readme.md for @push.rocks/smartmta

A high-performance, enterprise-grade Mail Transfer Agent (MTA) built from scratch in TypeScript with a Rust-powered SMTP engine — no nodemailer, no shortcuts. Automatic MX record discovery means you just call `sendEmail()` and smartmta figures out where to deliver.

Issue Reporting and Security

For reporting bugs, issues, or security vulnerabilities, please visit community.foss.global/. This is the central community hub for all issue reporting. Developers who sign and comply with our contribution agreement and go through identification can also get a code.foss.global/ account to submit Pull Requests directly.

Install

```
pnpm install @push.rocks/smartmta
# or
npm install @push.rocks/smartmta
```

After installation, run `pnpm build` to compile the Rust binary (`mailer-bin`). The Rust binary is **required** — `smartmta` will not start without it.

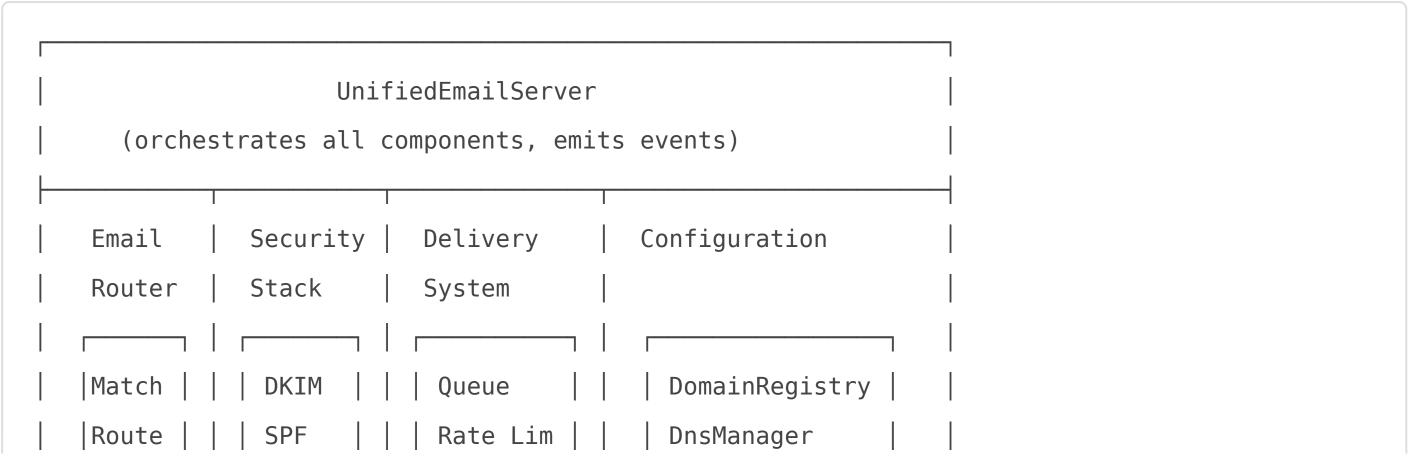
Overview

`@push.rocks/smartmta` is a **complete mail server solution** — SMTP server, SMTP client, email security, content scanning, and delivery management — all built with a custom SMTP implementation. The SMTP engine runs as a Rust binary for maximum performance, communicating with the TypeScript orchestration layer via JSON-over-stdin/stdout IPC.

⚡ What's Inside

Module	What It Does
Rust SMTP Server	High-performance SMTP engine in Rust — TCP/TLS listener, STARTTLS, AUTH, pipelining, per-connection rate limiting
Rust SMTP Client	Outbound delivery with connection pooling, retry logic, TLS negotiation, DKIM signing — all in Rust
DKIM	Key generation, signing, and verification — per domain, with automatic rotation
SPF	Full SPF record validation via Rust
DMARC	Policy enforcement and verification
Email Router	Pattern-based routing with priority, forward/deliver/reject/process actions
Bounce Manager	Automatic bounce detection via Rust, classification (hard/soft), and suppression tracking
Content Scanner	Spam, phishing, malware, XSS, and suspicious link detection — powered by Rust
IP Reputation	DNSBL checks, proxy/TOR/VPN detection, risk scoring via Rust
Rate Limiter	Hierarchical rate limiting (global, per-domain, per-IP)
Delivery Queue	Persistent queue with exponential backoff retry
Template Engine	Email templates with variable substitution
Domain Registry	Multi-domain management with per-domain configuration
DNS Manager	Automatic DNS record management (MX, SPF, DKIM, DMARC)

