The CMS Detector Control Systems Archiving Upgrade

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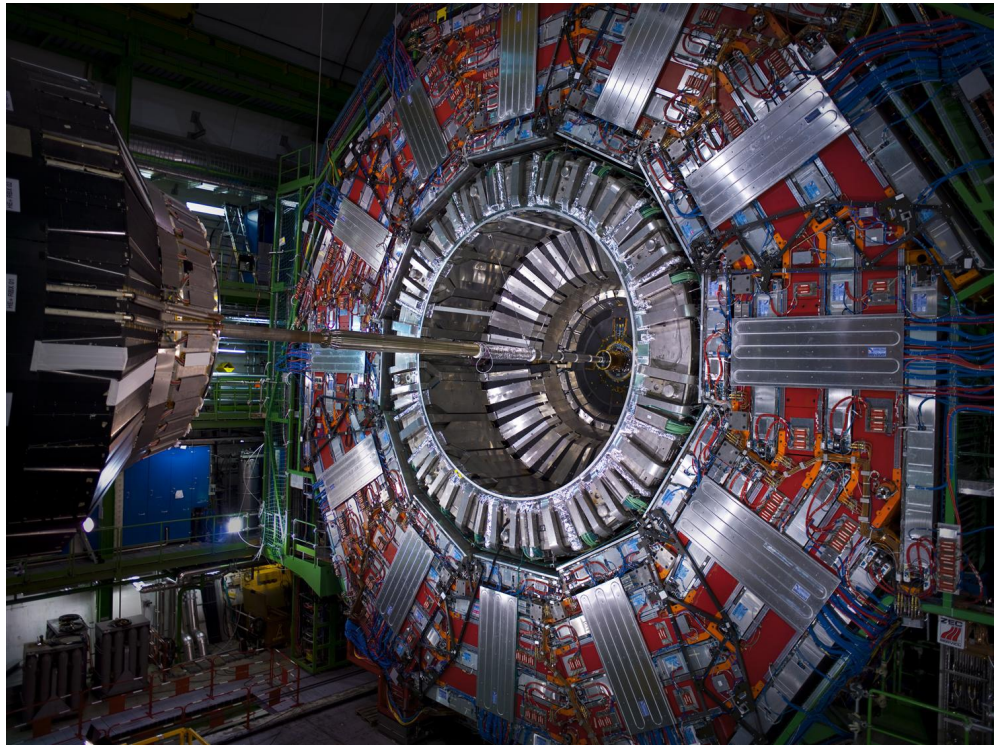
Introduction



- **The CMS experiment at CERN**
  - One of the four LHC detectors
  - General-purpose particle detector located 100 m underground near the French-Swiss borders
  - 241 institutes in 54 countries (May 2022)
  - Over 100 million readout/data channels

- **Phase-2 upgrades in preparation for the HL-LHC include:**
  - New inner tracker with higher resolution and timing capabilities.
  - New high-granularity end-cap calorimeter with improved energy resolution.
  - New muon system with better track reconstruction and momentum resolution.
  - A new trigger and data acquisition system that can handle the increased data rates from the HL-LHC.

CMS Detector Control System (DCS)

- **15 years of successful operations**
  - 24/7 uninterrupted monitoring and safe operations
  - 17 TB of conditions data into the CMS Oracle Conditions database
- **WinCC Open Architecture (OA) is the SCADA software**
  - JCOP and CMS framework built on top of WinCC OA
  - 25 distributed and redundant WinCC OA projects
  - ~ 55 Windows servers
  - ~ 21500 FSM nodes
- **Continuous maintenance and upgrades**
  - Upgrade to WinCC OA 3.16 during LS2 (2020) ✓
  - Upgrade to WinCC OA 3.19 during the end of year break 2023-2024

Figure 1: CMS control room

Figure 2: Top view of the CMS FSM

The Next Generation Archiver (NGA)

