



Synchronous Phase Angle Measurement Using Smart Meters

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RESEARCH

AMI data is asynchronous but would be more powerful if it were synchronous

AMI data

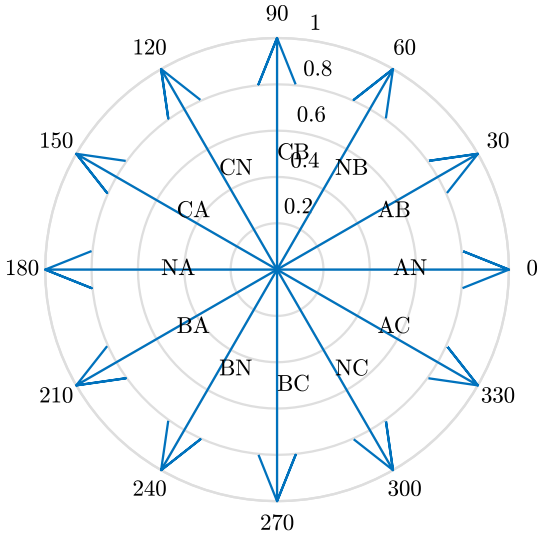
P | Q | |V| | |I| | power factor

+

voltage phase angle (referenced to substation)

Why would one want to do such a thing?

(wiring) phase detection



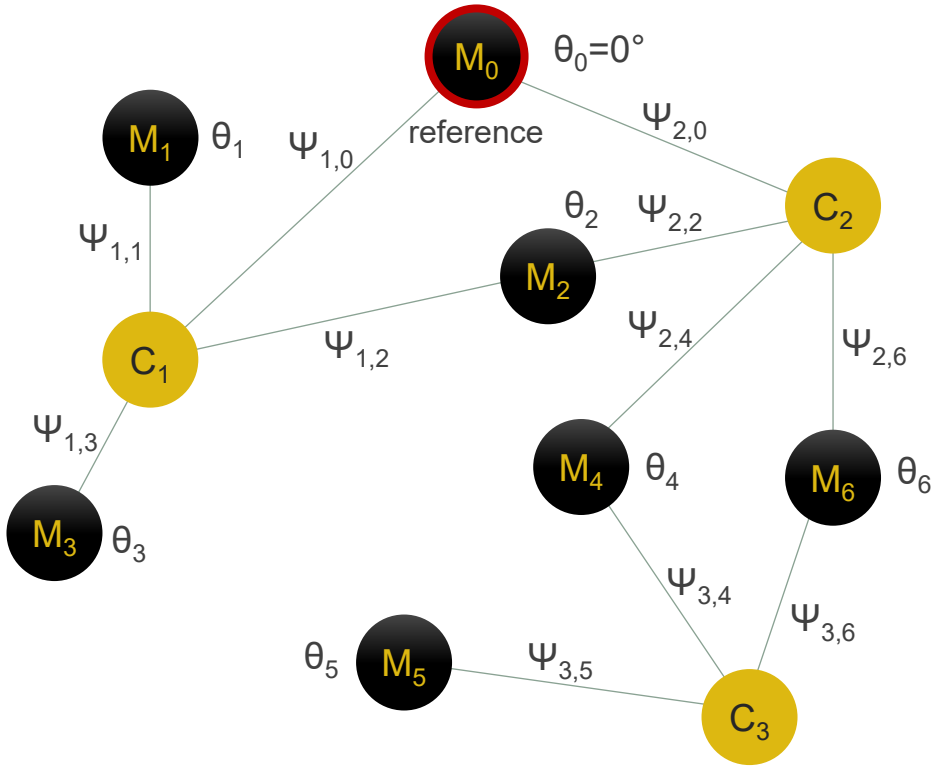
but also…

- **impedance estimation**
- **power flow**
- **loss localization**
- **island detection**
- **fault localization**