Architecture



```
│  │ Act  │ │ │ DMARC │ │ │ Retry    │ │  │ DKIMCreator    │   │
│  └──────┘ │ │ IPRep │ │ └─────────┘ │  │ Templates      │   │
│           │ │ Scan  │ │             │  └────────────────┘   │
│           │ └───────┘ │             │                       │
├───────────┴───────────┴─────────────┴───────────────────────┤
│            Rust Security Bridge (smartrust IPC)             │
├─────────────────────────────────────────────────────────────┤
│                  Rust Acceleration Layer                    │
│  ┌──────────────┐  ┌───────────────┐  ┌──────────────────┐  │
│  │ mailer-smtp  │  │mailer-security│  │   mailer-core    │  │
│  │ SMTP Server  │  │DKIM/SPF/DMARC │  │ Types/Validation │  │
│  │ SMTP Client  │  │IP Rep/Content │  │ MIME/Bounce      │  │
│  │ TLS/AUTH     │  │   Scanning    │  │   Detection      │  │
│  └──────────────┘  └───────────────┘  └──────────────────┘  │
└─────────────────────────────────────────────────────────────┘
```

Data flow for inbound mail:

1. Rust SMTP server accepts the connection and handles the full SMTP protocol
2. On `DATA` completion, Rust runs the security pipeline **in-process** (DKIM/SPF/DMARC verification, content scanning, IP reputation check) — zero IPC round-trips
3. Rust emits an `emailReceived` event via IPC with pre-computed security results attached
4. TypeScript processes the email (routing decisions using the pre-computed results, delivery)
5. Rust sends the final SMTP response to the client

Data flow for outbound mail:

1. TypeScript constructs the email and calls `sendEmail()` (defaults to MTA mode)
2. MTA mode automatically resolves MX records for each recipient domain, sorts by priority, and groups recipients for efficient delivery
3. Sends to Rust via IPC — Rust builds the RFC 2822 message, signs with DKIM, and delivers via its SMTP client with connection pooling
4. Result (accepted/rejected recipients, server response) returned to TypeScript

Usage

Setting Up the Email Server

The central entry point is `UnifiedEmailServer`, which orchestrates the Rust SMTP server, routing, security, and delivery:

```
import { UnifiedEmailServer } from '@push.rocks/smartmta';

const emailServer = new UnifiedEmailServer(dcRouterRef, {
  // Ports to listen on (465 = implicit TLS, 25/587 = STARTTLS)
  ports: [25, 587, 465],
  hostname: 'mail.example.com',

  // Multi-domain configuration
  domains: [
    {
      domain: 'example.com',
      dnsMode: 'external-dns',
      dkim: {
        selector: 'default',
        keySize: 2048,
        rotateKeys: true,
        rotationInterval: 90,
      },
      rateLimits: {
        outbound: { messagesPerMinute: 100 },
        inbound: { messagesPerMinute: 200, connectionsPerIp: 20 },
      },
    },
  ],

  // Routing rules (evaluated by priority, highest first)
  routes: [
    {
      name: 'catch-all-forward',
      priority: 10,
      match: {
        recipients: '*@example.com',
      },
      action: {
        type: 'forward',
        forward: {
          host: 'internal-mail.example.com',
```

```
          port: 25,
        },
      },
    },
    {
      name: 'reject-spam-senders',
      priority: 100,
      match: {
        senders: '*@spamdomain.com',
      },
      action: {
        type: 'reject',
        reject: {
          code: 550,
          message: 'Sender rejected by policy',
        },
      },
    },
  ],

  // Authentication settings for the SMTP server
  auth: {
    required: false,
    methods: ['PLAIN', 'LOGIN'],
    users: [{ username: 'outbound', password: 'secret' }],
  },

  // TLS certificates
  tls: {
    certPath: '/etc/ssl/mail.crt',
    keyPath: '/etc/ssl/mail.key',
  },

  maxMessageSize: 25 * 1024 * 1024, // 25 MB
  maxClients: 500,
});

// start() boots the Rust SMTP server, security bridge, DNS records, and delivery queue
await emailServer.start();
```

> **Note:** `start()` will throw if the Rust binary is not compiled. Run `pnpm build` first.

