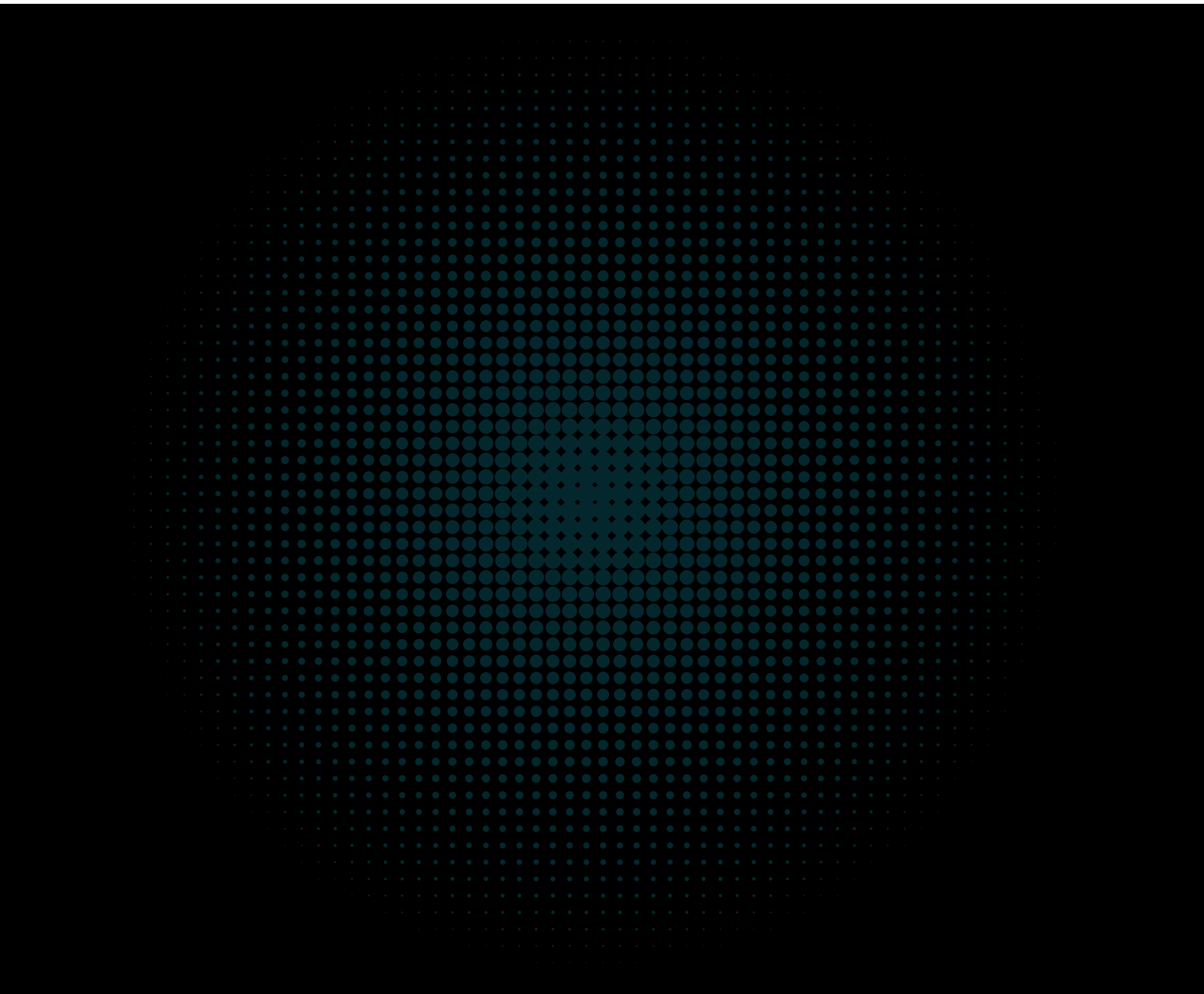
cmta.

CMTAT-FIX Specification

Functional specifications for integrating FIX (Financial Information eXchange) descriptors into CMTAT tokens on Ethereum and EVM-compatible blockchains.