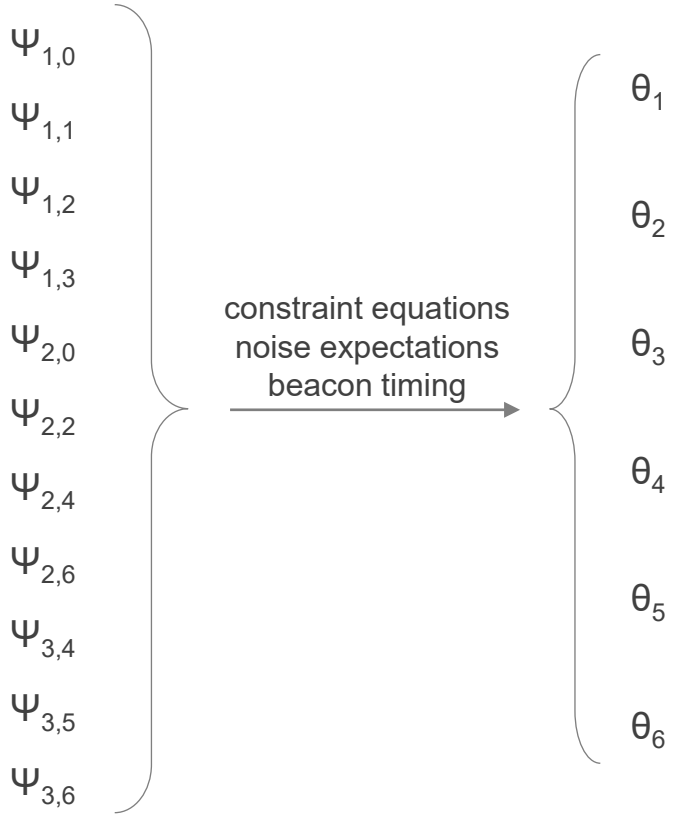
Aging infrastructure, increasing IBR and EV penetration require new distribution analytics

AMI communications network can be used to time-synchronize meters

Point-to-multipoint comms network
Each collector transmits one synchronization beacon



Cloud-based inference engine
Reference voltage phase angles (θ_n) computed



meters measure voltage phase ($\Psi_{m,n}$) when beacon received

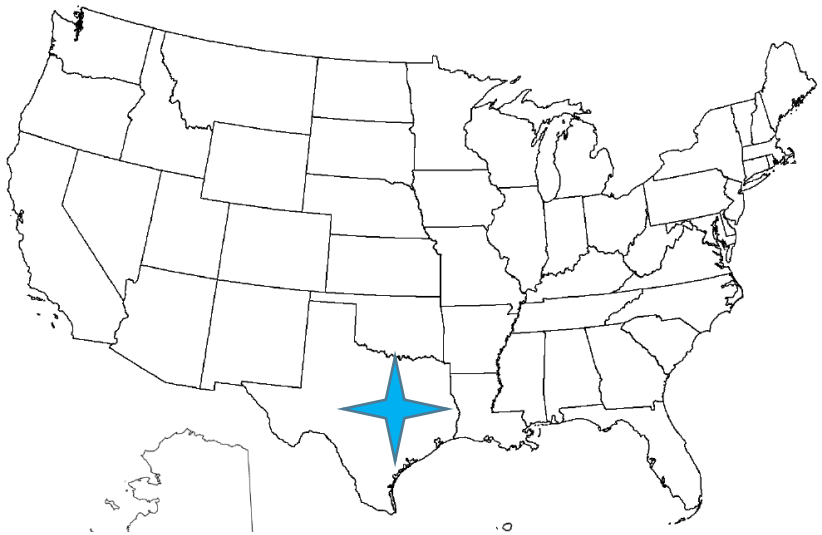
data redundancy enables error detection & noise reduction