- **Developed in collaboration between CERN and ETM**
- **Distinct separation of concerns between WinCC OA and database storages into frontend and backend modules**
- **Modular DB backend concept**
  - Support user-specific DB backend interfaces
- **Main improvements:**
  - Scalability
  - Performance
  - Flexibility

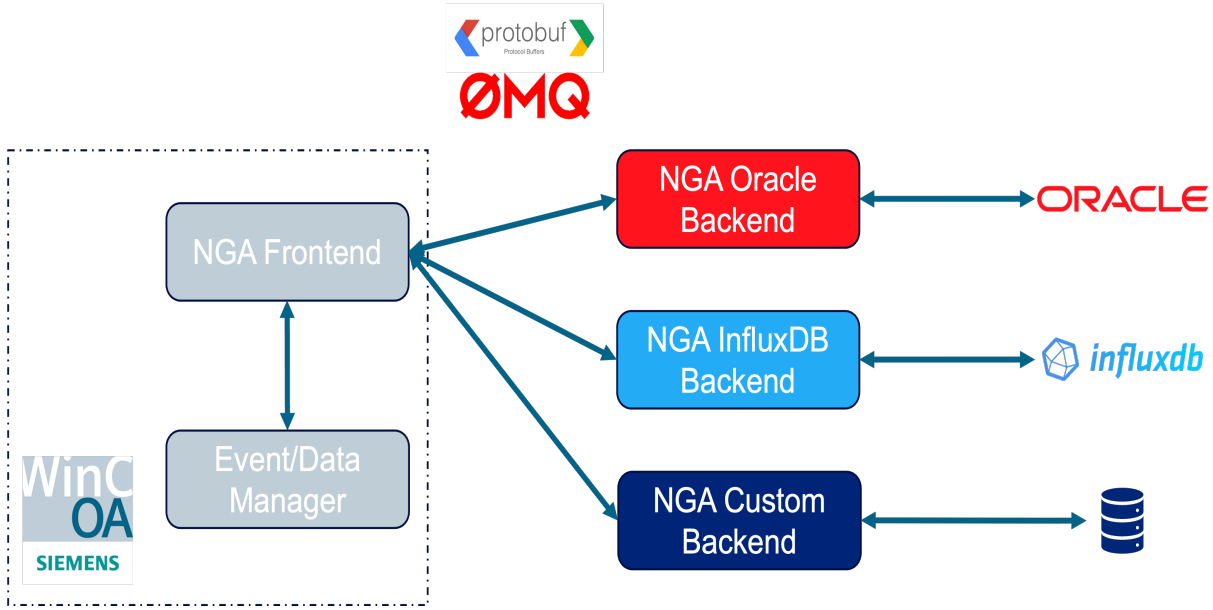
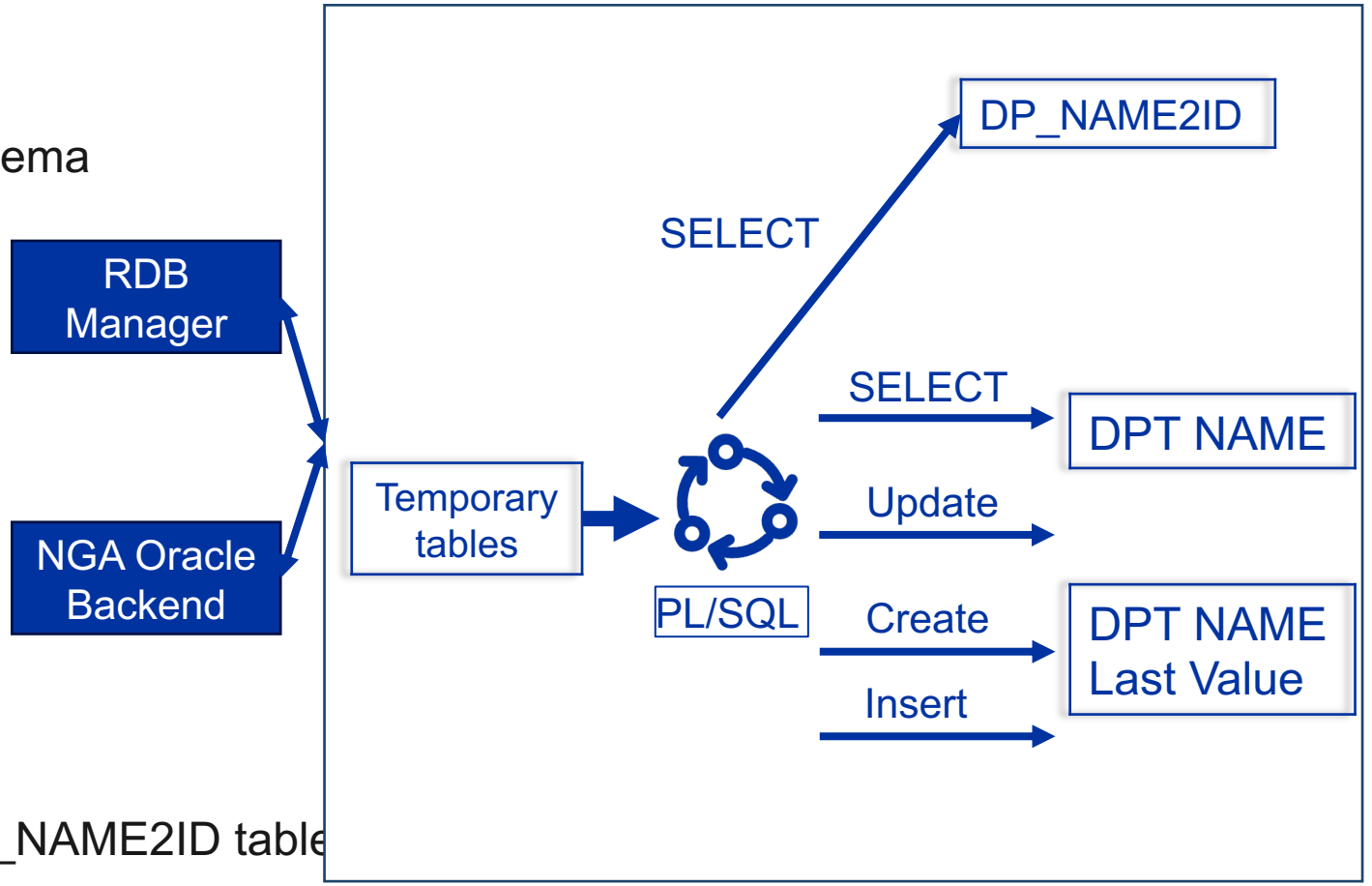