CMTAT-FIX version: v0.2.0
First published: April 2026



CMTAT-FIX

> This project has not undergone an audit and is provided as-is without any warranties.

Integration of FIX descriptor support for CMTAT (The Capital Markets and Technology Association Token) contracts.

This repository provides a modular engine system that enables CMTAT tokens to store, manage, and verify FIX (Financial Information eXchange) protocol descriptors on-chain.

This project was initially developed by Nethermind in collaboration with CMTA and Taurus.

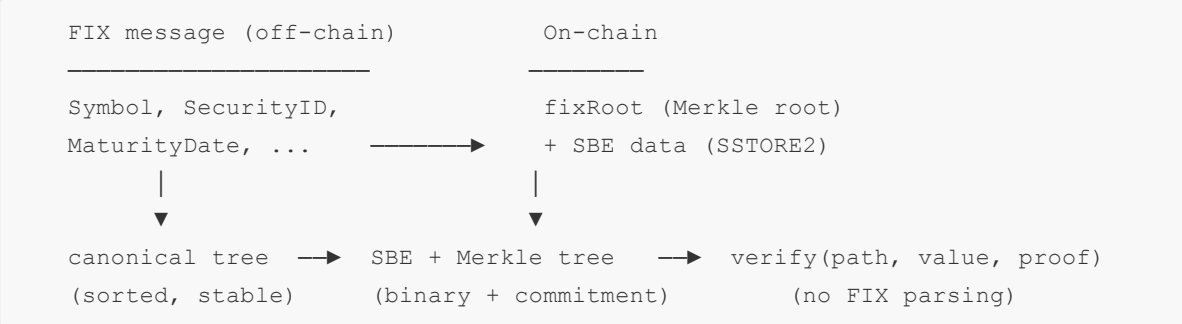
Overview

CMTAT-FIX extends CMTAT tokens with FIX descriptor capabilities through a dedicated engine architecture. The system allows tokens to:

- Store FIX descriptor data using SBE (Simple Binary Encoding) format
- Commit to descriptor structures via Merkle roots
- Verify field values against committed descriptors using Merkle proofs
- Deploy descriptor data efficiently using SSTORE2 pattern

How FIX messages are used to identify assets?

FIX (Financial Information eXchange) is the standard way traditional finance encode messages including describing instruments (e.g. Symbol, SecurityID, MaturityDate, Parties). Here, a **descriptor** is a FIX message (or subset) that identifies an asset. It is turned into a single, deterministic form, then committed on-chain so anyone can prove specific fields without the contract ever parsing FIX.



The contract stores only the Merkle root and SBE data; it never parses FIX. Verification is a separate call: callers supply path, value, and Merkle proof, and the contract checks the proof against the stored root.

Details (canonicalization, SBE encoding, Merkle rules, verification) are in the FIX Descriptor Specification.

Terminology

Term	Meaning
Descriptor	The FIX message subset describing instrument characteristics (e.g. Symbol, SecurityID, MaturityDate, Parties).
Canonical form	Deterministic representation (sorted keys, consistent encoding) so all implementations agree.
Path	Location of a field in the tree (e.g. scalar `[55]` for Symbol, or `[453, 0, 448]` for first Party's PartyID). On-chain, the path is passed as CBOR-encoded bytes (`pathCBOR`).
SBE	Simple Binary Encoding; efficient binary format for the descriptor.
fixRoot	Merkle root committing to all descriptor fields; stored onchain.
Merkle proof	Sibling hashes proving a (path, value) leaf under the stored fixRoot.

Architecture

The repo is split into an **engine** (reusable for any compliant token) and **CMTAT integration** (module + example token).

