

Circuit Breaker Asset Management using Intelligent Electronic Device (IED) Based Health Monitoring

Carey Schneider

Mike Skidmore

Zak Campbell

Jason Byerly

Kyle Phillips

American Electric Power

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- ❑ Introduction
 - Asset Health Analysis
- ❑ Circuit Breaker Asset Management
 - Station Asset Management Group
- ❑ The AEP Asset Health Center
- ❑ Circuit Breaker Past Practices
 - Digital Relays
 - Dedicated Circuit Breaker Monitors
- ❑ New Methods
 - Goals
 - Parameter Needs
- ❑ Suggested Best Practices
 - Circuit Breaker Event File Parsing
 - Circuit Breaker Virtual Monitoring

Introduction: Asset Health Analysis

- ❑ T&D utilities are tasked with maintaining a large fleet of aging assets
 - At AEP, 33% of circuit breakers are over 30 years old
- ❑ Historically asset management was done at a local level, but has transitioned to a central function

Asset health is not a new concept

- We have been inspecting and testing our equipment for years
- This analysis has been used to make maintenance and replacement decisions... expert analysis from local engineers provided reliable but costly asset management



Circuit Breaker Asset Management



- ❑ Station Asset Management Group
 - Responsible for the maintenance, replacement, and failure mitigation of substation equipment
 - Maintenance plans based on regulations and time-based guidelines
 - Circuit breaker visual inspections
 - Circuit breaker preventative maintenance
 - Replacement plans based on age, funding, and equipment reliability
 - Circuit breaker replacement algorithm
 - Breaker renewal initiatives