Figure 2: NGA architecture overview

CMS Oracle Conditions DB - Description

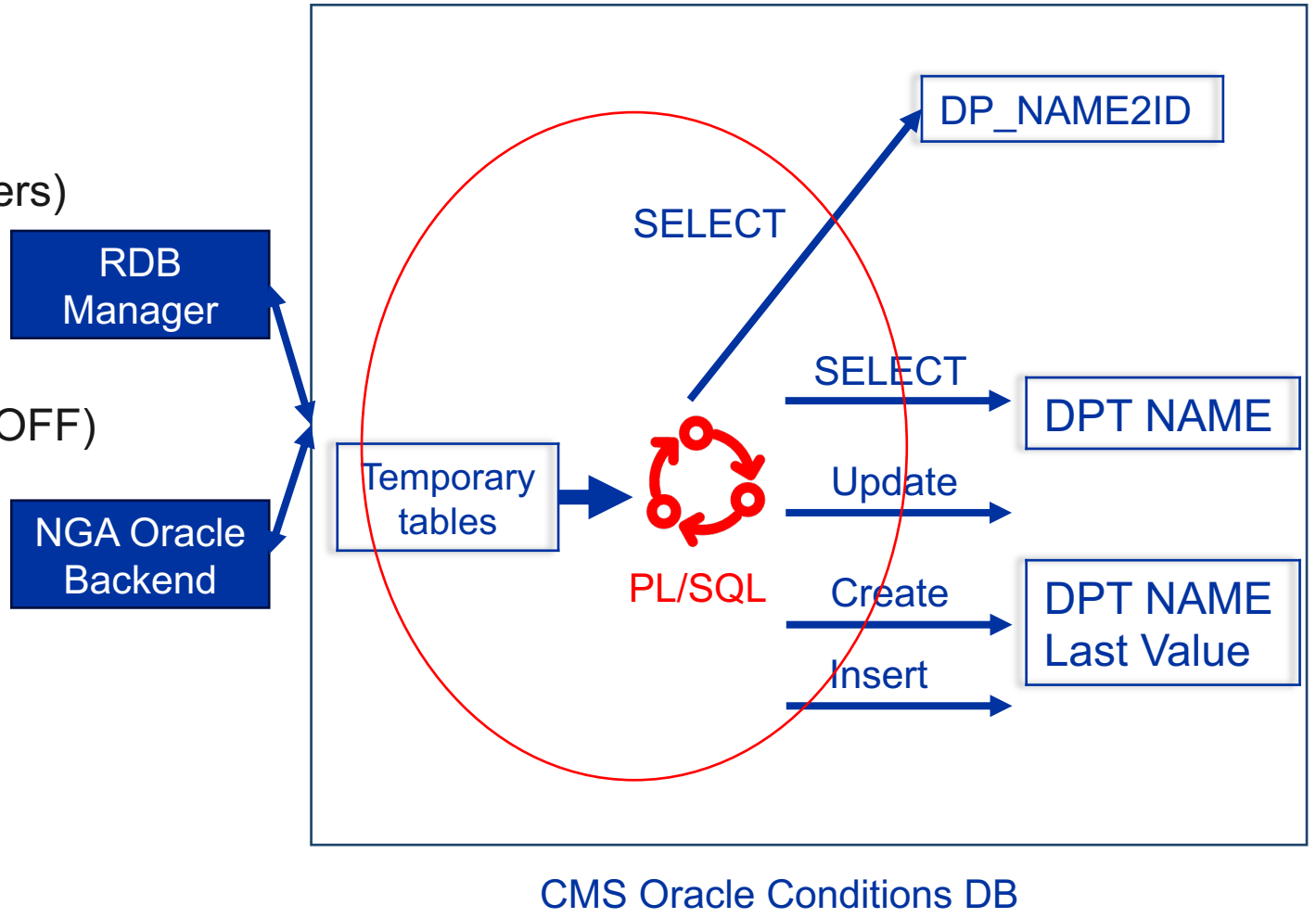
- **CMS Oracle Conditions DB**
  - Built on top of the official ETM Oracle DB schema
  - Custom PL/SQL
    - Dynamic table creation aligned with the data structures in WinCC OA
      - Table with complete history for every DataPoint Type (DPT)
      - Column per DataPoint Element (DPE)
    - Last value table for every DPT
    - Data is first written into temporary tables before transferring to final tables
    - DB static identifier for every datapoint (DP_NAME2ID table
      - Addressing potential DP ID changes in WinCC OA during project reinstallation