Project structure

```
CMTAT-FIX/
├── .github/
│   └── workflows/
│       └── lint.yml                        # CI: forge lint (SBE/CBOR findings
filtered)
├── src/
│   ├── engine/                             # Engine (reusable; works with any
compliant token)
│   │   ├── FixDescriptorEngine.sol
│   │   ├── FixDescriptorEngineBase.sol
│   │   ├── interfaces/
│   │   │   └── IFixDescriptorEngine.sol
│   │   └── modules/
│   │       ├── FixDescriptorModule.sol
│   │       └── VersionModule.sol
│   ├── FixDescriptorEngineModule.sol       # CMTAT module (reusable)
│   └── CMTAT/                              # Example CMTAT token using the
module
│       └── CMTATWithFixDescriptor.sol
├── lib/
│   └── CMTAT/                              # CMTAT submodule
├── test/
│   ├── CMTATWithFixDescriptor.t.sol
│   ├── FixDescriptorEngine.t.sol
│   ├── FixDescriptorEngineBase.t.sol
│   └── FixDescriptorEngineModule.t.sol
```

```
├── scripts/
│   └── DeployCMTATWithFixDescriptor.s.sol
├── foundry.toml
└── package.json
```

Engine (reusable)

The **FixDescriptorEngine** works with **any token** that implements `IFixDescriptorEngine` (e.g. `token()`); it is not tied to CMTAT. All engine code lives in `src/engine/`:

- **FixDescriptorEngine** / **FixDescriptorEngineBase** – Main contracts; one instance per token
- **interfaces/IFixDescriptorEngine.sol** – Minimum interface for binding
- **modules/FixDescriptorModule.sol** – Core descriptor logic (SBE, SSTORE2, Merkle verification)
- **modules/VersionModule.sol** – Version tracking

CMTAT integration

- **FixDescriptorEngineModule** (`src/`) – CMTAT module that plugs the engine into a CMTAT token (ERC-7201 storage, engine reference); reusable by any CMTAT token
- **CMTATWithFixDescriptor** (`src/CMTAT/`) – Example CMTAT token using the module; forwards `IFixDescriptor` to the bound engine

Design Principles

- **One Engine Per Token**: Each `FixDescriptorEngine` instance is bound to a single token at construction
- **Modular Architecture**: Engine is bound via the module (`setFixDescriptorEngine`); it can be **set or replaced**, not cleared back to `address(0)` once bound
- **Gas Efficient**: Uses SSTORE2 for efficient on-chain data storage
- **Verifiable**: Merkle tree commitments enable cryptographic verification of descriptor fields

Dependencies

- **CMTAT** v3.2.0 - Core token framework
- **@fixdescriptorkit/contracts** ^1.0.2 - FIX descriptor library
- **@openzeppelin/contracts-upgradeable** 5.6.0 - Upgradeable contracts

Foundry configuration

See `foundry.toml`:

- Solidity: 0.8.34
- EVM version: `Prague`
- Lint:
  - `asm-keccak256` excluded (use of `keccak256()` is intentional)
  - We keep SBE & CBOR in identifiers per the Solidity style guide and the official specs: SBE, CBOR.

Installation

Prerequisites

- Foundry (for development and testing)
- Node.js (for npm dependencies)

Setup

1. Clone the repository with submodules:

```
git clone git@github.com:CMTA/CMTAT-FIX.git --recurse-submodules
cd CMTAT-FIX
```

