
const allSnapshots = await repo.listSnapshots();

// Filter by tags
const prodSnapshots = await repo.listSnapshots({
  tags: { environment: 'production' },
});

// Filter by date range
const recentSnapshots = await repo.listSnapshots({
  after: '2026-03-01T00:00:00Z',
  before: '2026-03-22T00:00:00Z',
});

// Get a specific snapshot
const snap = await repo.getSnapshot('snapshot-id-here');
```

Verify Repository Integrity

```
// Quick check — validates index consistency
const quick = await repo.verify({ level: 'quick' });

// Standard — reads pack headers and validates checksums
const standard = await repo.verify({ level: 'standard' });

// Full — decompresses and re-hashes every chunk
const full = await repo.verify({ level: 'full' });

console.log(`OK: ${full.ok}`);
console.log(`Packs checked: ${full.stats.packsChecked}`);
console.log(`Chunks checked: ${full.stats.chunksChecked}`);
```

Prune Old Snapshots

```
// Dry run first
const preview = await repo.prune({ keepLast: 5, keepDays: 30 }, true);
console.log(`Would remove ${preview.removedSnapshots} snapshots, free ${preview.freedBytes}
bytes`);

// Execute for real
const result = await repo.prune({
  keepLast: 5,
  keepDays: 30,
  keepWeeks: 12,
  keepMonths: 6,
});
console.log(`Removed ${result.removedSnapshots} snapshots, ${result.removedPacks} packs`);
```

Repair & Maintenance

```
// Repair — rebuild index, remove stale locks, attempt parity recovery
const repairResult = await repo.repair();
console.log(`Index rebuilt: ${repairResult.indexRebuilt}`);
console.log(`Packs repaired via parity: ${repairResult.packsRepaired}`);

// Rebuild global index from pack .idx files
await repo.reindex();

// Remove stale locks
await repo.unlock();
await repo.unlock({ force: true }); // force-remove all locks
```

Event Subscriptions

Monitor ingest progress and errors with RxJS-based event streams:

```
// Track ingest progress
const sub = repo.on('ingest:progress', (data) => {
  console.log(`${data.operation}: ${data.percentage}% — ${data.message}`);
});
```

```
// Track completed ingests
repo.on('ingest:complete', (data) => {
  console.log(`Snapshot ${data.snapshotId} complete — ${data.newChunks} new chunks`);
});

// Track verification errors
repo.on('verify:error', (error) => {
  console.error(`Verification error in ${error.pack || error.chunk}: ${error.error}`);
});

// Unsubscribe when done
sub.unsubscribe();
```

Close the Repository

```
await repo.close();
```

□□ Repository Structure

When initialized, a repository has the following on-disk layout:

```
backup-repo/
├── config.json          # Repository config (chunking, compression, encryption, parity)
├── packs/
│   ├── data/            # Binary pack files (.pack) and indexes (.idx)
│   └── parity/          # Reed-Solomon parity packs
├── snapshots/           # JSON snapshot manifests
├── index/               # Global chunk index (hash → pack location)
├── keys/                # Encrypted key files (for passphrase-protected repos)
└── locks/               # Advisory locks for concurrent access
```

□□ How It Works

1. **Chunking** — Incoming data is split into variable-size chunks using FastCDC with a gear-based rolling hash. Chunk sizes range from 64 KB to 1 MB (avg 256 KB). Content-defined

boundaries mean that insertions or edits only affect nearby chunks, maximizing dedup across versions.
2. **Hashing** — Each chunk is hashed with SHA-256 for content addressing. If a chunk's hash already exists in the global index, it's deduplicated — only a reference is stored.
3. **Compression** — New chunks are compressed with gzip (default) or zstd before storage. Per-chunk compression flags are stored in the index.
4. **Encryption** — If a passphrase is set, a random 256-bit master key is generated, wrapped with an Argon2id-derived key, and stored in a key file. Every chunk is encrypted with AES-256-GCM using a unique nonce.
5. **Packing** — Compressed (and optionally encrypted) chunks are appended into binary pack files (~8 MB target). Each pack has an associated `.idx` file with chunk offsets, sizes, and flags for O(1) lookup.
6. **Parity** — After every group of 20 data packs, a Reed-Solomon RS(20,1) parity pack is generated. If any single pack in the group is lost or corrupted, it can be fully reconstructed.
7. **Snapshots** — A JSON manifest records the chunk list, tags, sizes, and item metadata. Snapshots are immutable — pruning removes snapshots but never alters existing pack data in-place.
8. **Restore** — The snapshot manifest is read, chunks are looked up in the global index, fetched from pack files, decompressed, decrypted if needed, and streamed back in order via a Unix socket.

□□ API Reference

`ContainerArchive`

Method	Description
`static init(path, options?)`	Create a new repository. Returns `Promise<ContainerArchive>`
`static open(path, options?)`	Open an existing repository. Returns `Promise<ContainerArchive>`
`ingest(stream, options?)`	Ingest a single data stream. Returns `Promise<ISnapshot>`
`ingestMulti(items, options?)`	Ingest multiple streams as one snapshot. Returns `Promise<ISnapshot>`
`restore(snapshotId, options?)`	Restore a snapshot. Returns `Promise<ReadableStream>`
`listSnapshots(filter?)`	List snapshots with optional tag/date filtering. Returns `Promise<ISnapshot[]>`
`getSnapshot(id)`	Get a specific snapshot. Returns `Promise<ISnapshot>`
`verify(options?)`	Verify repository integrity (quick/standard/full). Returns `Promise<IVerifyResult>`

Method	Description
`prune(retention, dryRun?)`	Remove old snapshots and garbage-collect packs. Returns `Promise<IPruneResult>`
`repair()`	Rebuild index, remove stale locks, attempt parity recovery. Returns `Promise<IRepairResult>`
`reindex()`	Rebuild the global index from pack `.idx` files. Returns `Promise<void>`
`unlock(options?)`	Remove advisory locks. Returns `Promise<void>`
`on(event, handler)`	Subscribe to events. Returns `Subscription`
`close()`	Close the repository and terminate the Rust process. Returns `Promise<void>`

Key Interfaces