Sending Emails (Automatic MX Discovery)

The recommended way to send email is `sendEmail()`. It defaults to **MTA mode**, which automatically resolves MX records for each recipient domain via DNS — you don't need to know the destination mail server:

```
import { Email, UnifiedEmailServer } from '@push.rocks/smartmta';

// Build an email
const email = new Email({
  from: 'sender@example.com',
  to: ['alice@gmail.com', 'bob@company.org'],
  subject: 'Hello from smartmta! ',
  text: 'Plain text body',
  html: '<h1>Hello!</h1><p>HTML body with <strong>formatting</strong></p>',
  priority: 'high',
  attachments: [
    {
      filename: 'report.pdf',
      content: pdfBuffer,
      contentType: 'application/pdf',
    },
  ],
});

// Send — MTA mode auto-discovers MX servers for gmail.com and company.org
const emailId = await emailServer.sendEmail(email);

// Optionally specify a delivery mode explicitly
const emailId2 = await emailServer.sendEmail(email, 'mta');
```

In MTA mode, smartmta:

- Resolves MX records for each recipient domain (e.g. `gmail.com`, `company.org`)

- Sorts MX hosts by priority (lowest = highest priority per RFC 5321)
- Tries each MX host in order until delivery succeeds
- Falls back to the domain's A record if no MX records exist
- Groups recipients by domain for efficient batch delivery
- Signs outbound mail with DKIM automatically

Delivery Modes

`sendEmail()` accepts a mode parameter that controls how the email is delivered:

```
public async sendEmail(
  email: Email,
  mode: EmailProcessingMode = 'mta',  // 'mta' | 'forward' | 'process'
  route?: IEmailRoute,
  options?: {
    skipSuppressionCheck?: boolean;
    ipAddress?: string;
    isTransactional?: boolean;
  }
): Promise<string>
```

Mode	Description
`mta` (default)	**Auto MX discovery** — resolves MX records via DNS, delivers directly to the recipient's mail server. No relay configuration needed.
`forward`	**Relay delivery** — forwards the email to a configured SMTP host (e.g. an internal mail gateway or third-party relay).
`process`	**Scan + deliver** — runs the content scanning / security pipeline first, then delivers via auto MX resolution.

Direct SMTP Delivery (Low-Level)

For cases where you know the exact target SMTP server (e.g. relaying to a specific host), use the lower-level `sendOutboundEmail()`:

```
// Send directly to a known SMTP server (bypasses MX resolution)
const result = await emailServer.sendOutboundEmail('smtp.example.com', 587, email, {
  auth: { user: 'sender@example.com', pass: 'your-password' },
  dkimDomain: 'example.com',
```

```
  dkimSelector: 'default',
});

console.log(`Accepted: ${result.accepted.join(', ')}`);
console.log(`Response: ${result.response}`);
// -> Accepted: recipient@example.com
// -> Response: 2.0.0 Ok: queued
```

The `sendOutboundEmail` method:

- Automatically resolves DKIM keys from the `DKIMCreator` for the specified domain
- Uses connection pooling in Rust — reuses TCP/TLS connections across sends
- Configurable connection and socket timeouts via `outbound` options on the server

DKIM Signing & Key Management

DKIM key management is handled by `DKIMCreator`, which generates, stores, and rotates keys per domain. Signing is performed automatically by the Rust SMTP client during outbound delivery:

```
import { DKIMCreator } from '@push.rocks/smartmta';

const dkimCreator = new DKIMCreator('/path/to/keys', storageManager);

// Auto-generate keys if they don't exist
await dkimCreator.handleDKIMKeysForDomain('example.com');

// Get the DNS record you need to publish
const dnsRecord = await dkimCreator.getDNSRecordForDomain('example.com');
console.log(dnsRecord);
// -> { type: 'TXT', name: 'default._domainkey.example.com', value: 'v=DKIM1; k=rsa; p=...' }

// Check if keys need rotation
const needsRotation = await dkimCreator.needsRotation('example.com', 'default', 90);
if (needsRotation) {
  const newSelector = await dkimCreator.rotateDkimKeys('example.com', 'default', 2048);
  console.log(`Rotated to selector: ${newSelector}`);
}
```

