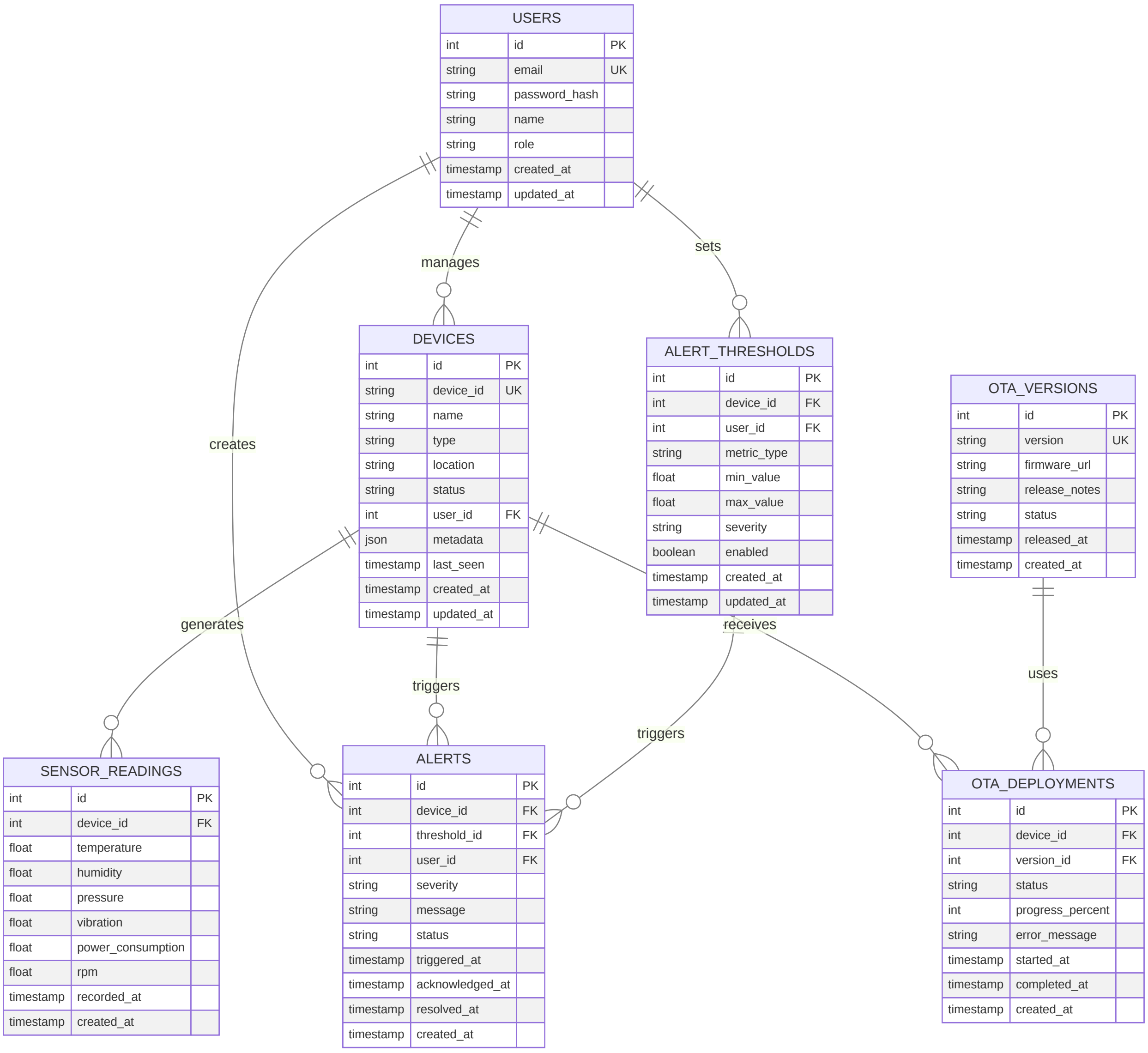
Smart Factory IoT - Database Schema

Entity Relationship Diagram



USERS

int	id	PK
string	email	UK
string	password_hash	
string	name	
string	role	
timestamp	created_at	
timestamp	updated_at	

DEVICES

int	id	PK
string	device_id	UK
string	name	
string	type	
string	location	
string	status	
int	user_id	FK
json	metadata	
timestamp	last_seen	
timestamp	created_at	
timestamp	updated_at	