2. Install npm dependencies:

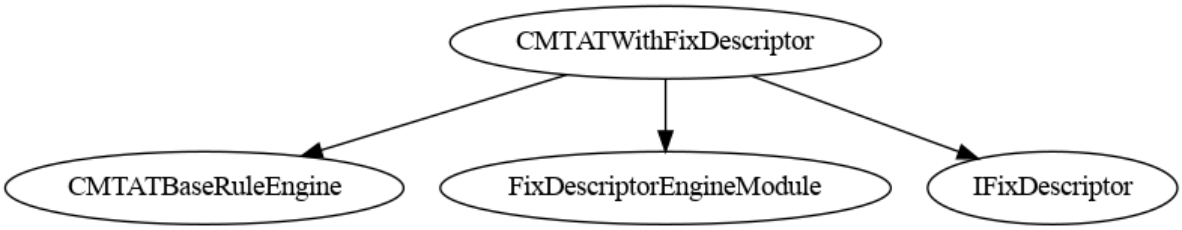
```
npm install
```

3. Install Foundry dependencies:

```
forge install
```

Architecture Diagrams

CMTATWithFixDescriptor



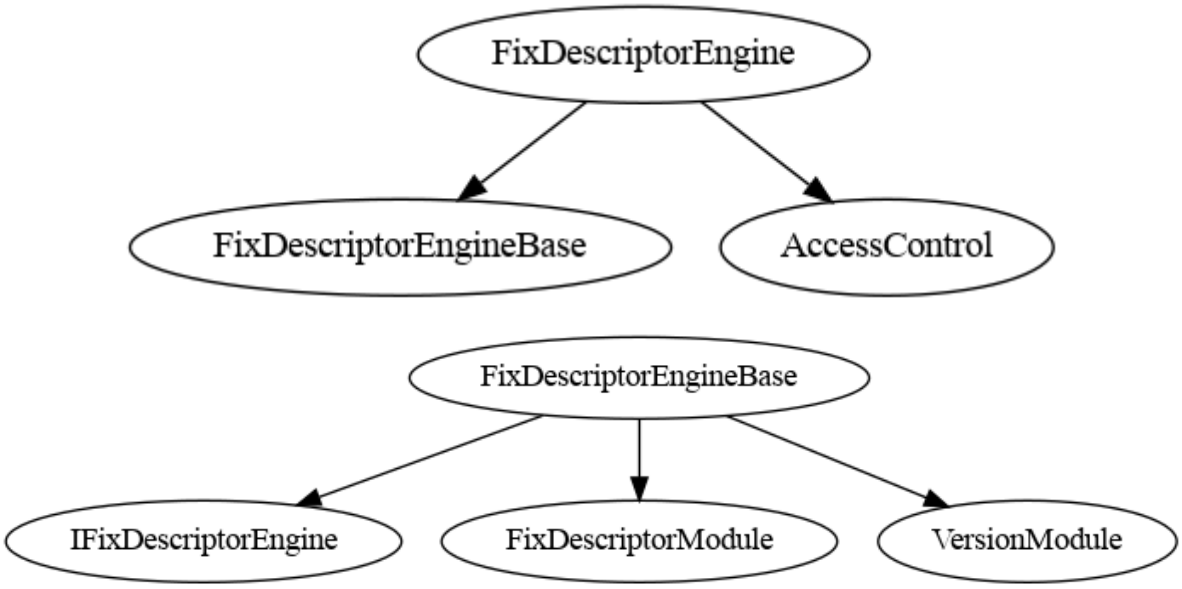
Contracts Description Table

Contract	Type	Bases		
└	**Function Name**	**Visibility**	**Mutability**	**Modifiers**
CMTATWithFixDescriptor	Implementation	CMTATBaseRuleEngine, FixDescriptorEngineModule, IFixDescriptor		
└		Public ❗	🛑	NO ❗
└	getFixDescriptor	External ❗		NO ❗
└	getFixRoot	External ❗		NO ❗
└	verifyField	External ❗		NO ❗
└	getFixSBEChunk	External ❗		NO ❗
└	getDescriptorEngine	External ❗		NO ❗
└	_authorizeSetDescriptorEngine	Internal 🔒	🛑	onlyRole
└	supportsInterface	Public ❗		NO ❗
└	setDescriptorWithSBE	External ❗	🛑	onlyRole
└	setDescriptor	External ❗	🛑	onlyRole

Legend

Symbol	Meaning
🛑	Function can modify state
💵	Function is payable

FixDescriptorEngine



See more in ./doc/surya

Usage

Basic Integration

1. Deploy the Token

```
CMTATWithFixDescriptor implementation = new CMTATWithFixDescriptor();
ERC1967Proxy proxy = new ERC1967Proxy(address(implementation), "");
CMTATWithFixDescriptor token = CMTATWithFixDescriptor(address(proxy));
token.initialize(admin, erc20Attrs, extraInfo, engines);
```