When `UnifiedEmailServer.start()` is called:

- DKIM keys are generated or loaded for every configured domain

- Signing is applied to all outbound mail via the Rust security bridge
- Key rotation is checked automatically based on your `rotationInterval` config

🛡️ Email Authentication (SPF, DKIM, DMARC)

All verification is powered by the Rust binary. For inbound mail, `UnifiedEmailServer` runs the full security pipeline **automatically** — DKIM, SPF, DMARC, content scanning, and IP reputation in a single Rust pass. Results are attached as headers (`Received-SPF`, `X-DKIM-Result`, `X-DMARC-Result`).

You can also use the individual verifiers directly:

```
import { DKIMVerifier, SpfVerifier, DmarcVerifier } from '@push.rocks/smartmta';

// SPF verification
const spfVerifier = new SpfVerifier();
const spfResult = await spfVerifier.verify(email, senderIP, heloDomain);
// -> { result: 'pass' | 'fail' | 'softfail' | 'neutral' | 'none', domain, ip }

// DKIM verification
const dkimVerifier = new DKIMVerifier();
const dkimResult = await dkimVerifier.verify(rawEmailContent);
// -> [{ is_valid: true, domain: 'example.com', selector: 'default', status: 'pass' }]

// DMARC verification
const dmarcVerifier = new DmarcVerifier();
const dmarcResult = await dmarcVerifier.verify(email, spfResult, dkimResult);
// -> { action: 'pass' | 'quarantine' | 'reject', policy, spfDomainAligned, dkimDomainAligned
}
```

🔀 Email Routing

Pattern-based routing engine with priority ordering and flexible match criteria. Routes are evaluated by priority (highest first):

```
import { EmailRouter } from '@push.rocks/smartmta';

const router = new EmailRouter([
```

```
{
  name: 'admin-mail',
  priority: 100,
  match: {
    recipients: 'admin@example.com',
    authenticated: true,
  },
  action: {
    type: 'deliver',
  },
},
{
  name: 'external-forward',
  priority: 50,
  match: {
    recipients: '*@example.com',
    sizeRange: { max: 10 * 1024 * 1024 }, // under 10MB
  },
  action: {
    type: 'forward',
    forward: {
      host: 'backend-mail.internal',
      port: 25,
      preserveHeaders: true,
    },
  },
},
{
  name: 'process-with-scanning',
  priority: 10,
  match: {
    recipients: '*@*',
  },
  action: {
    type: 'process',
    process: {
      scan: true,
      dkim: true,
      queue: 'normal',
    },
```

```
    },
  },
]);

// Evaluate routes against an email context
const matchedRoute = await router.evaluateRoutes(emailContext);
```

Route Action Types

Action	Description
`forward`	Forward the email to another SMTP server via the Rust SMTP client
`deliver`	Queue for local MTA delivery
`process`	Queue for processing (with optional content scanning and DKIM signing)
`reject`	Reject with a configurable SMTP error code and message

Match Criteria

Criterion	Description
`recipients`	Glob patterns for recipient addresses (`*@example.com`)
`senders`	Glob patterns for sender addresses
`clientIp`	IP addresses or CIDR ranges
`authenticated`	Require authentication status
`headers`	Match specific headers (string or RegExp)
`sizeRange`	Message size constraints (`{ min?, max? }`)
`subject`	Subject line pattern (string or RegExp)
`hasAttachments`	Filter by attachment presence