```
interface ISnapshot {
  id: string;
  version: number;
  createdAt: string;
  tags: Record<string, string>;
  originalSize: number;
  storedSize: number;
  chunkCount: number;
  newChunks: number;
  reusedChunks: number;
  items: ISnapshotItem[];
}

interface IRetentionPolicy {
  keepLast?: number;
  keepDays?: number;
  keepWeeks?: number;
  keepMonths?: number;
}

interface IVerifyResult {
  ok: boolean;
  errors: IVerifyError[];
  stats: {
```

```
    packsChecked: number;
    chunksChecked: number;
    snapshotsChecked: number;
  };
}
```

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changelog.md for @serve.zone/containerarchive

2026-03-23 - 0.1.3 - fix(repo)

no changes to commit

2026-03-23 - 0.1.2 - fix(package)

rename package namespace from @push.rocks to @serve.zone

- Updates the published package name to @serve.zone/containerarchive
- Aligns repository, bugs, homepage, README usage examples, and generated commit metadata with the new namespace

2026-03-23 - 0.1.1 - fix(repo)

no changes to commit

2026-03-22 - 0.1.0 - feat(rust-core)

add zstd chunk compression support and rewrite partially referenced packs during prune

- introduce selectable gzip or zstd compression with per-chunk flags persisted in the global index
- restore and verify now detect the compression algorithm from stored flags and validate encrypted chunk handling

- prune now rewrites partially referenced packs to reclaim space and exposes rewritten pack counts in the API
- add coverage for zstd repository ingest, restore, and verify flows
- add project readme documentation

2026-03-22 - 0.0.2 - fix(repository)

no changes to commit

2026-03-22 - 0.0.1 - ingest and recovery

Expanded the backup engine with parity-integrated ingest and faster encrypted restore paths.

- Wired parity generation into the ingest pipeline with automatic triggering after every configured number of packs
- Stored `ParityConfig` in repository `config.json`
- Optimized encrypted restore by storing nonces in global index entries, avoiding IDX re-reads on the fast path with cache fallback
- Improved repair to attempt parity-based pack reconstruction before reindexing

2026-03-21 - 0.0.1 - initial engine and parity foundations

Initial release of the content-addressed incremental backup engine, including core architecture and early parity-enabled ingest capabilities.

- Implemented a Rust-first backup engine with a TypeScript facade using the smartproxy/smartstorage pattern
- Added core backup features including FastCDC chunking, SHA-256 hashing, gzip compression, AES-256-GCM encryption with Argon2id, binary pack files, global index, snapshots, locking, verification, pruning, and repair
- Added Unix socket streaming between TypeScript and Rust through `@push.rocks/smartrust` RustBridge IPC for ingest and restore
- Introduced multi-item ingest, processing multiple items sequentially into a single snapshot with separate chunk lists

- Added Reed-Solomon parity support for pack file groups to enable single-pack-loss recovery
- Extended repair to attempt parity-based recovery for missing pack files
- Verified the implementation with passing integration and Rust unit tests