Distribution state estimation: Experiences incorporating the evolving spectrum of distribution measurement capabilities and operating needs

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Background

- State estimation heavily used in transmission
- NERC IRO-002 R7 requires state estimation for reliability coordinators
- Experience base from support and success in transmission estimation.
- Real-time DMS analysis in production

Purposes of estimation

- Real-time state
  - Limit monitoring
  - topology confirmation
  - Control availability and verification
- Initialization of real-time or study applications
  - Reconfiguration, manual or optimization
  - Reactive control
  - Demand or loss reduction
- Model validation or correction

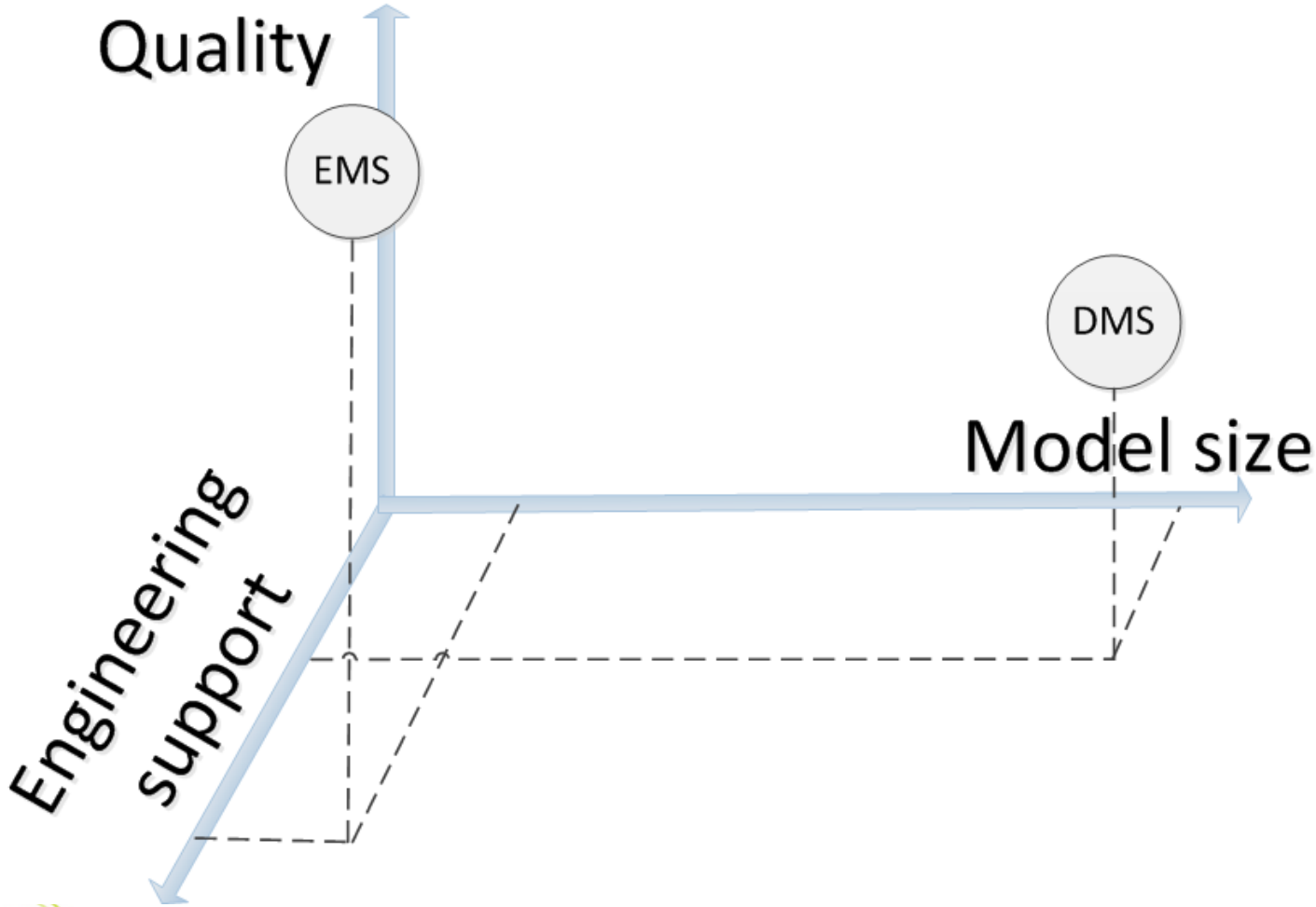
Data models

- Elephant in the room = Data models

Data model challenges

- Large scale
- Quality challenge
- Validation difficulty
- Rate of change
- Unbalanced with neutral