2. Deploy FixDescriptorEngine

Option A: With Constructor Initialization

```
bytes memory sbeData = hex"...";
bytes32 merkleRoot = bytes32(...);
bytes32 schemaHash = keccak256("your-dictionary");

IFixDescriptor.FixDescriptor memory descriptor = IFixDescriptor.FixDescriptor({
    schemaHash: schemaHash,
    fixRoot: merkleRoot,
    fixSBEPtr: address(0),
    fixSBELen: 0,
    schemaURI: "ipfs://..."
```

```
});

FixDescriptorEngine engine = new FixDescriptorEngine(
    address(token),
    admin,
    sbeData,
    descriptor
);
```

Option B: Post-Deployment Initialization

```
FixDescriptorEngine engine = new FixDescriptorEngine(
    address(token),
    admin,
    "",
    IFixDescriptor.FixDescriptor({
        schemaHash: bytes32(0),
        fixRoot: bytes32(0),
        fixSBEPtr: address(0),
        fixSBELen: 0,
        schemaURI: ""
    })
);

engine.setFixDescriptorWithSBE(sbeData, descriptor);
```

3. Link Engine to Token

```
// Caller must be authorized by token policy (typically DEFAULT_ADMIN_ROLE
holder)
token.setFixDescriptorEngine(address(engine));
```

By design, the default deployment flow links the descriptor engine in a separate step (post-`initialize`). This mirrors the CMTAT approach for other optional engines and keeps deployment standardized. Integrators that require atomic binding can call `__fixDescriptorEngineModuleInitUnchained(...)` from a custom initializer.

4. Query Descriptor Information

```
IFixDescriptor.FixDescriptor memory desc = token.getFixDescriptor();
bytes32 root = token.getFixRoot();
```

5. Verify Field Values

```
bytes calldata pathCBOR; // CBOR-encoded field path
bytes calldata value;   // Raw FIX value bytes
bytes32[] calldata proof; // Merkle proof
bool[] calldata directions; // Direction array

bool isValid = token.verifyField(pathCBOR, value, proof, directions);
```

Advanced Usage

Updating Descriptors

```
// Grant DESCRIPTOR_ADMIN_ROLE on engine
engine.grantRole(engine.DESCRIPTOR_ADMIN_ROLE(), admin);

// Update descriptor
IFixDescriptor.FixDescriptor memory newDescriptor = ...;
engine.setFixDescriptor(newDescriptor);

// Or deploy new SBE data and update
engine.setFixDescriptorWithSBE(newSbeData, newDescriptor);
```

Reading SBE Data

```
// Read chunk of SBE data
bytes memory chunk = engine.getFixSBEChunk(startOffset, size);
```

Testing

Run the test suite using Foundry:

```
# Run all tests
forge test

# Run with verbosity
forge test -vvv

# Run specific test file
forge test --match-path test/CMTATWithFixDescriptor.t.sol
```

Coverage

```
forge coverage --no-match-coverage "(script|mocks|test)" --report lcov &&
genhtml lcov.info --branch-coverage --output-dir coverage
```

See Solidity Coverage in VS Code with Foundry & Foundry forge coverage

Deployment

Use the provided deployment script:

```
forge script
scripts/DeployCMTATWithFixDescriptor.s.sol:DeployCMTATWithFixDescriptor \
  --rpc-url $RPC_URL \
  --broadcast \
  --verify
```

Set environment variables:

- `PRIVATE_KEY` - Deployer private key

- `ADMIN_ADDRESS` - Admin address for roles
- `TOKEN_ADDRESS` - Deployed token/proxy address to bind the engine to

Interface Compliance

The system implements the `IFixDescriptor` interface from `@fixdescriptorkit/contracts`, providing:

- `getFixDescriptor()` - Retrieve complete descriptor
- `getFixRoot()` - Get Merkle root commitment
- `verifyField()` - Verify field values with Merkle proofs
- `getDescriptorEngine()` - Get engine address

Security

> Warning: this project has not been audited

Access Control

Roles

- **DESCRIPTOR_ADMIN_ROLE** (on engine): Can set/update descriptors
- **DESCRIPTOR_ENGINE_ROLE** (on token): Can set the engine address
- **DEFAULT_ADMIN_ROLE** (on engine): Has all roles