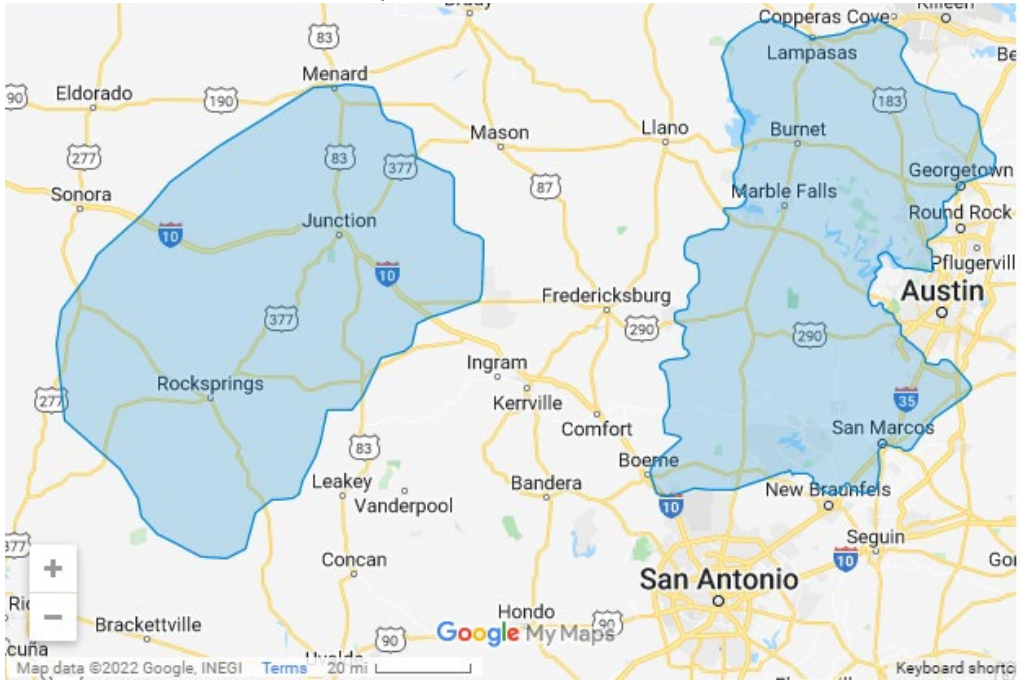
Laboratory and field data show total error < 1°

This technology is used to estimate wiring phase at PEC

Pedernales Electric Cooperative at a Glance

number of meters	372,000 (largest co-op in US)
number of collectors	270
area covered	8,100 sq. miles
substations	76
distribution lines	~24,000 miles