󰀀 Rate Limiting

Hierarchical rate limiting to protect your server and maintain deliverability:

```
import { Delivery } from '@push.rocks/smartmta';
const { UnifiedRateLimiter } = Delivery;

const rateLimiter = new UnifiedRateLimiter({
```

```
  global: {
    maxMessagesPerMinute: 1000,
    maxRecipientsPerMessage: 500,
    maxConnectionsPerIP: 20,
    maxErrorsPerIP: 10,
    maxAuthFailuresPerIP: 5,
    blockDuration: 600000, // 10 minutes
  },
  domains: {
    'example.com': {
      maxMessagesPerMinute: 100,
      maxRecipientsPerMessage: 50,
    },
  },
});

// Check before sending
const allowed = rateLimiter.checkMessageLimit(
  'sender@example.com',
  '192.168.1.1',
  recipientCount,
  undefined,
  'example.com'
);

if (!allowed.allowed) {
  console.log(`Rate limited: ${allowed.reason}`);
}
```

□□ Bounce Management

Automatic bounce detection (via Rust), classification, and suppression tracking:

```
import { Core } from '@push.rocks/smartmta';
const { BounceManager } = Core;

const bounceManager = new BounceManager();

// Process an SMTP failure
```

```
const bounce = await bounceManager.processSmtpFailure(
  'recipient@example.com',
  '550 5.1.1 User unknown',
  { originalEmailId: 'msg-123' }
);
// -> { bounceType: 'invalid_recipient', bounceCategory: 'hard', ... }

// Check if an address is suppressed due to bounces
const suppressed = bounceManager.isEmailSuppressed('recipient@example.com');

// Manage the suppression list
bounceManager.addToSuppressionList('bad@example.com', 'repeated hard bounces');
bounceManager.removeFromSuppressionList('recovered@example.com');
```

📧 Email Templates

Template engine with variable substitution for transactional and notification emails:

```
import { Core } from '@push.rocks/smartmta';
const { TemplateManager } = Core;

const templates = new TemplateManager({
  from: 'noreply@example.com',
  footerHtml: '<p>&copy; 2026 Example Corp</p>',
});

// Register a template
templates.registerTemplate({
  id: 'welcome',
  name: 'Welcome Email',
  description: 'Sent to new users',
  from: 'welcome@example.com',
  subject: 'Welcome, {{name}}!',
  bodyHtml: '<h1>Welcome, {{name}}!</h1><p>Your account is ready.</p>',
  bodyText: 'Welcome, {{name}}! Your account is ready.',
  category: 'transactional',
});

// Create an Email object from the template
```

```
const email = await templates.createEmail('welcome', {
  to: 'newuser@example.com',
  variables: { name: 'Alice' },
});
```

🌐 DNS Management

When `UnifiedEmailServer.start()` is called, it automatically ensures MX, SPF, DKIM, and DMARC records are in place for all configured domains:

```
const emailServer = new UnifiedEmailServer(dcRouterRef, {
  hostname: 'mail.example.com',
  domains: [
    {
      domain: 'example.com',
      dnsMode: 'external-dns', // managed via Cloudflare API
    },
  ],
  // ... other config
});

// DNS records are set up automatically on start:
//   - MX records pointing to your mail server
//   - SPF TXT records authorizing your server IP
//   - DKIM TXT records with public keys from DKIMCreator
//   - DMARC TXT records with your policy
await emailServer.start();
```

🦀 Rust Acceleration Layer

Performance-critical operations are implemented in Rust and communicate with the TypeScript runtime via `@push.rocks/smartrust` (JSON-over-stdin/stdout IPC). The Rust workspace lives at `rust/` with four crates:

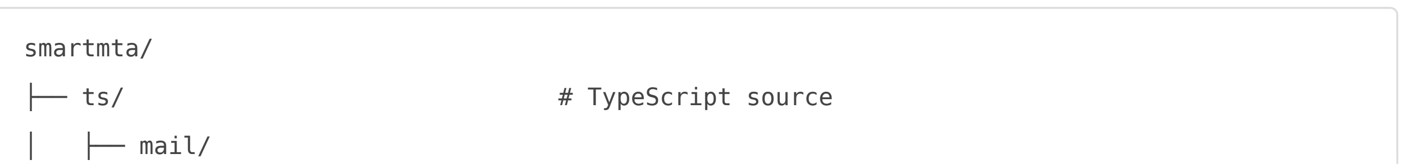
Crate	Status	Purpose
`mailer-core`	✅ Complete (26 tests)	Email types, validation, MIME building, bounce detection