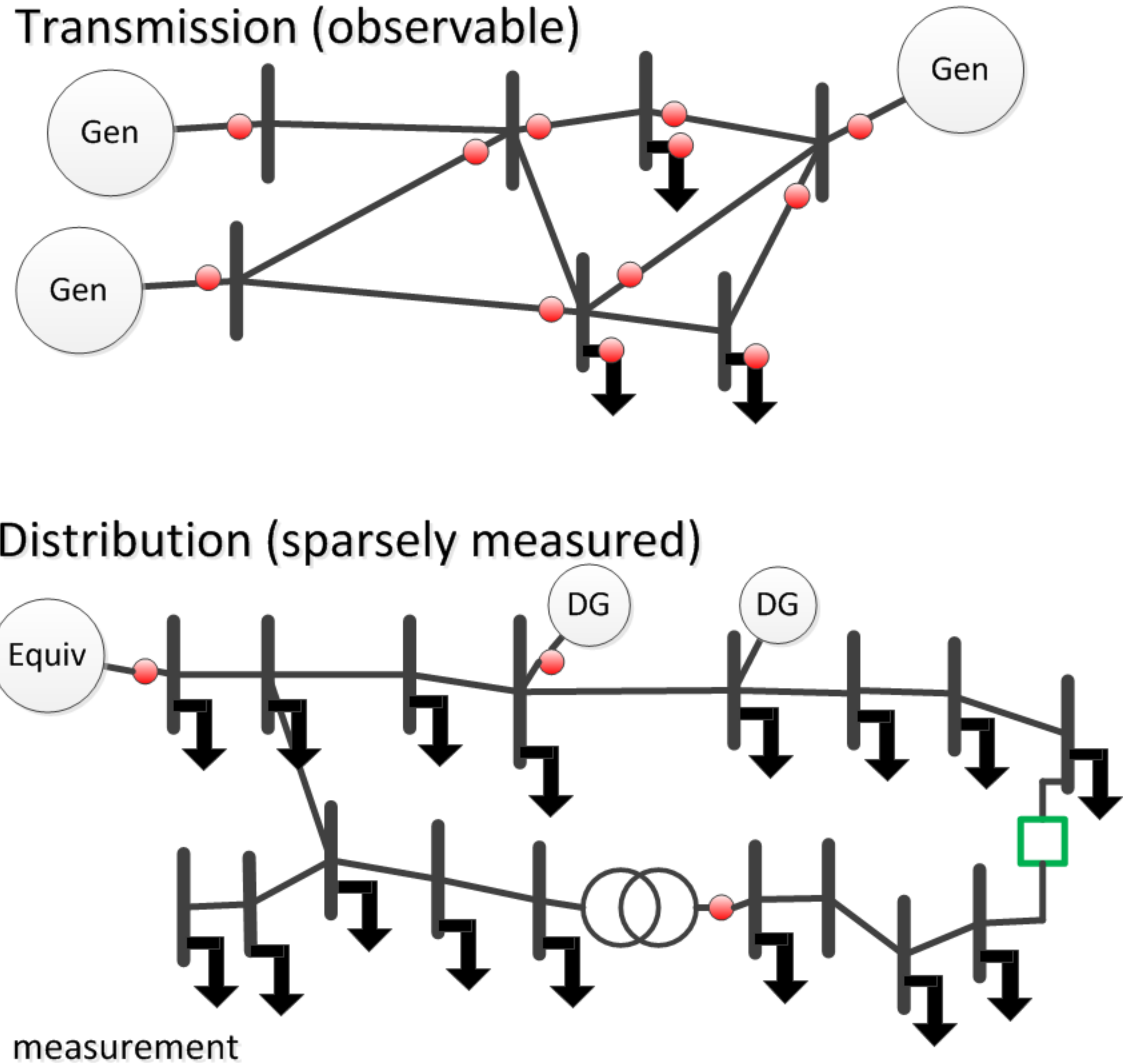
Model Quality Comparison



Measurement sources

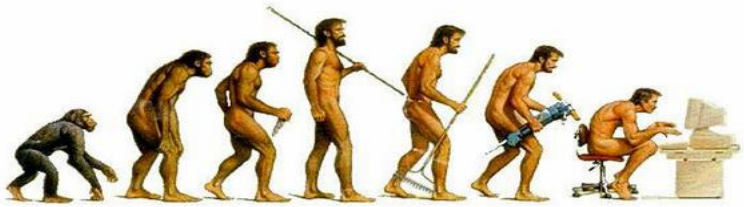
- Traditional substation SCADA measurements
- Feeder capacitors and switches
- Line sensors – increasing volume
- PMU measurements – rare today
- Metering data
  - The other elephant
  - volume, latency, time-skew

Scarcity of traditional Measurements



Evolution

- Planning model, study powerflow from drawings and billing data
- Manual or off-line matching of case to billing and known construction and switching states
- Online ties to SCADA for switch status and feeder head measurements.
- Supplement with additional measurements
- Traditional state estimation and error detection



Solution techniques

- Manual matching of loads
- Load, cap, and tap adjustment to match measurements, topology, and load distribution patterns
- Weighted Least Squares (WLS) textbook
- Weighted Least Absolute Value (WLAV)
- Linear estimators based on PMU data

Leverage experience

- Experience from transmission (EMS) state estimation
- Best approaches depend on available data, model quality, and committed support
- Expectations should fit the situation

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A distribution utility perspective

- Initial Benefits Identified
- New Benefits Identified
- Future Benefits Identified

Initial Benefits Identified

- Preliminary work performed in 2000 – 2003 timeframe
  - To ascertain benefits when applied to electrical distribution system
  - To determine what data is required for convergence
- Two benefits identified
  - Provides “Base Case” for all analysis
  - Identifies telemetry values that may be erroneous

New Benefits Identified

- Additional data provided to Outage Evaluation system
  - Substantiate prediction of protective device operation
  - Determination of loss of load
    - Non-telemetry loads
    - Supplement outage restoration efforts
- Identification of failed (or lost) telemetry measurements

Future Benefits Identified

- State of communication network
  - Individual remote site
  - Master communication site
- State of integrated DMS applications
  - AMI
  - Crew Management
  - GIS-supported mapping updates

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