ALERT_THRESHOLDS

int	id	PK
int	device_id	FK
int	user_id	FK
string	metric_type	
float	min_value	
float	max_value	
string	severity	
boolean	enabled	
timestamp	created_at	
timestamp	updated_at	

OTA_VERSIONS

int	id	PK
string	version	UK
string	firmware_url	
string	release_notes	
string	status	
timestamp	released_at	
timestamp	created_at	

SENSOR_READINGS

int	id	PK
int	device_id	FK
float	temperature	
float	humidity	
float	pressure	
float	vibration	
float	power_consumption	
float	rpm	
timestamp	recorded_at	
timestamp	created_at	

ALERTS

int	id	PK
int	device_id	FK
int	threshold_id	FK
int	user_id	FK
string	severity	
string	message	
string	status	
timestamp	triggered_at	
timestamp	acknowledged_at	
timestamp	resolved_at	
timestamp	created_at	

OTA_DEPLOYMENTS

int	id	PK
int	device_id	FK
int	version_id	FK
string	status	
int	progress_percent	
string	error_message	
timestamp	started_at	
timestamp	completed_at	
timestamp	created_at	

Table Specifications

USERS

Stores user account information and authentication credentials.

Column	Type	Constraints	Description
id	INT	PRIMARY KEY, AUTO_INCREMENT	Unique user identifier
email	VARCHAR(255)	UNIQUE, NOT NULL	User email address
password_hash	VARCHAR(255)	NOT NULL	Bcrypt hashed password
name	VARCHAR(255)	NOT NULL	User full name
role	ENUM	NOT NULL	User role (admin, operator, user)
created_at	TIMESTAMP	NOT NULL	Account creation time
updated_at	TIMESTAMP	NOT NULL	Last update time

DEVICES

Represents IoT devices in the factory.

Column	Type	Constraints	Description
id	INT	PRIMARY KEY, AUTO_INCREMENT	Unique device identifier
device_id	VARCHAR(255)	UNIQUE, NOT NULL	Device hardware ID
name	VARCHAR(255)	NOT NULL	Device display name
type	VARCHAR(100)	NOT NULL	Device type (sensor, gateway, etc.)
location	VARCHAR(255)	NOT NULL	Physical location
status	ENUM	NOT NULL	Device status (online, offline, error)
user_id	INT	FOREIGN KEY	Owner user ID
metadata	JSON		Additional device information
last_seen	TIMESTAMP		Last communication timestamp
created_at	TIMESTAMP	NOT NULL	Creation time
updated_at	TIMESTAMP	NOT NULL	Last update time

SENSOR_READINGS

Time-series data from device sensors.

Column	Type	Constraints	Description
id	INT	PRIMARY KEY, AUTO_INCREMENT	Unique reading identifier
device_id	INT	FOREIGN KEY, NOT NULL	Associated device
temperature	FLOAT		Temperature in Celsius
humidity	FLOAT		Humidity percentage
pressure	FLOAT		Pressure in kPa
vibration	FLOAT		Vibration level
power_consumption	FLOAT		Power in Watts
rpm	FLOAT		Rotations per minute
recorded_at	TIMESTAMP	NOT NULL	Sensor reading timestamp
created_at	TIMESTAMP	NOT NULL	Record creation time

Indexes:

- `device_id, recorded_at` (composite index for time-series queries)
- `recorded_at` (for time range queries)

ALERTS

System alerts triggered by threshold violations.

Column	Type	Constraints	Description
id	INT	PRIMARY KEY, AUTO_INCREMENT	Unique alert identifier
device_id	INT	FOREIGN KEY, NOT NULL	Associated device
threshold_id	INT	FOREIGN KEY	Triggered threshold
user_id	INT	FOREIGN KEY	Alert owner
severity	ENUM	NOT NULL	Severity level (critical, warning, info)
message	TEXT	NOT NULL	Alert description
status	ENUM	NOT NULL	Alert status (active, acknowledged, resolved)
triggered_at	TIMESTAMP	NOT NULL	Alert trigger time
acknowledged_at	TIMESTAMP		Acknowledgment time
resolved_at	TIMESTAMP		Resolution time
created_at	TIMESTAMP	NOT NULL	Record creation time

Indexes:

- `user_id, created_at` (for user alert queries)
- `status, severity` (for alert filtering)

ALERT_THRESHOLDS

Configuration for alert triggers.