Crate	Status	Purpose
`mailer-security`	Complete (22 tests)	DKIM sign/verify, SPF, DMARC, IP reputation/DNSBL, content scanning
`mailer-smtp`	Complete (106 tests)	Full SMTP protocol engine — TCP/TLS server + client, STARTTLS, AUTH, pipelining, connection pooling, in-process security pipeline
`mailer-bin`	Complete	CLI + smartrust IPC bridge — wires everything together

What Runs Where

Operation	Runs In	Why
SMTP server (port listening, protocol, TLS)	Rust	Performance, memory safety, zero-copy parsing
SMTP client (outbound delivery, connection pooling)	Rust	Connection management, TLS negotiation
DKIM signing & verification	Rust	Crypto-heavy, benefits from native speed
SPF validation	Rust	DNS lookups with async resolver
DMARC policy checking	Rust	Integrates with SPF/DKIM results
IP reputation / DNSBL	Rust	Parallel DNS queries
Content scanning (text patterns)	Rust	Regex engine performance
Bounce detection (pattern matching)	Rust	Regex engine performance
Email validation & MIME building	Rust	Parsing performance
Email routing & orchestration	TypeScript	Business logic, flexibility
Delivery queue & retry	TypeScript	State management, persistence
Template rendering	TypeScript	String interpolation
Domain & DNS management	TypeScript	API integrations

Project Structure



```
smartmta/
├── ts/                                 # TypeScript source
│   ├── mail/
```

```
│   │   ├── core/                    # Email, EmailValidator, BounceManager, TemplateManager
│   │   ├── delivery/                # DeliveryQueue, DeliverySystem, RateLimiter
│   │   ├── routing/                 # UnifiedEmailServer, EmailRouter, DomainRegistry,
DnsManager
│   │   └── security/                # DKIMCreator, DKIMVerifier, SpfVerifier, DmarcVerifier
│   └── security/                    # ContentScanner, IPReputationChecker, RustSecurityBridge
├── rust/                            # Rust workspace
│   └── crates/
│       ├── mailer-core/             # Email types, validation, MIME, bounce detection
│       ├── mailer-security/         # DKIM, SPF, DMARC, IP reputation, content scanning
│       ├── mailer-smtp/             # Full SMTP server + client (TCP/TLS, rate limiting,
pooling)
│       └── mailer-bin/              # CLI + smartrust IPC bridge
├── test/                            # Test suite (116 TypeScript + 154 Rust tests)
├── dist_ts/                         # Compiled TypeScript output
└── dist_rust/                       # Compiled Rust binaries
```

🧪 Testing

The project has comprehensive test coverage with both unit and end-to-end tests:

```
# Build Rust binary first
pnpm build

# Run all tests
pnpm test

# Run specific test files
tstest test/test.e2e.server-lifecycle.node.ts --verbose --timeout 60
tstest test/test.e2e.inbound-smtp.node.ts --verbose --timeout 60
tstest test/test.e2e.routing-actions.node.ts --verbose --timeout 60
tstest test/test.e2e.outbound-delivery.node.ts --verbose --timeout 60
```

E2E tests exercise the full pipeline — starting `UnifiedEmailServer`, connecting via raw TCP sockets, sending SMTP transactions, verifying routing actions, and testing outbound delivery through a mock SMTP receiver.

API Reference

Exported Classes (top-level)

Class	Description
`UnifiedEmailServer`	Main entry point — orchestrates SMTP server, routing, security, and delivery
`Email`	Email message class with validation, attachments, headers, and RFC 822 serialization
`EmailRouter`	Pattern-based route matching and evaluation engine
`DomainRegistry`	Multi-domain configuration manager
`DnsManager`	Automatic DNS record management
`DKIMCreator`	DKIM key generation, storage, rotation
`DKIMVerifier`	DKIM signature verification (delegates to Rust)
`SpfVerifier`	SPF record validation (delegates to Rust)
`DmarcVerifier`	DMARC policy enforcement (delegates to Rust)

Namespaced Exports

Namespace	Classes
`Core`	`Email`, `EmailValidator`, `TemplateManager`, `BounceManager`
`Delivery`	`UnifiedDeliveryQueue`, `MultiModeDeliverySystem`, `DeliveryStatus`, `UnifiedRateLimiter`

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