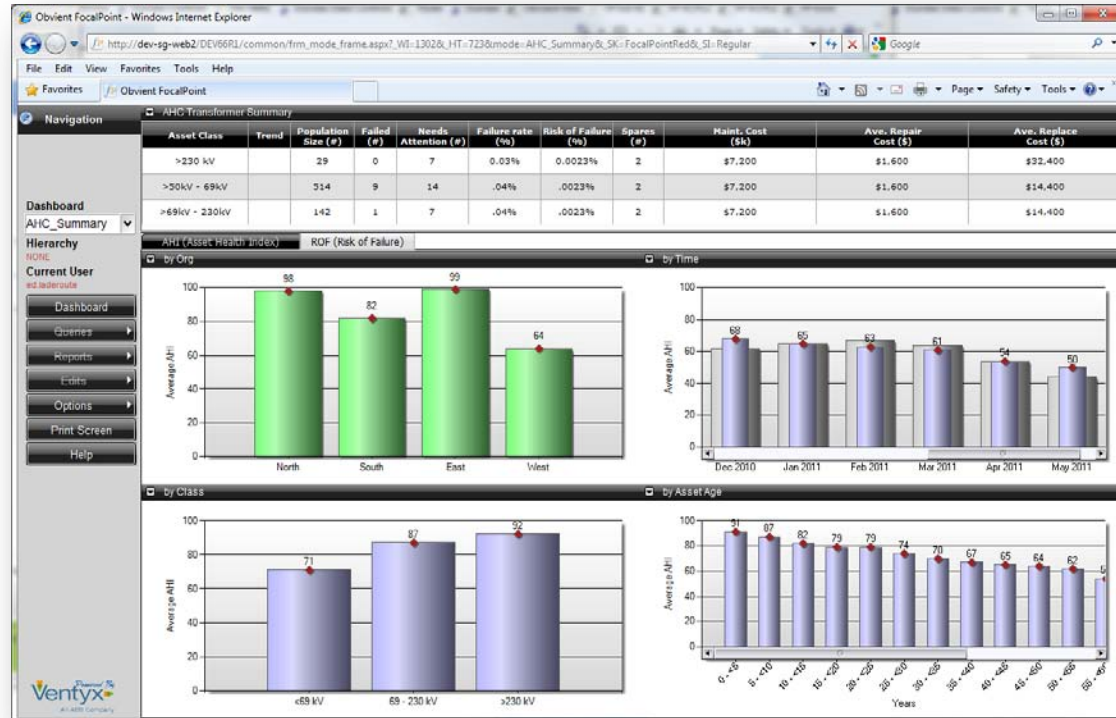


The AEP Asset Health Center



AHC Software Solution

- Web-based tool
- Multiple data sources:
 - Nameplate
 - Inspection results
 - Test results
 - SCADA
 - **Fault files**
 - **Real time monitors**
- Algorithms
 - Circuit breaker, battery, and transformer
- Dashboards
 - Replacement score automation
 - Maintenance score automation



□ How we got here!

I. Digital relays

- Built in breaker contact wear function
- Required detailed breaker information, the fault history of breaker, and did not filter relay test operations
 - *Limits the usage on large scale!*
 - *False alarms to operations and field!*
 - *Not centrally controlled!*

II. Dedicated circuit breaker monitors

- SF6 pressure/density, motor current, heater current, breaker contact wear, alarms, and log data
- Complicated, duplicative, and prone to failure
 - *High cost for minimal benefit!*

New Breaker Health Monitoring Methods



- ❑ What is the goal?
 - Automation and aggregation of real time health data of circuit breakers to allow implementation of condition based maintenance
- ❑ How can we achieve our goal?
 - **Leverage existing digital relay knowledge and existing digital relay data to provide circuit breaker health monitoring and analysis**



New Breaker Health Monitoring Needs



- Parameters for CB health
 - Contact wear (I^2T)
 - SF6 gas temperature
 - SF6 gas moisture and density
 - Operating coil current
 - Motor current
 - Operation counts
 - Load current
 - Voltages
 - Contact timings

❑ Parsing CB Control Relay Event Records

- Oscillography traces from protective relays
- Event based triggers create files on server automatically
- Circuit breaker wear calculated on per-pole basis
 - Based on fault trips only
 - Positive sequence current and voltage minimums
 - Maximum RMS current must be above minimum value
- Test events are ignored

