Lab 8: Transactions and permissions

Course: SQL Server Database Development (ITE-5223)
Database: AdventureWorks2019
Schema Used: Reporting
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1. Executive Summary

This report documents the design, implementation, and validation of transactional integrity, concurrency control, and role-based access control for the AdventureWorks IoT Operations Platform.
The platform ingests high-volume telemetry from SmartBike consumer devices and industrial manufacturing sensors.
To meet enterprise requirements, the database solution ensures:

- ACID-compliant multi-step telemetry ingestion
- Protection against partial writes and corrupted packets
- Concurrency handling under high-throughput workloads
- Least-privilege access control for IoT departments
- Full auditability and error logging

The report summarizes schema creation, transactional workflow logic, failure scenario handling, concurrency behavior under different isolation levels, and validation of role-based permissions.

2. IoT Business Case Overview

AdventureWorks expanded its business into IoT-enabled devices in two major divisions:
1.SmartBike

- Consumer bicycles with GPS, cadence, temperature, crash detection, and battery sensors
- Sends telemetry every 30 seconds

2.Manufacturing IoT

- Factory-floor devices monitoring temperature, vibration, operational status
- Used for predictive maintenance and real-time monitoring

The backend database processes more than 250,000 telemetry messages per hour.
To ensure reliability and regulatory compliance (GDPR / CCPA), the system must:

- Prevent partial telemetry ingestion
- Detect invalid or corrupted sensor data
- Maintain consistent device state under concurrent operations
- Enforce strict security boundaries between IoT teams

This lab simulates a production IoT backend for both consumer and industrial devices.

3. Transaction Workflow

The stored procedure IoT.usp_ProcessTelemetryCycle performs atomic processing of a complete telemetry cycle.
It ensures that all five dependent records are created successfully, or the entire operation rolls back.

Processing Steps:

1.Validate Device Registration:
- Reject unregistered, invalid, or decommissioned devices.

2.Validate Sensor Inputs
- Temperature range –40 to 85°C
- Battery level 0–100%
- Latitude/Longitude cannot be NULL and must be within valid ranges

3.Insert Raw Telemetry into IoT.Telemetry.
4.Update LastHeartbeat in IoT.Device.
5.Insert DeviceHealth Summary
- Computes TemperatureStatus, BatteryStatus, VibrationStatus
- Marks device as Healthy/Unhealthy

6.Insert Alerts into IoT.Alert
- Low/Critical battery
- High temperature

7.Insert TelemetryAudit Record
- Processing duration
- Number of records inserted
- Status (Completed or CompletedWithAlerts)

8.Commit Transaction

Rollback Conditions

If any failure occurs:
- Missing or invalid DeviceID
- Sensor readings outside acceptable ranges
- Null or invalid coordinates
- Any conversion error or unexpected exception

Then:
- Entire transaction rolls back
- Detailed error entry is written to IoT.TelemetryErrorLog

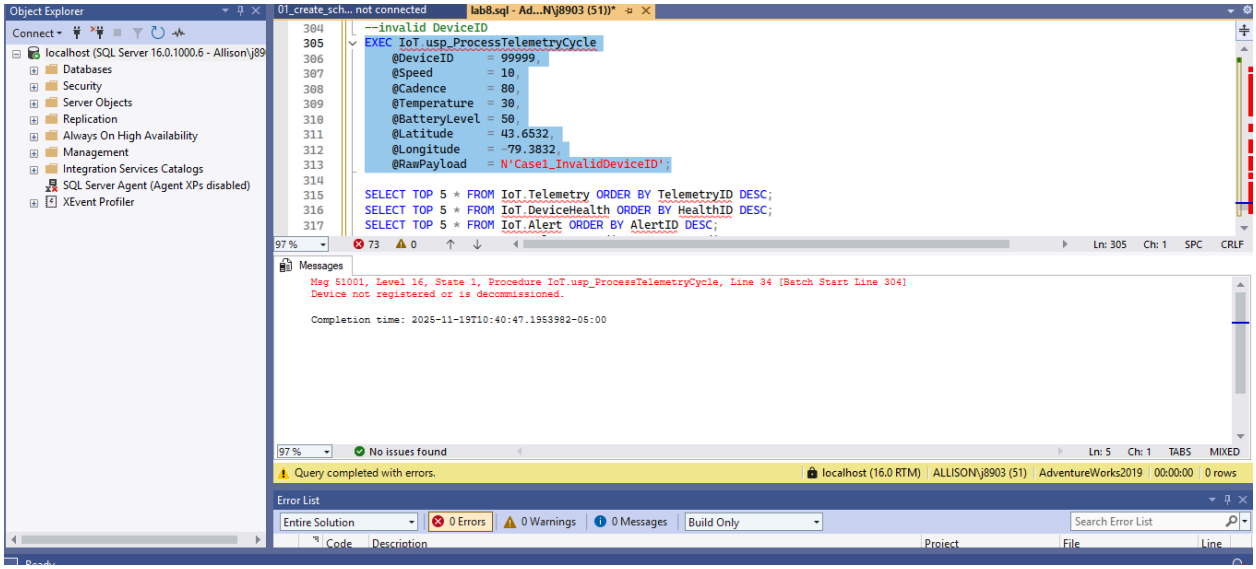
This ensures 100% data integrity during telemetry ingestion.