Column	Type	Constraints	Description
id	INT	PRIMARY KEY, AUTO_INCREMENT	Unique threshold identifier
device_id	INT	FOREIGN KEY, NOT NULL	Associated device
user_id	INT	FOREIGN KEY, NOT NULL	Threshold owner
metric_type	VARCHAR(100)	NOT NULL	Metric being monitored
min_value	FLOAT		Minimum acceptable value
max_value	FLOAT		Maximum acceptable value
severity	ENUM	NOT NULL	Alert severity level
enabled	BOOLEAN	NOT NULL	Whether threshold is active
created_at	TIMESTAMP	NOT NULL	Creation time
updated_at	TIMESTAMP	NOT NULL	Last update time

OTA_VERSIONS

Firmware version management.

Column	Type	Constraints	Description
id	INT	PRIMARY KEY, AUTO_INCREMENT	Unique version identifier
version	VARCHAR(50)	UNIQUE, NOT NULL	Version number (semver)
firmware_url	VARCHAR(500)	NOT NULL	Download URL
release_notes	TEXT		Version release notes
status	ENUM	NOT NULL	Version status (draft, released, deprecated)
released_at	TIMESTAMP		Release timestamp
created_at	TIMESTAMP	NOT NULL	Creation time

OTA_DEPLOYMENTS

Tracks firmware update deployments to devices.

Column	Type	Constraints	Description
id	INT	PRIMARY KEY, AUTO_INCREMENT	Unique deployment identifier
device_id	INT	FOREIGN KEY, NOT NULL	Target device
version_id	INT	FOREIGN KEY, NOT NULL	Firmware version
status	ENUM	NOT NULL	Deployment status (pending, in_progress, completed, failed)
progress_percent	INT		Update progress (0-100)
error_message	TEXT		Error details if failed
started_at	TIMESTAMP		Deployment start time
completed_at	TIMESTAMP		Deployment completion time
created_at	TIMESTAMP	NOT NULL	Record creation time

Indexes:

- `device_id, status` (for device deployment queries)
- `version_id, status` (for version deployment tracking)

Query Patterns

Real-time Sensor Data

```sql
SELECT * FROM SENSOR_READINGS
WHERE device_id = ? AND recorded_at > NOW() - INTERVAL 1 HOUR
ORDER BY recorded_at DESC
LIMIT 100;
```

Active Alerts

```sql
SELECT a.*, d.name as device_name, u.email as user_email
FROM ALERTS a
JOIN DEVICES d ON a.device_id = d.id
JOIN USERS u ON a.user_id = u.id
WHERE a.status = 'active'
ORDER BY a.severity DESC, a.triggered_at DESC;
```

Device Status Overview

```sql
SELECT
    d.id, d.name, d.status,
    COUNT(CASE WHEN a.status = 'active' THEN 1 END) as active_alerts,
    MAX(sr.recorded_at) as last_reading
FROM DEVICES d
LEFT JOIN ALERTS a ON d.id = a.device_id
LEFT JOIN SENSOR_READINGS sr ON d.id = sr.device_id
GROUP BY d.id;
```

Performance Optimization

Indexing Strategy

- Primary keys on all tables
- Foreign key indexes for joins
- Composite indexes for common queries
- Timestamp indexes for time-range queries

Query Optimization

- Use EXPLAIN to analyze queries
- Avoid N+1 queries with proper joins
- Batch operations for bulk updates
- Pagination for large result sets

Caching Strategy

- Cache frequently accessed thresholds
- Cache device metadata
- Cache user roles and permissions
- Invalidate cache on updates

Data Retention Policy

Table	Retention	Archive
USERS	Indefinite	N/A
DEVICES	Indefinite	N/A
SENSOR_READINGS	90 days	Archive to S3
ALERTS	1 year	Archive to S3
ALERT_THRESHOLDS	Indefinite	N/A
OTA_VERSIONS	Indefinite	N/A
OTA_DEPLOYMENTS	1 year	Archive to S3

Backup & Recovery

Backup Strategy

- Daily incremental backups
- Weekly full backups
- Backup retention: 30 days
- Off-site backup storage

Recovery Procedure

1. Identify recovery point
2. Restore from backup
3. Verify data integrity
4. Sync with replicas
5. Resume operations

Security Considerations

Data Protection

- Encrypt sensitive fields at rest
- Use parameterized queries to prevent SQL injection
- Implement row-level security for multi-tenant data
- Audit all data modifications

Access Control

- Role-based access to data
- User can only see their own devices
- Admin can see all data
- Operator has read-only access

Compliance

- GDPR compliance for user data
- Data anonymization for deleted users
- Audit logs for all modifications
- Encryption in transit (HTTPS/TLS)