□ Circuit breaker wear per pole calculation

$$i^2t = \int_{ll}^{ul} i^2 dt$$

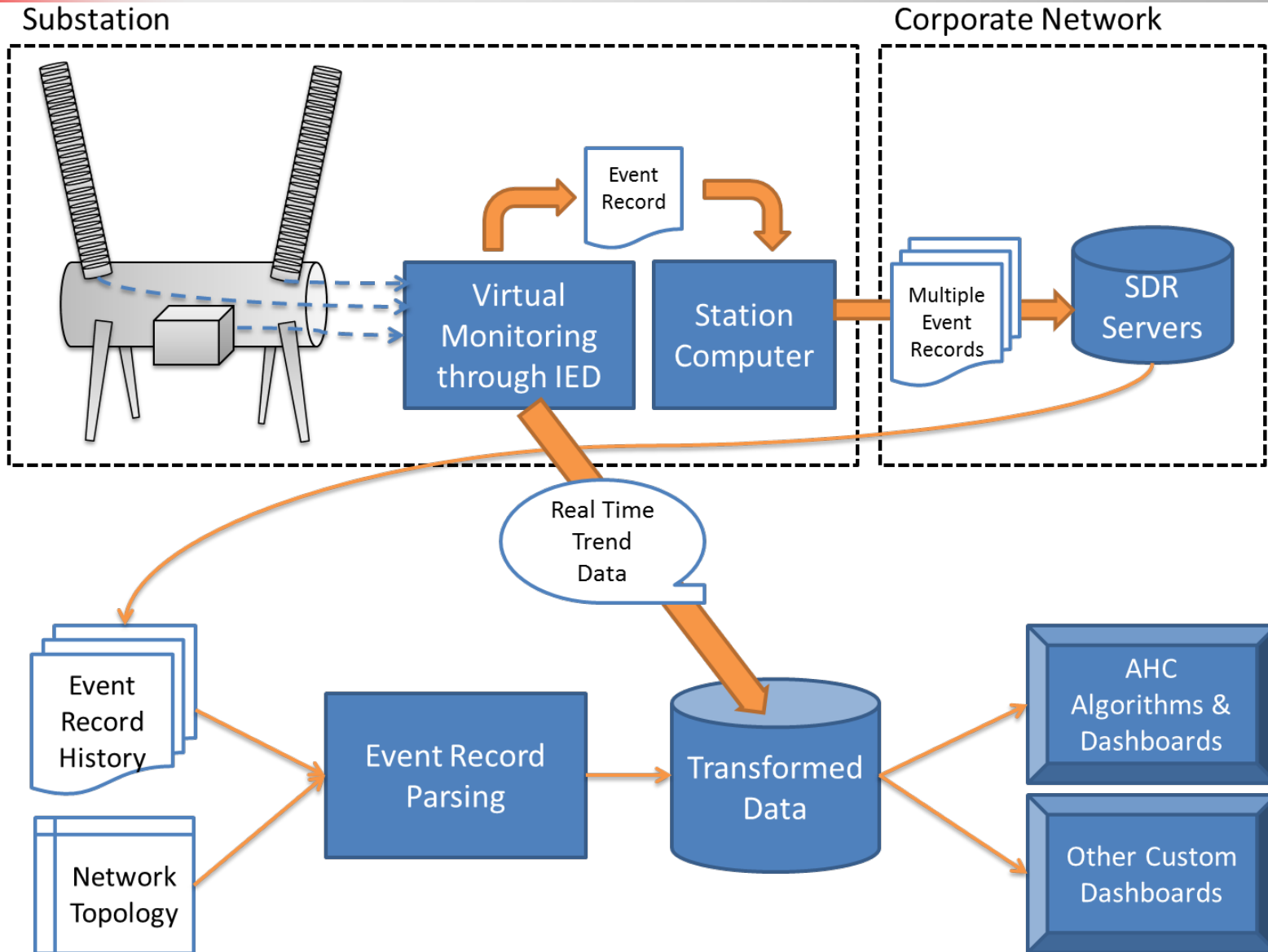
- i = RMS current per pole
 - ll = time (sec) when arcing begins
 - ul = time (sec) when the current is extinguished
 - The time is estimated based on trip coil energization
- Data gathered from fault files to calculate the integral
- Result is passed to AHC software for visualization, algorithm analysis, trending, and messaging

Suggested Best Practice: Virtual Monitoring



- ❑ Virtual Monitoring through a Standard Breaker Control Relay Package
- ❑ Circuit breakers are controlled and monitored using an IED relay
- ❑ Breaker control relay functions
 - Breaker control
 - Automatic reclosing
 - Supervisory control and data acquisition
 - Disturbance monitoring
 - Asset health monitoring

Suggested Best Practice: Virtual Monitoring



Suggested Best Practice: Virtual Monitoring



- ❑ Three types of event records
 - Oscillography, sequence of event, and fault records
- ❑ The relay is time synchronized
- ❑ Event records, voltages, and currents are collected
- ❑ The substation computer organizes the data based on relay location
- ❑ Relay location is converted to serial number

Suggested Best Practice: Virtual Monitoring



- Remote module for circuit breaker monitoring
- Readings
 - SF6 density
 - Motor run time
 - Trip coil currents
- Readings sent to a CBM relay
- The CBM relay is also time synchronized
- The relay data is aligned via GPS time for an event

❑ So what?

- Auxiliary 'a' and 'b' contacts, trip coil currents, and close coil are collected for any breaker operation
- The Asset Health system will determine operation time and operation type based on the data

❑ Final outcome: Advanced Monitoring Techniques

- Fault clearing times (per pole)
- Operation performance using coil signature analysis
- Contact wear using i^2t actual calculations
- Real time SF6 analysis
- Breaker reliability

Questions?