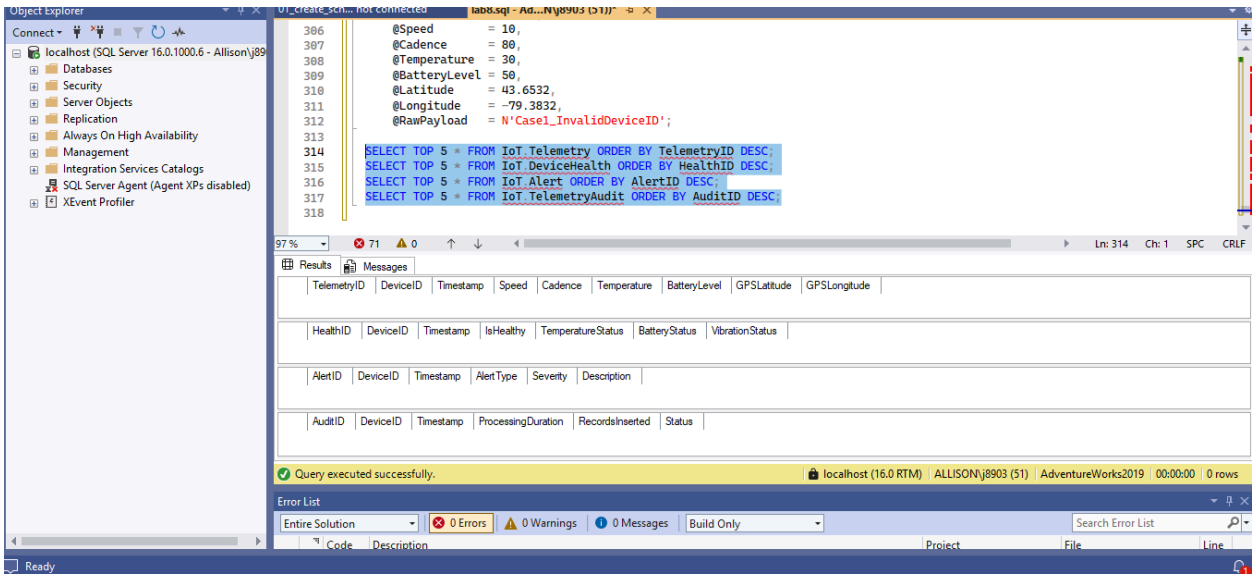
4. Failure Scenarios

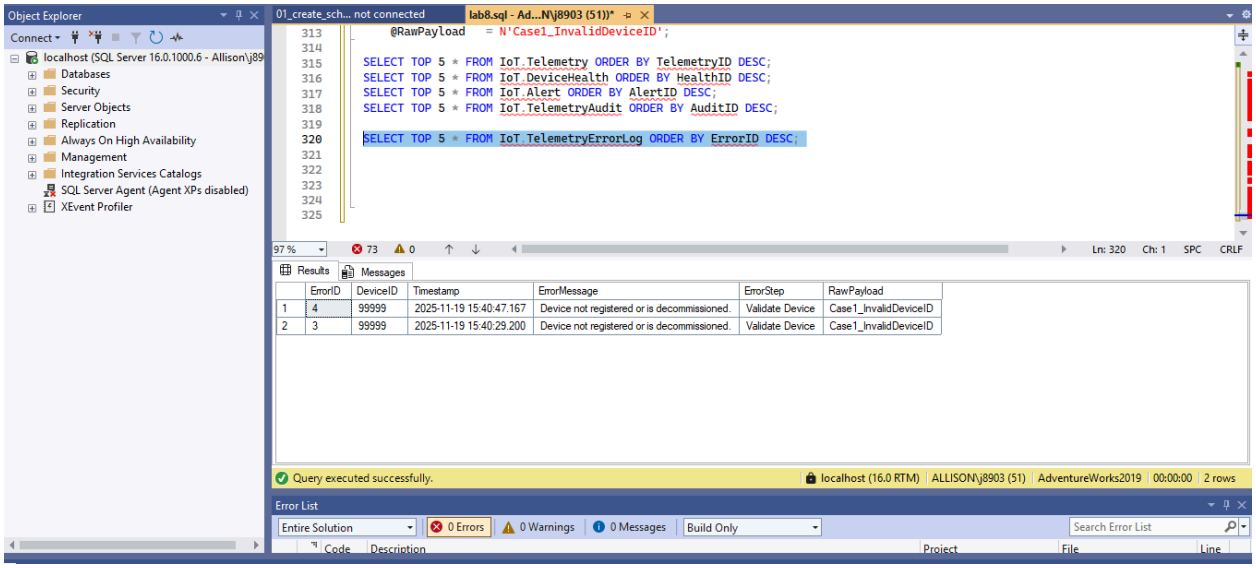
Three failure scenarios were executed to verify correct rollback and error logging.

Failure Case 1 – Invalid DeviceID
- DeviceID = 99999 (not registered)
- Stored procedure throws error "Device not registered"

- Result:
    1. No telemetry, health, alert, audit rows created
    2. IoT.TelemetryErrorLog contains an error entry with ErrorStep = "Validate Device"