Role Resolution Behavior

- `FixDescriptorEngine.hasRole(...)` is overridden so any account with `DEFAULT_ADMIN_ROLE` is treated as having every role (including `DESCRIPTOR_ADMIN_ROLE`), even if not explicitly granted.
- `getRoleMember(...)` / `getRoleMemberCount(...)` from `AccessControlEnumerable` still report only explicitly granted members for each role.
- Operationally: role enumeration may omit default admins unless they are also explicitly granted that role.

Permission Flow

1. Token caller authorized by token policy sets engine address (`DESCRIPTOR_ENGINE_ROLE` path)
2. Engine writes are allowed for `DESCRIPTOR_ADMIN_ROLE` and the bound token caller
3. Default admin on engine has all permissions

Security considerations

- Engine is bound to token at construction (immutable)
- Descriptor updates are authorized for `DESCRIPTOR_ADMIN_ROLE` and the bound token caller
- Merkle proofs enable cryptographic verification without revealing full descriptor
- SSTORE2 pattern ensures efficient and secure data storage

Audit

Tools

Slither

Report performed with Slither:

```
slither .  --checklist --filter-paths "openzeppelin-contracts|test|CMTAT|forge-std|mocks" > slither-report.md
```

File	Report	Feedback
slither-report.md	No findings captured	-

Aderyn

Report performed with Aderyn:

```
aderyn -x mocks --output aderyn-report.md
```

File	Report	Feedback
aderyn-report.md	1 High, 4 Low	aderyn-report-feedback.md

Nethermind Audit Agent

Automated scans (AI-generated; not a substitute for a full manual audit).

File	Report	Feedback
audit_agent_report_v0.2.0.pdf	1 Low, 2 Info	audit_agent_report_v0.2.0-feedback.m
audit_agent_report_v0.1.0.pdf	1 Info, 2 Best Practices	audit_agent_report_v0.1.0-feedback.m

Finding summary:

ID	Title	Aderyn Severity	Verdict
H-1	Contract Name Reused in Different Files	High	False Positive
L-1	Centralization Risk	Low	Valid by Design / Acknowledge
L-2	PUSH0 Opcode	Low	Conditional / N/A (Prague target)

ID	Title	Aderyn Severity	Verdict
L-3	Unchecked Return	Low	False Positive
L-4	Unspecific Solidity Pragma	Low	Valid by Design / Acknowledge

API Reference

FixDescriptorEngine

Main engine contract. One instance is bound to one token at construction time. Inherits `FixDescriptorEngineBase`, `AccessControlEnumerable`.

State Variables

Name	Type	Description
`token`	`address` (immutable)	Address of the token this engine is bound to
`DESCRIPTOR_ADMIN_ROLE`	`bytes32` (constant)	Role required to set/update descriptors

Functions

Function	Signature	Access	Description
`constructor`	`(address token_, address admin, bytes sbeData_, FixDescriptor descriptor_)`	—	Binds engine to `token_`, grants `DEFAULT_ADMIN_ROLE` to `admin`. Optionally initializes descriptor from `sbeData_` / `descriptor_`.
`hasRole`	`(bytes32 role, address account) → bool`	public view	Override: `DEFAULT_ADMIN_ROLE` holders implicitly hold all roles.
`getFixDescriptor`	`() → FixDescriptor`	external view	Returns the stored FIX descriptor struct.
`getFixRoot`	`() → bytes32`	external view	Returns the Merkle root commitment of the descriptor.