CMS Oracle Conditions DB

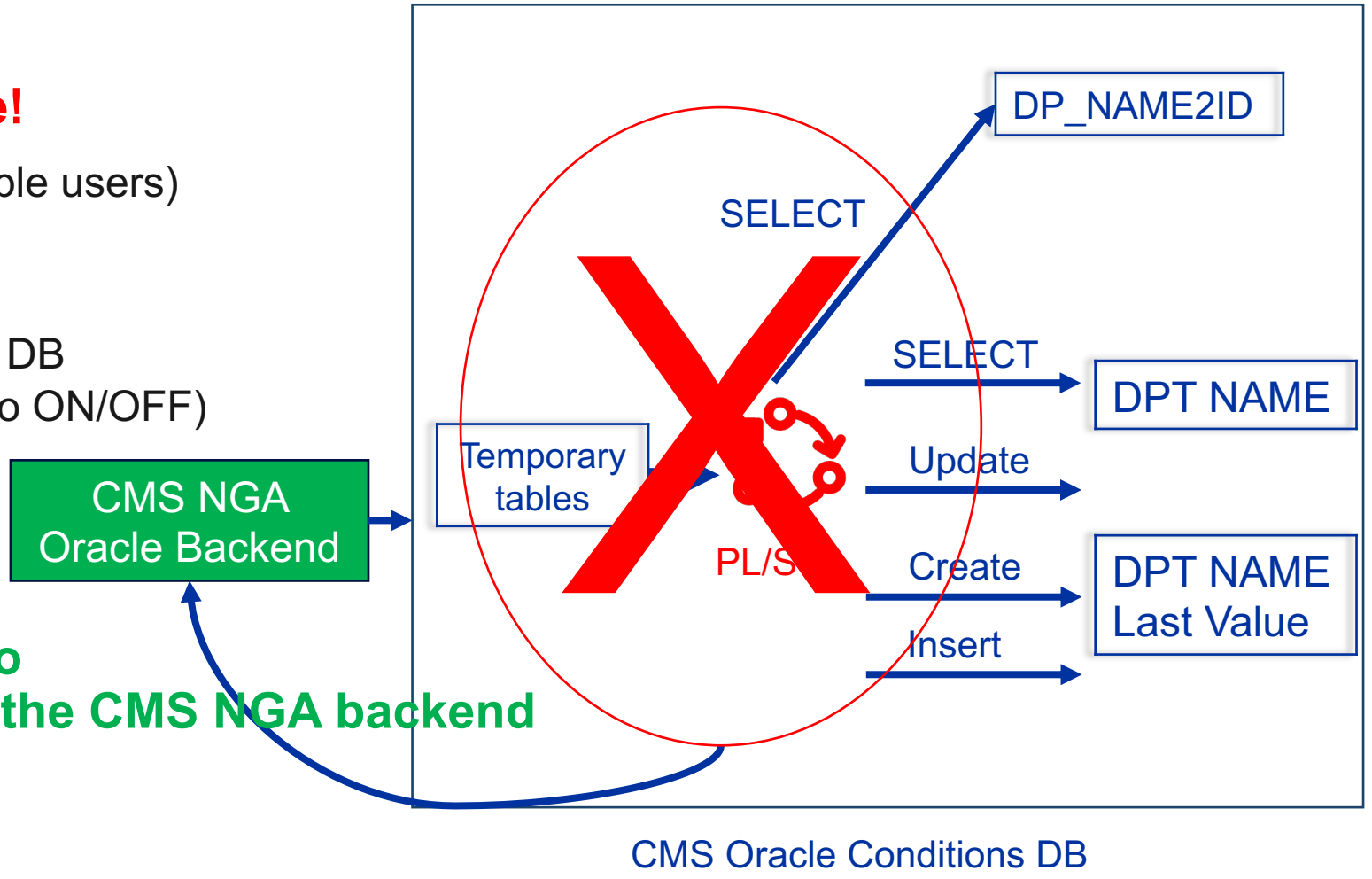
CMS Oracle Conditions DB - Problem

- **Big load on the central database!**
  - One Oracle conditions DB (with multiple users) serves all the CMS DCS projects
  - A significant burst of data load on the DB on state transitions of the detectors (to ON/OFF) within a brief period.