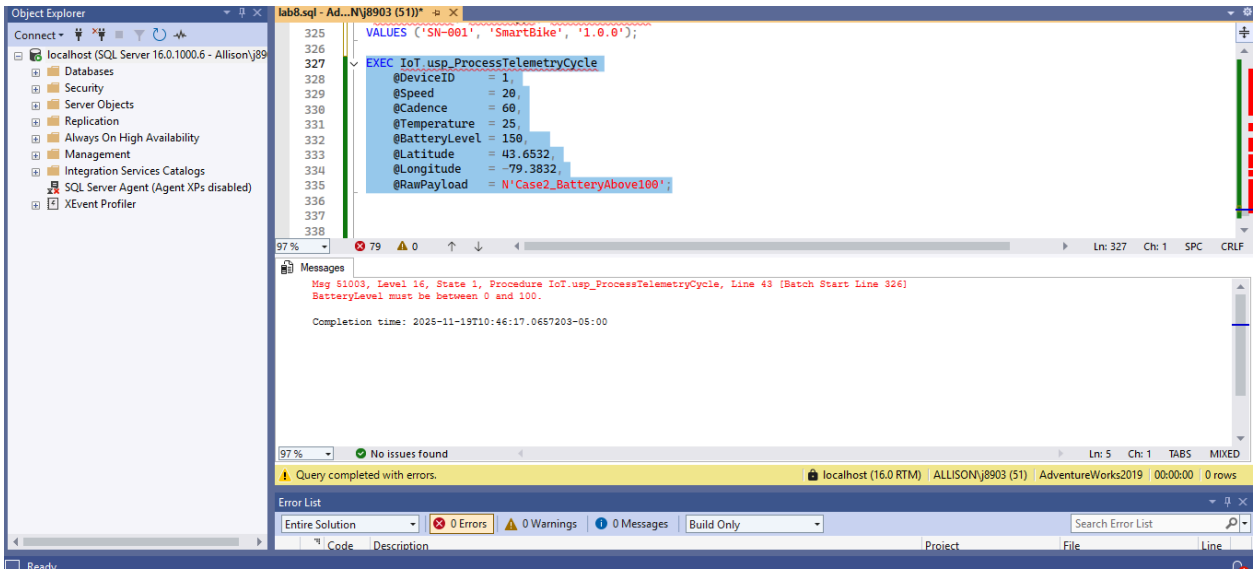


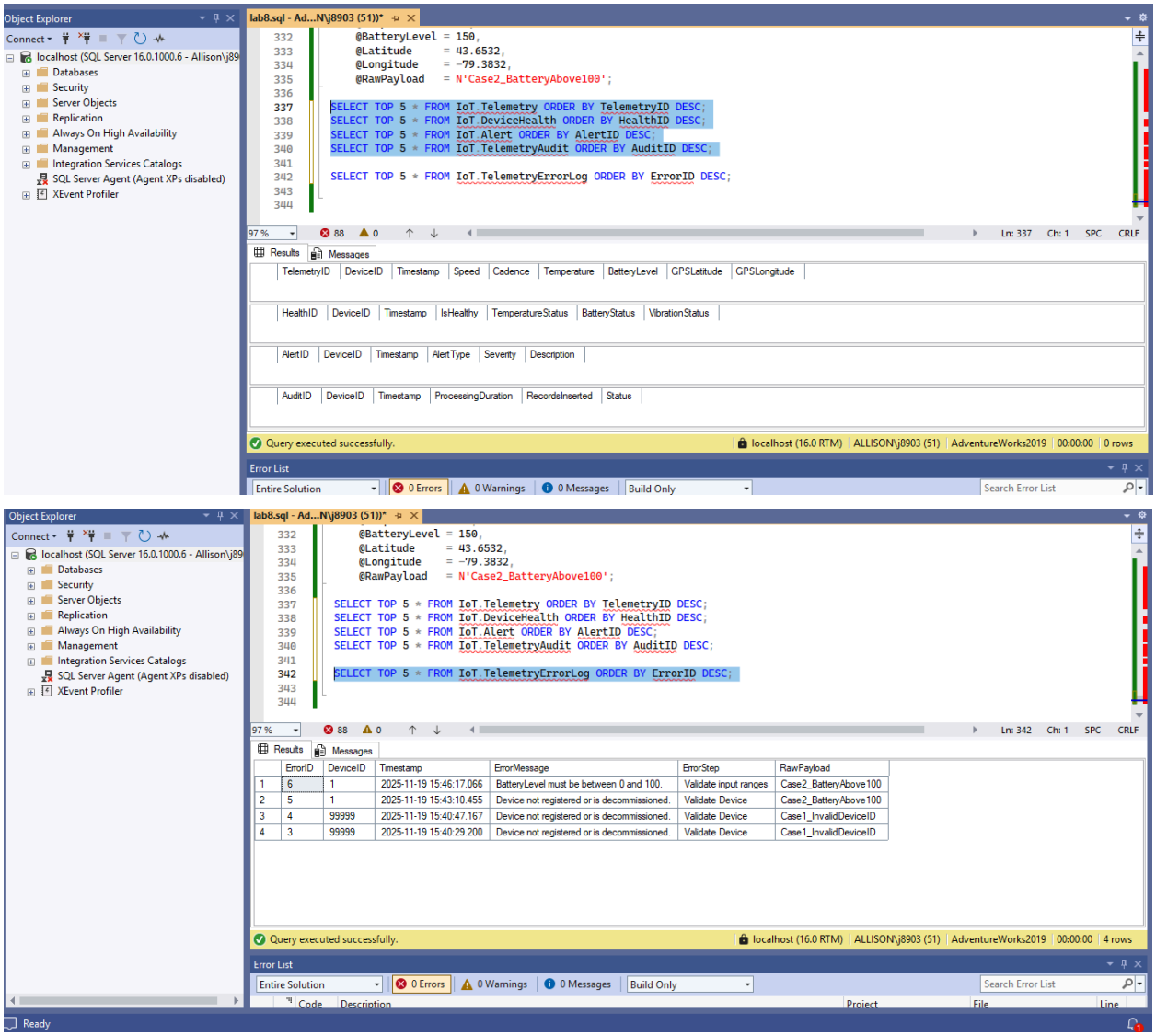




Failure Case 2 – BatteryLevel > 100

- Violates sensor rules (0–100%)
- Stored procedure throws custom error
- Result:
    1. Transaction rolled back
    2. Error logged with ErrorStep = "Validate input ranges"





Failure Case 3 – Missing GPS Coordinates

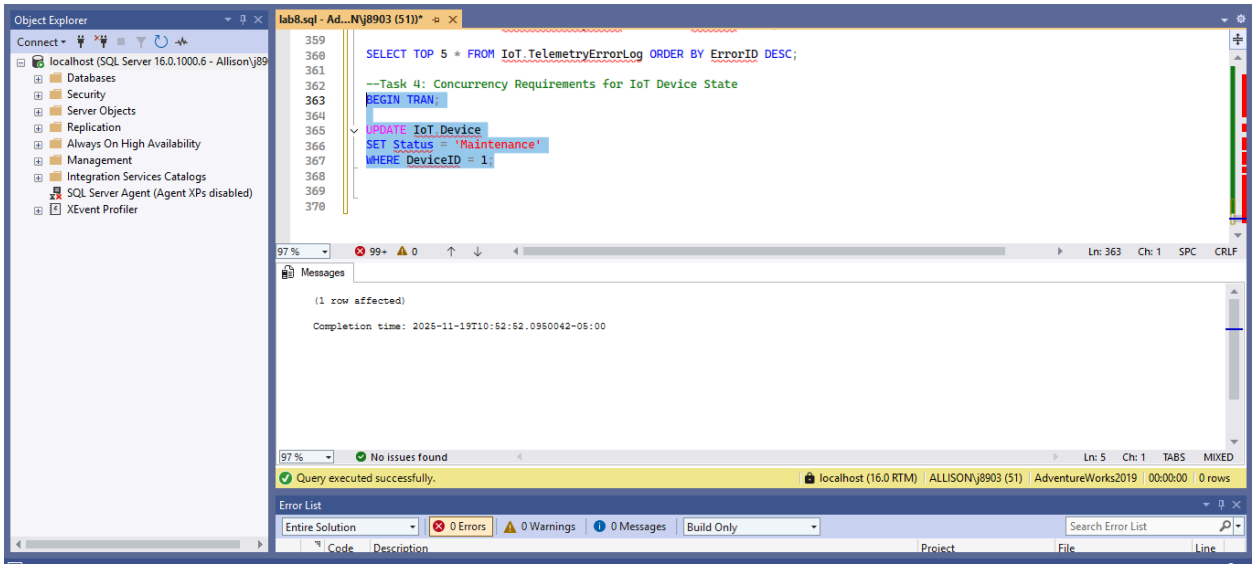
- Latitude = NULL
- Procedure rejects NULL GPS
- Result:
    1. The transaction was rolled back to prevent partial telemetry ingestion.
    2. TelemetryErrorLog contains correct error and RawPayload

5. Concurrency Analysis

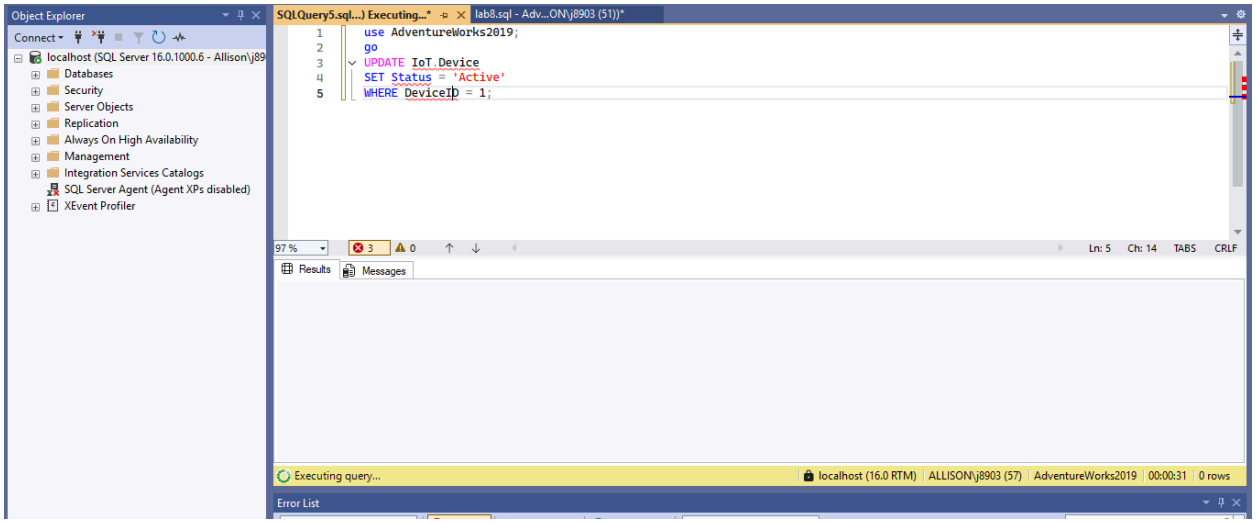
Multiple concurrency scenarios were executed using two SQL Server sessions to observe blocking behavior and isolation level differences.