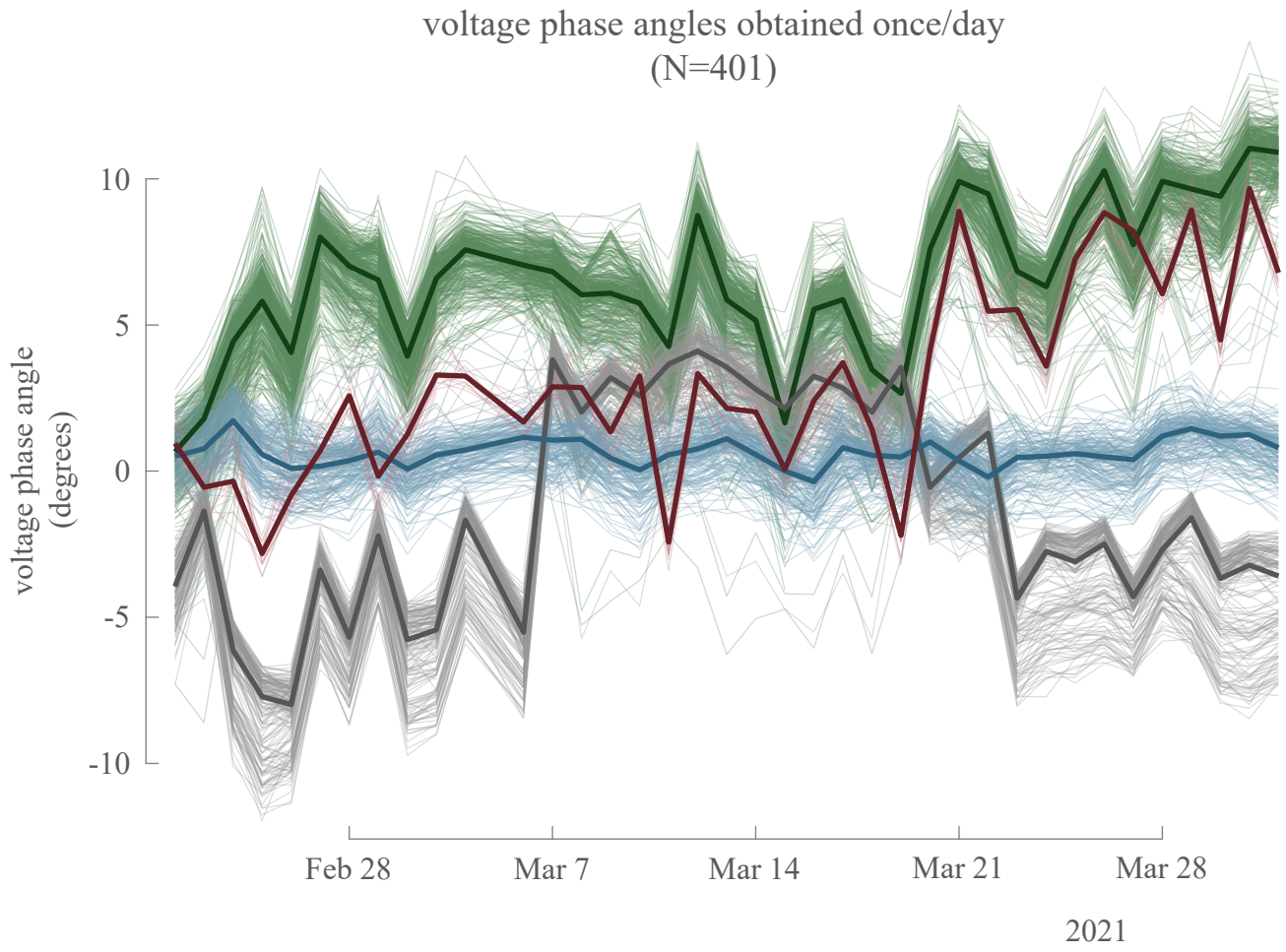


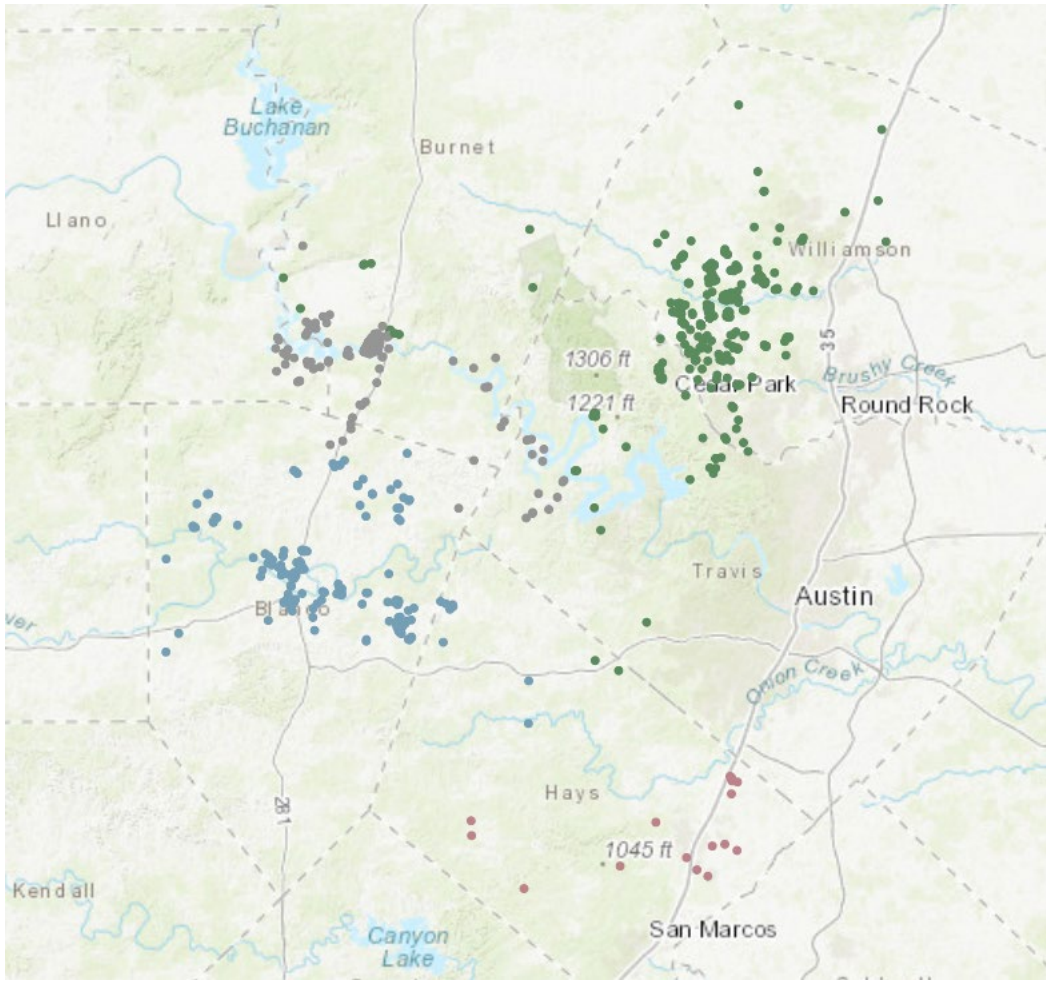
Aclara I-210+c
electric meter

Aclara RF
data collection unit

System configured to provide one snapshot per day of voltage phase angles at every meter