Function	Signature	Access	Description
`verifyField`	`(bytes pathCBOR, bytes value, bytes32[] proof, bool[] directions) → bool`	external view	Verifies a single FIX field value against the committed Merkle root.
`getFixSBEChunk`	`(uint256 start, uint256 size) → bytes`	external view	Reads a chunk of SBE-encoded data from SSTORE2 storage.
`setFixDescriptor`	`(FixDescriptor descriptor)`	external	Sets/updates the descriptor. Requires `DESCRIPTOR_ADMIN_ROLE` or caller is the bound token.
`setFixDescriptorWithSBE`	`(bytes sbeData, FixDescriptor descriptor) → address sbePtr`	external	Deploys SBE data via SSTORE2 and atomically updates the descriptor. Returns the deployed data contract address. Requires `DESCRIPTOR_ADMIN_ROLE` or caller is the bound token.
`version`	`() → string`	external pure	Returns the version string (e.g. `"1.0.0"`).
`getRoleMemberCount`	`(bytes32 role) → uint256`	public view	Returns the number of accounts with `role`. Inherited from `AccessControlEnumerable`.
`getRoleMember`	`(bytes32 role, uint256 index) → address`	public view	Returns the account at position `index` in the role's member set. Inherited from `AccessControlEnumerable`.

FixDescriptorEngineModule

CMTAT module that stores a reference to a `FixDescriptorEngine` on the token contract. Uses ERC-7201 namespaced storage.

State Variables

Name	Type	Description
`DESCRIPTOR_ENGINE_ROLE`	`bytes32` (constant)	Role required to set the engine address on the token

Functions

Function	Signature	Access	Description
`setFixDescriptorEngine`	`(address engine)`	external	Sets the engine address. Verifies the engine is bound to this token (`engine.token() == address(this)`). Authorization is implementation-defined via `_authorizeSetDescriptorEngine()`.
`getDescriptorEngine`	`() → address`	external view	Returns the stored engine address, or `address(0)` if not set.
`fixDescriptorEngine`	`() → address`	public view	Alias for `getDescriptorEngine`. Used internally by `CMTATWithFixDescriptor`.

CMTATWithFixDescriptor

Example token implementation combining `CMTATBaseRuleEngine` with `FixDescriptorEngineModule`. All `IFixDescriptor` calls are forwarded to the bound engine.

State Variables

Name	Type	Description
`DESCRIPTOR_ADMIN_ROLE`	`bytes32` (constant)	Role required to call descriptor write helpers on the token

Functions

Function	Signature	Access	Description
`getFixDescriptor`	`() → FixDescriptor`	external view	Forwarded to `FixDescriptorEngine.getFixDescriptor()`. Reverts if engine is not set.
`getFixRoot`	`() → bytes32`	external view	Forwarded to `FixDescriptorEngine.getFixRoot()`. Reverts if engine is not set.
`verifyField`	`(bytes pathCBOR, bytes value, bytes32[] proof, bool[] directions) → bool`	external view	Forwarded to `FixDescriptorEngine.verifyField()`. Reverts if engine is not set.
`getFixSBEChunk`	`(uint256 start, uint256 size) → bytes`	external view	Forwarded to `FixDescriptorEngine.getFixSBEChunk()`. Reverts if engine is not set.
`getDescriptorEngine`	`() → address`	external view	Returns the engine address (overrides both `FixDescriptorEngineModule` and `IFixDescriptor`).

Function	Signature	Access	Description
`setDescriptorWithSBE`	`(bytes sbeData, FixDescriptor descriptor) → address sbePtr`	external	Convenience helper: calls `engine.setFixDescriptorWithSBE()`. Requires `DESCRIPTOR_ADMIN_ROLE`.
`setDescriptor`	`(FixDescriptor descriptor)`	external	Convenience helper: calls `engine.setFixDescriptor()`. Requires `DESCRIPTOR_ADMIN_ROLE`.
`supportsInterface`	`(bytes4 interfaceId) → bool`	public view	ERC-165 support. Returns `true` for `IFixDescriptor` in addition to inherited interfaces.

License

Mozilla Public License 2.0 (MPL-2.0). See `LICENSE`.

Contributing

Contributions are welcome! Please ensure:

- Code follows existing patterns and style
- Tests are added for new features
- Documentation is updated accordingly

References

- FIX Descriptor Specification – Canonicalization, SBE encoding, Merkle commitment, onchain verification
- CMTAT Solidity
- FIX Protocol
- FixDescriptorKit