1 Blocking Scenario

A:



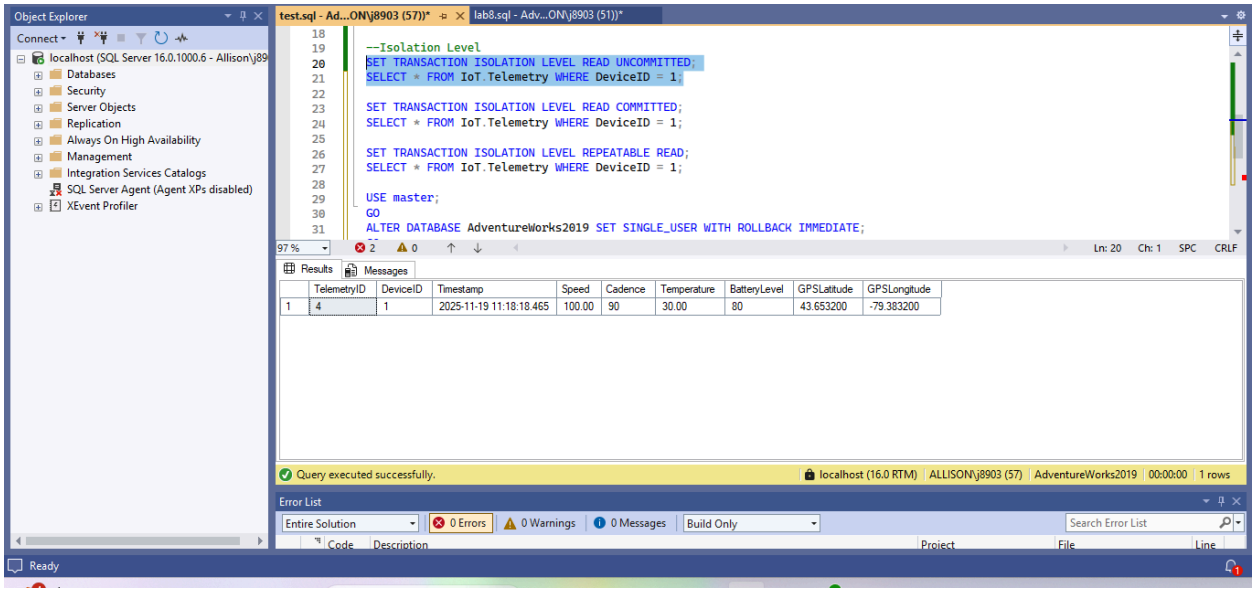
B:



Observation:
B becomes BLOCKED
This simulates high-volume ingestion conflicting with maintenance actions.

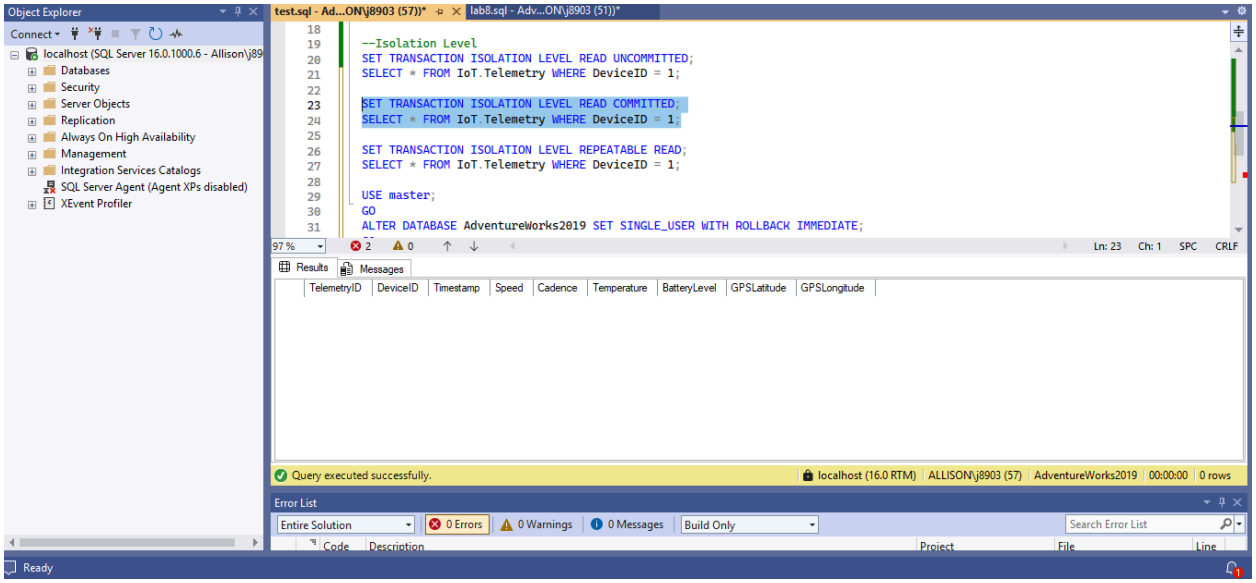
2 Dirty Read – READ UNCOMMITTED

- B can see uncommitted telemetry inserts
- Demonstrates dirty reads allowed under this isolation level



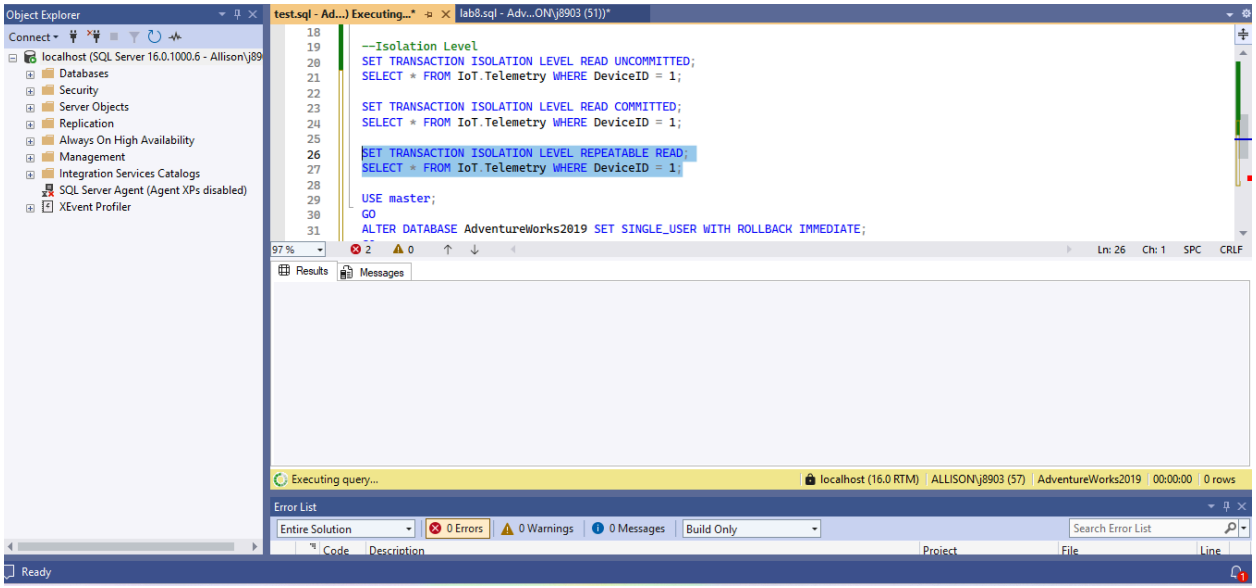
3 READ COMMITTED

- B waits for A to commit
- Prevents dirty reads
- Default and safest isolation level for transactional systems