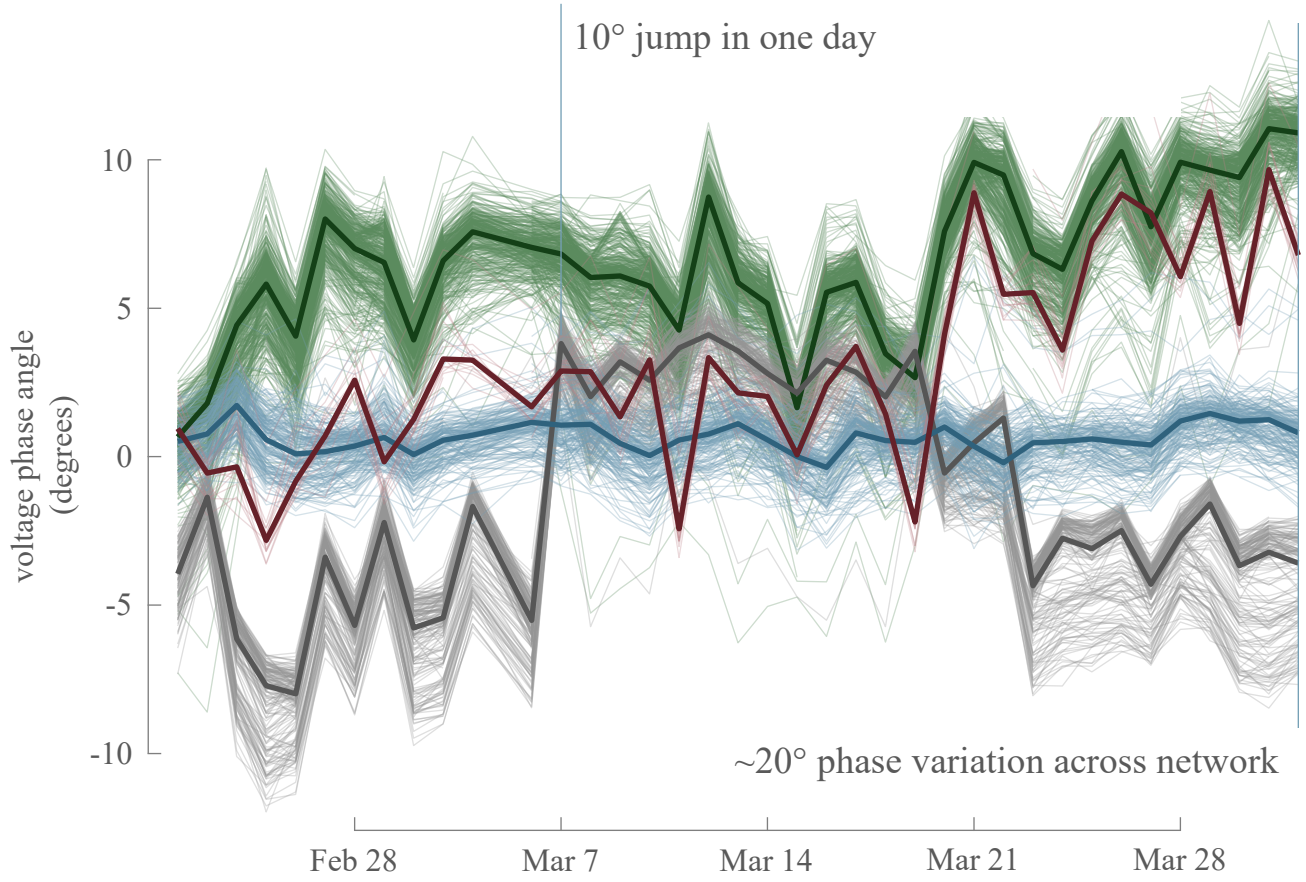
Voltage phase angles show significant variation over 1 month





Clustering by k-means on select bins of phase angle sequence DTFT

We are focused on expanding capabilities to explain observations



- work with PEC to explain observed phenomena
- scale up to ~400,000 meters
- Collect snapshots more frequently (e.g. 2-12 snapshots/day)
- merge with other AMI data

Answers to these questions could provide framework for future distribution analytics