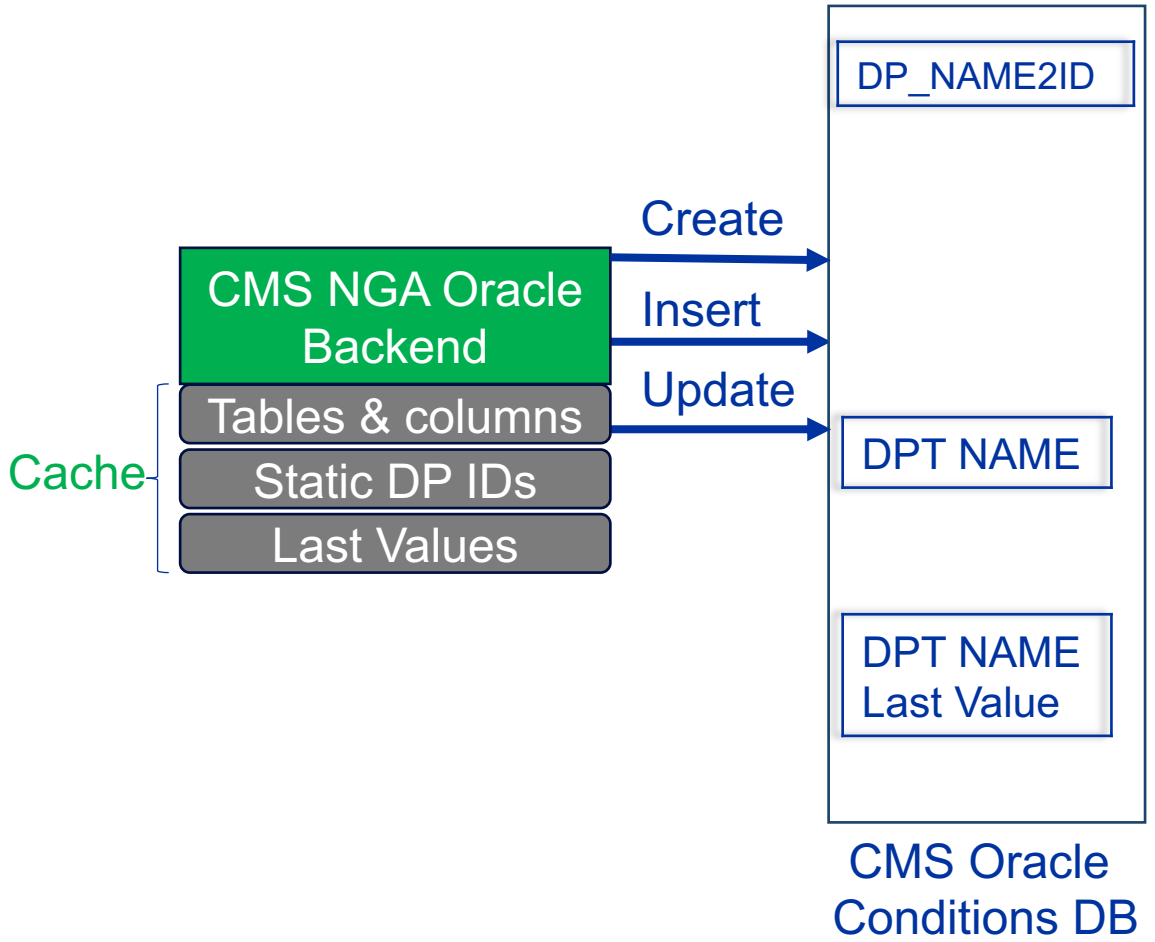
CMS Oracle Conditions DB - Solution

- **Big load on the central database!**
  - One Oracle conditions DB (with multiple users) serves all the CMS DCS projects
  - A significant burst of data load on the DB on state transitions of the detectors (to ON/OFF) within a brief period.
- **Move the PL/SQL functionality to a distributed architecture using the CMS NGA backend**