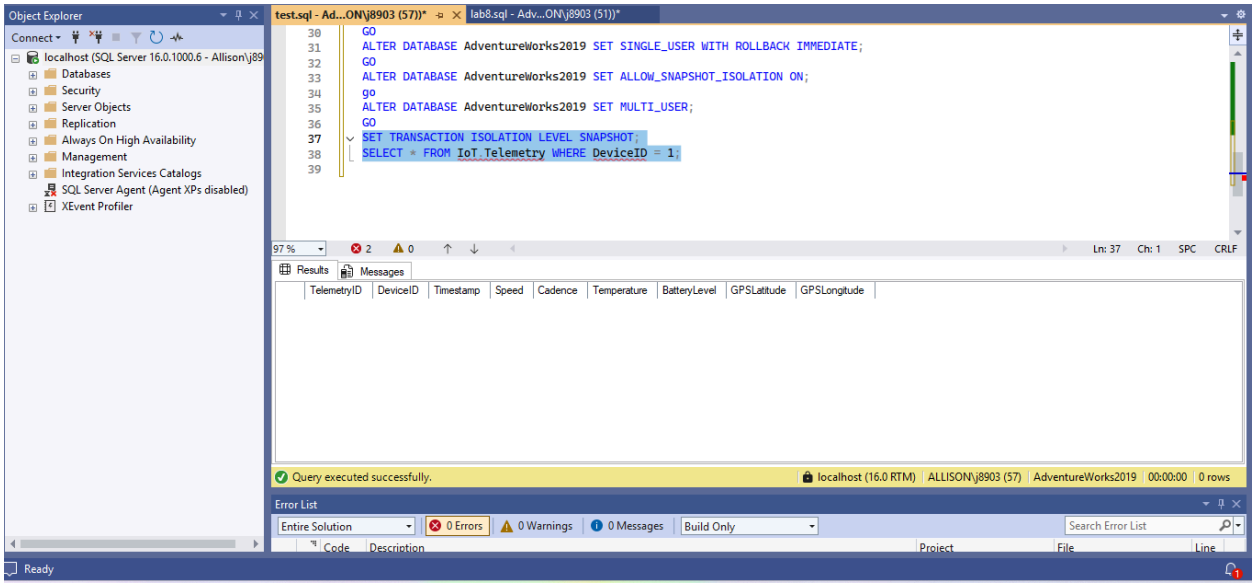
4 REPEATABLE READ

- Prevents changes to rows read by B
- A cannot update those rows until B commits



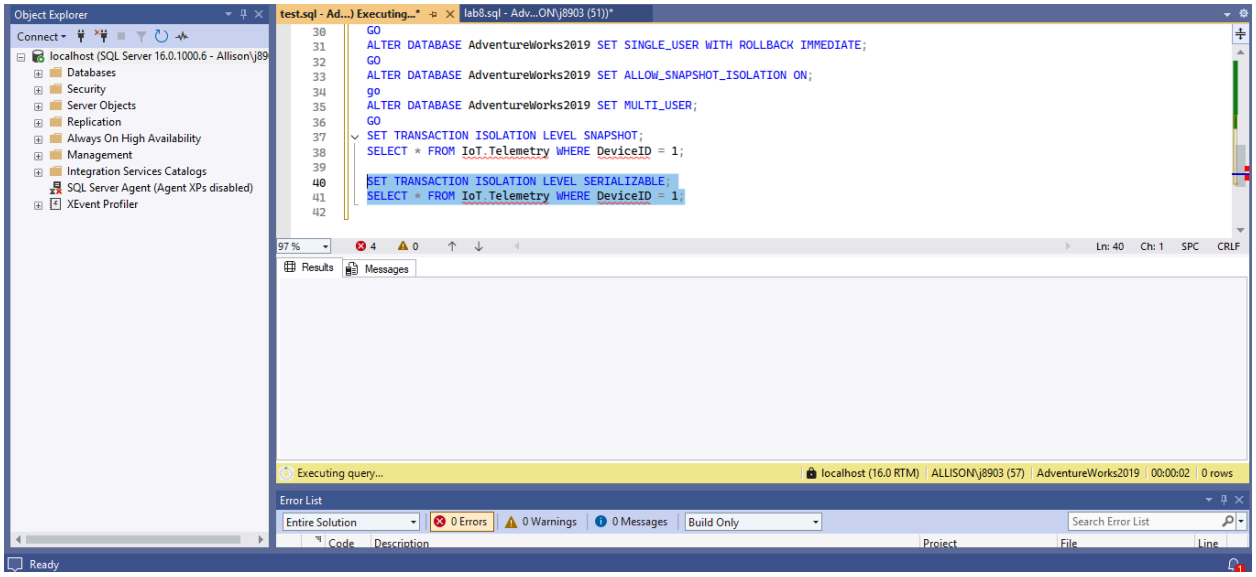
5 SNAPSHOT Isolation

- B reads a consistent version of the data
- Does not block nor get blocked
- Ideal for high-volume telemetry analytics



6 SERIALIZABLE

- Under SERIALIZABLE isolation, the transaction in B logically restricts concurrent inserts into the same key range.
- Although the INSERT in A was not visibly blocked due to the lack of an index on DeviceID, SERIALIZABLE is still designed to prevent phantom reads and enforce the strictest ACID guarantees.
- In a properly indexed environment, the Session A insert would be blocked until Session B completes.



6. Role-Based Access Control

Roles were created to match real-world IoT departmental responsibilities while following the Least Privilege Principle.

1 IoTDeviceAgent

Allowed:

- INSERT / UPDATE on IoT.Device
- SELECT on IoT.Device

Denied:

- Any INSERT/UPDATE/DELETE on telemetry-related tables

Used for device registration staff.

2 TelemetryIngestionService

Allowed:

INSERT Telemetry, DeviceHealth, Alert, Audit
UPDATE Device.LastHeartbeat
SELECT Device

Denied:

UPDATE Device metadata (SerialNumber, FirmwareVersion, etc.)

Represents automated ingestion microservices.

3 IoTAnalyst

Allowed:

- SELECT all IoT tables

Denied:

- INSERT / UPDATE / DELETE any IoT table

Analysts can read data but cannot affect operations.

4 IoTFieldTechnician
Denied:

- SELECT DeviceOwner or any customer-linked data
- SELECT all telemetry data (Per privacy restrictions)

5 SecurityComplianceOfficer
Allowed:

- SELECT Device, DeviceOwner, Telemetry, Alerts, ErrorLog

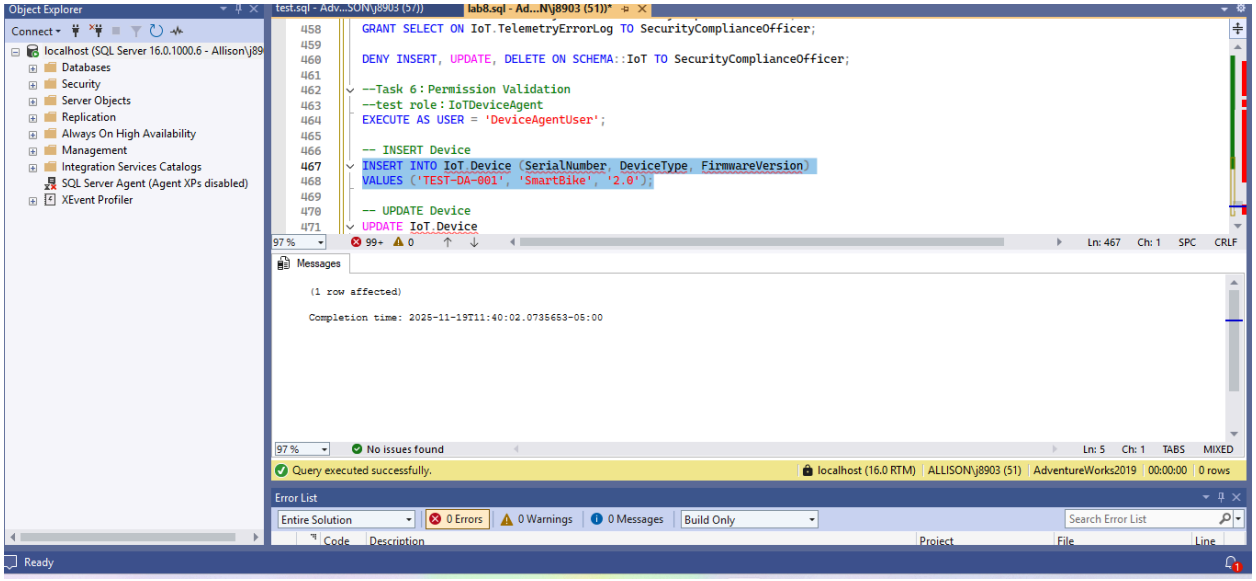
Denied:

- All modification operations

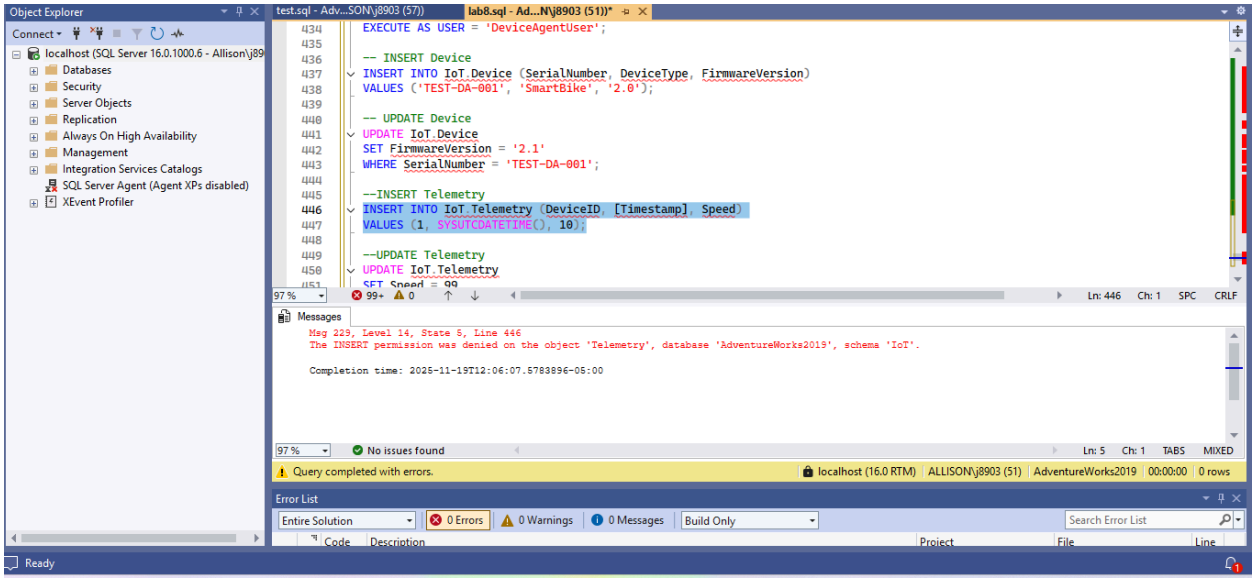
Used for GDPR/CCPA regulatory review.

7. Permission Validation

Each role was tested using EXECUTE AS USER.
1.IoTDeviceAgent
INSERT Device → success