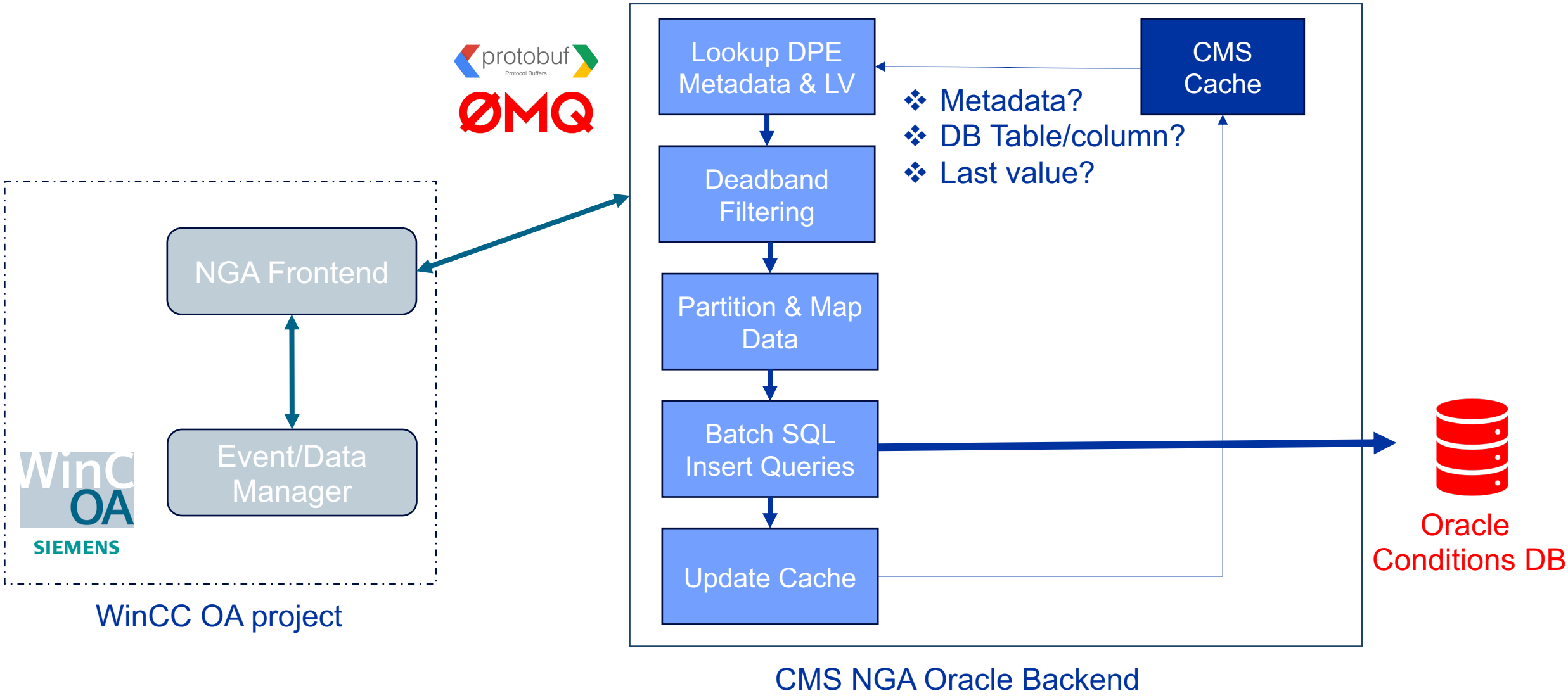


CMS NGA Oracle Backend - Design

- **Built on top of the official NGA Oracle backend**
- **Extended features**
  - Caching mechanism
    - In-memory caching data from the conditions DB
      - Tables and columns
      - Static DP identifiers
      - Last value records
  - Efficient memory usage
    - Shared pointers (QExplicitlySharedDataPointer)
    - Avoid unnecessary data duplication
  - Optimized writing procedures to the CMS conditions DB
    - Batch SQL insert/update queries to the DB tables



CMS NGA Oracle Backend – Data flow



CMS NGA Oracle Backend – Current Status

- **Finalized development phase – Beta version released**
- **Test phase started**
- **Initial benchmark tests show up to 40% faster writing**
  - Could be optimized with configuration tuning
- **Deployment into production during end of year break 2023-2024**

CMS NGA Oracle Backend – Recap

- **CMS uses a custom conditions DB optimized for third-party access**
- **CMS has built its custom Oracle NGA backend**
  - Optimized Caching mechanism
  - Optimized DB insertions
  - Reducing the load on central DB
- **Promising benchmark results in preparation for even higher data rates**
- **Deployment in the production systems during the end of year break break 2023-2024!**

Thank you!