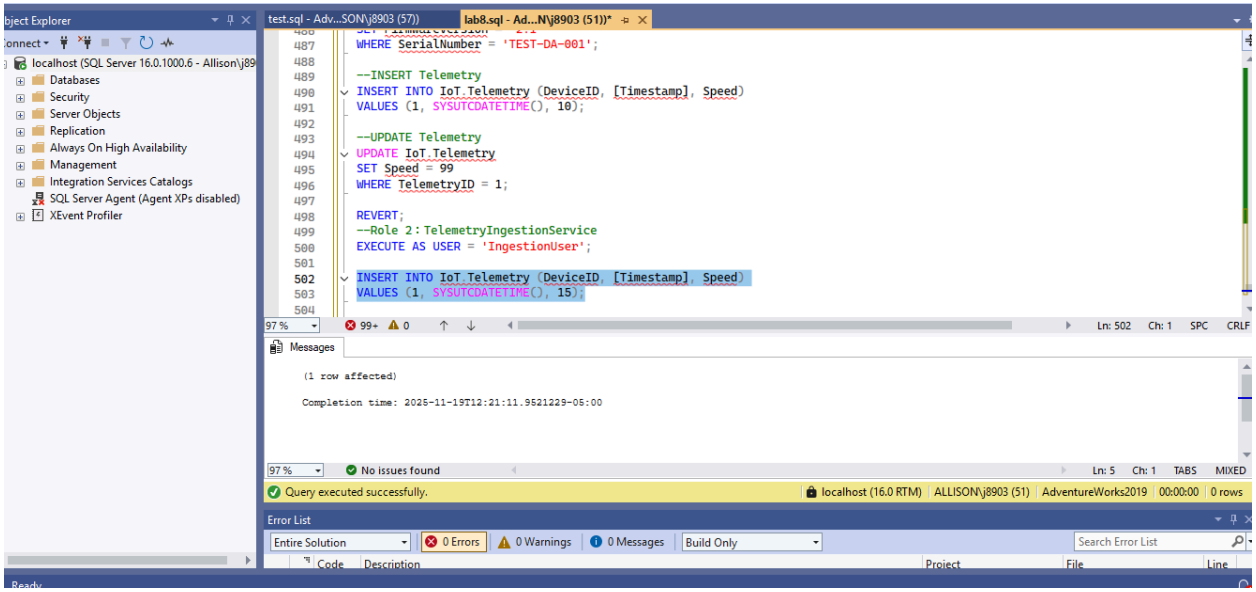


INSERT Telemetry → denied

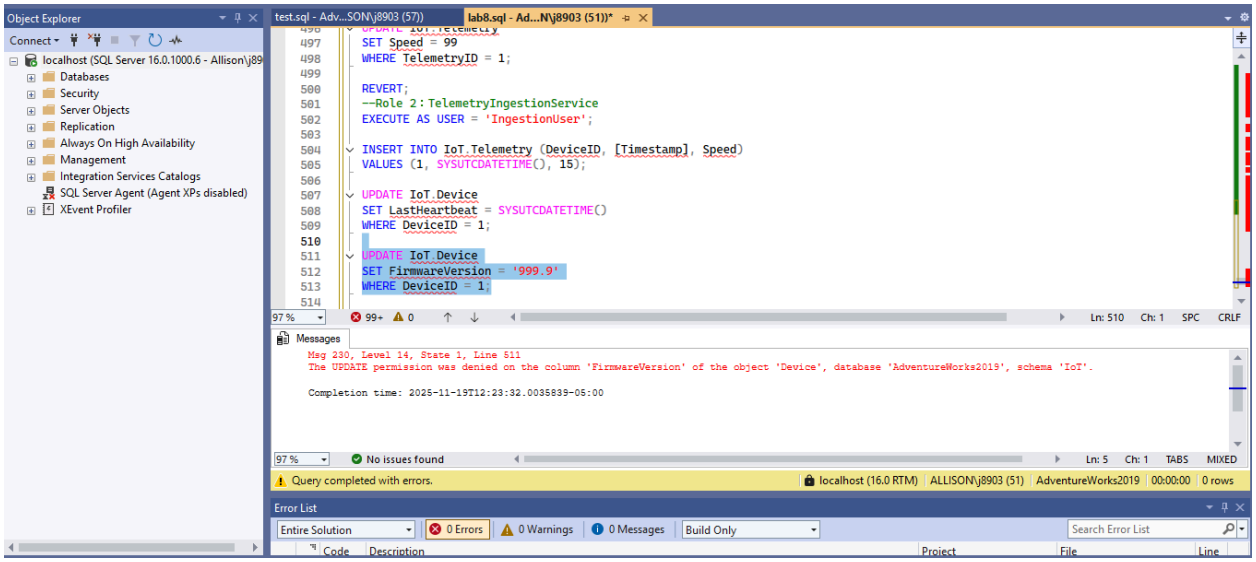


2,TelemetryIngestionService

INSERT Telemetry → success

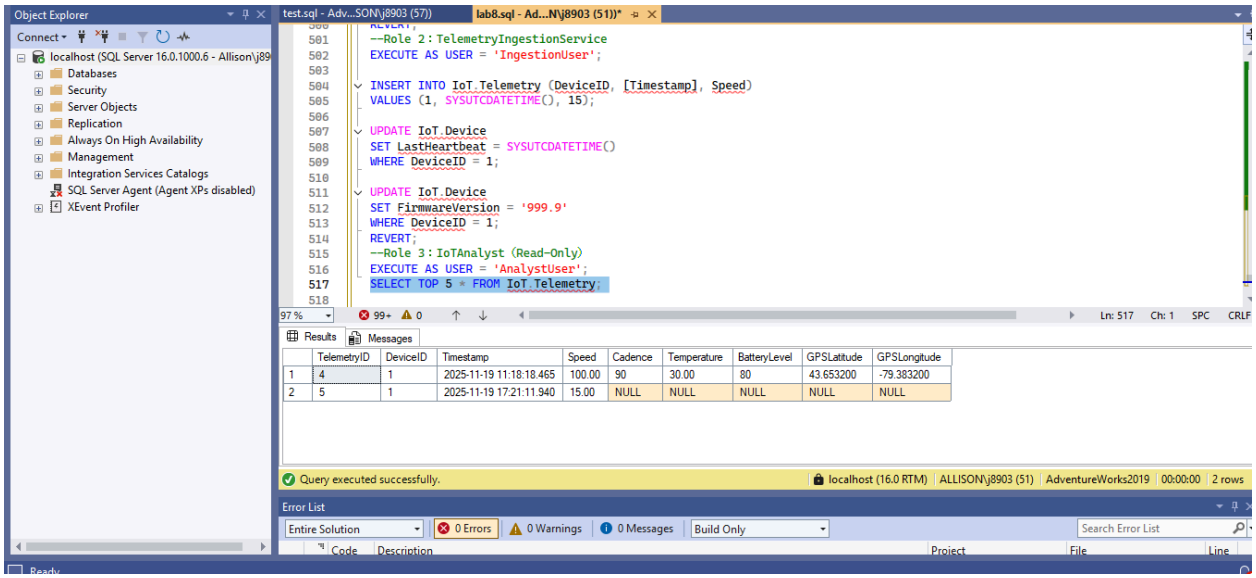


UPDATE FirmwareVersion → denied

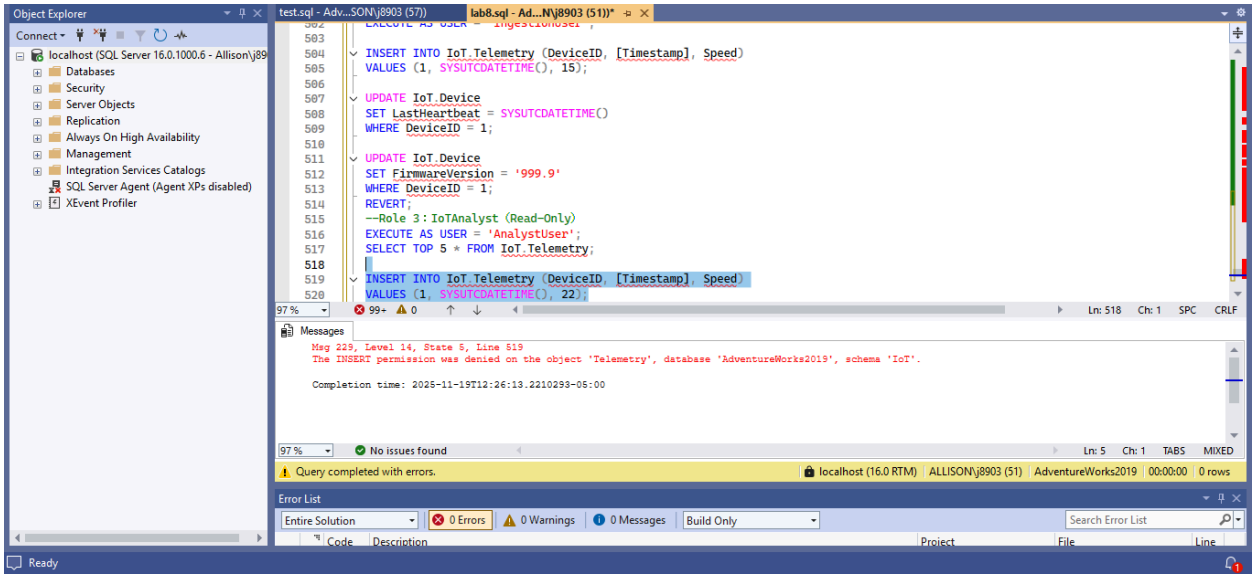


3.IoTAnalyst

SELECT → success

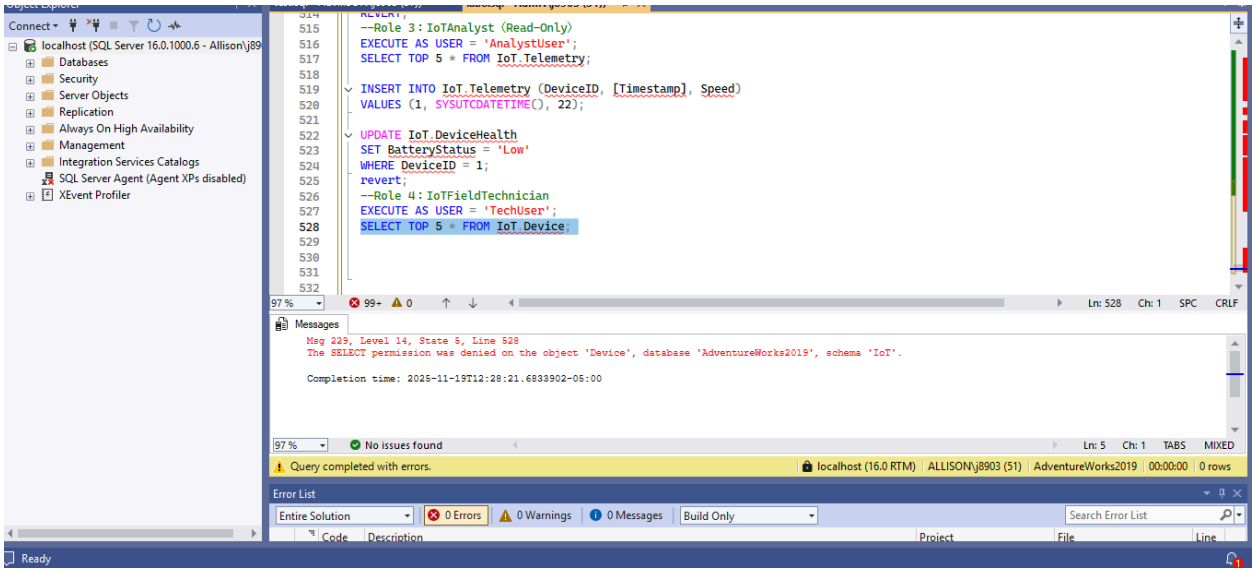


INSERT → denied



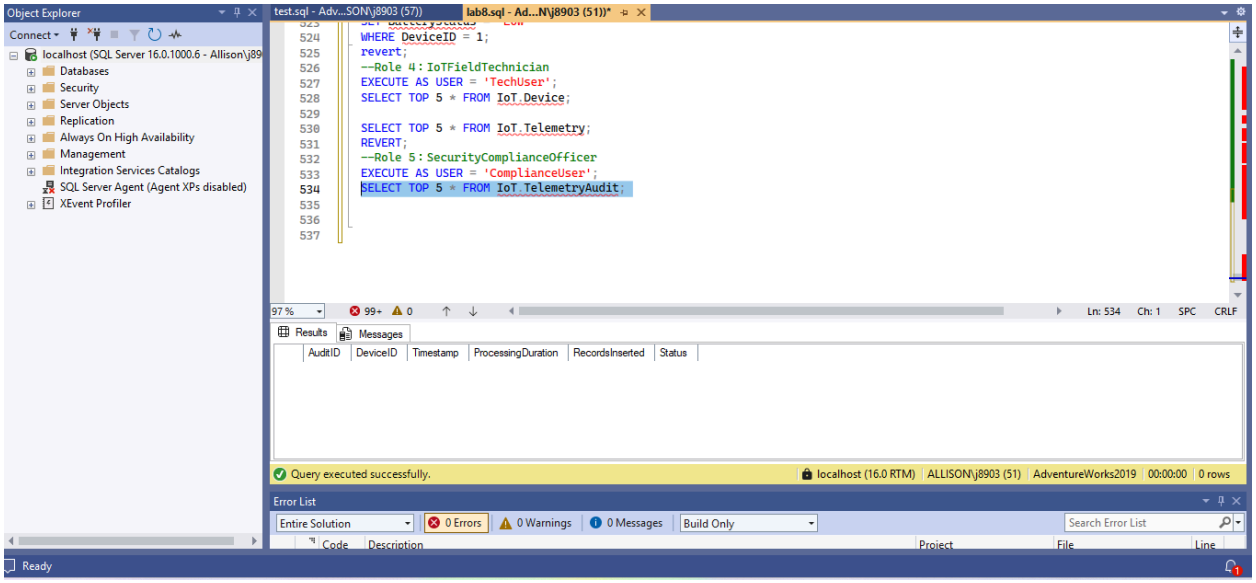
4. IoTFieldTechnician

SELECT Device → denied

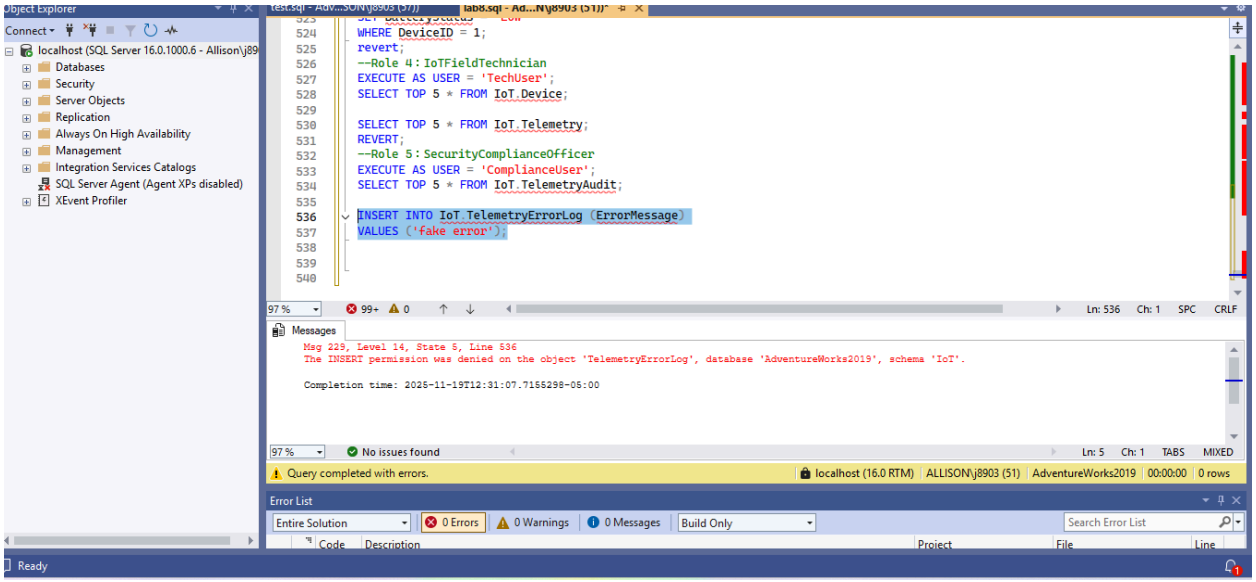


5.SecurityComplianceOfficer

SELECT Audit → success



INSERT ErrorLog → denied



All tests confirmed permissions were correctly enforced.

8. Conclusion

This lab successfully implemented a production-grade IoT backend aligned with enterprise database engineering standards.

Key achievements include:

1.ACID-Compliant Telemetry Pipeline

Prevents partial sensor data ingestion and ensures reliable device health computation.

2.Advanced Concurrency Control

Blocking, dirty reads, repeatable reads, and snapshot isolation behaviors were validated across real SQL Server sessions.

3.Secure Role-Based Access Control
Strict least-privilege permissions ensure compliance with privacy regulations (GDPR/CCPA).
4. Professional Logging & Auditing
TelemetryErrorLog and TelemetryAudit provide operational traceability for monitoring, debugging, and compliance review.
Overall, the system is secure, reliable, and scalable for large-scale real-time IoT deployments.