Preliminary Exam Presentation

Scalable Multi-Period Optimal Power Flow for Active Distribution Systems

Aryan Ritwajeet Jha

Pursuing PhD (ECE) Power Systems

Introduction and Motivation

- What leads to MPOPF problem?
- What's MPOPF problem?
- How to tackle it?
- Intended Contributions of this PhD

Introduction and Motivation

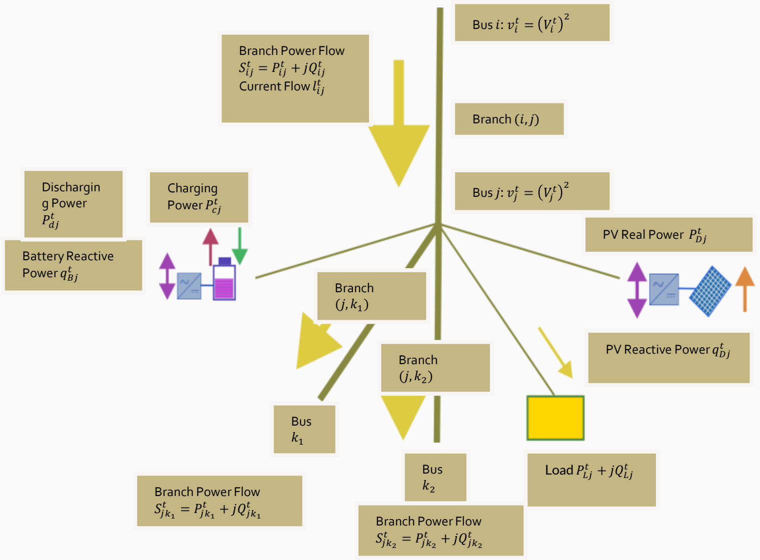
What introduces the Multi-Period Optimal Power Flow (MPOPF)? Problem?

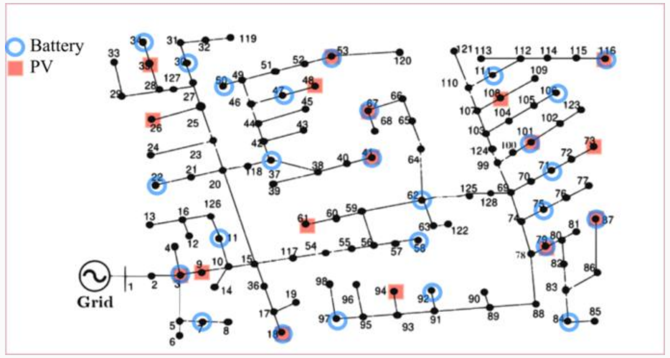
- The distribution grid is changing due to rising penetration of **Grid-Edge Devices (GEDs)** such as PVs and **Batteries**
- Eg. EVs, On-grid storage, flexible buildings

- These battery devices introduce **inter-temporal** behaviour – their actions at one time affect future states
  - This creates temporal coupling constraints
- As a result, traditional OPF (single-period) is no longer sufficient
  - The problem becomes Multi-Period OPF (MPOPF)

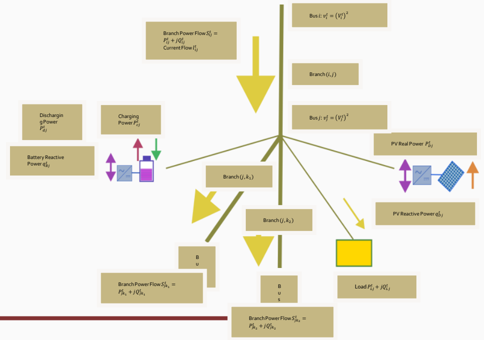
$$B_j^t = B_j^{t-1} + \Delta t \eta_c P_{c_j}^t - \Delta t \frac{1}{\eta_d} P_{d_j}^t$$

- MPOPF problems are much larger (size scales with **#devices x time-horizon**)
  - Leading to computational bottlenecks

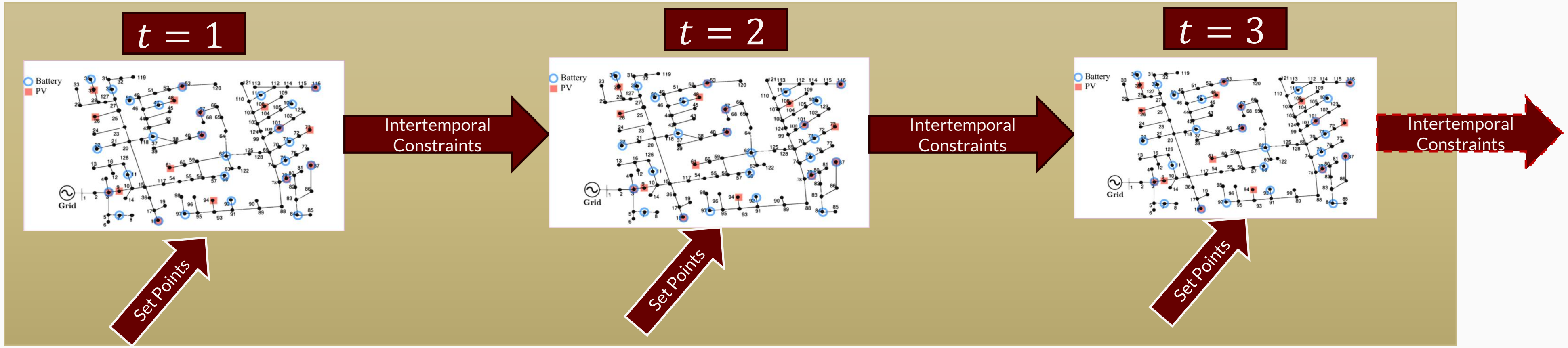




Introduction and Motivation



MPOPF Problem Visual



Rectangle sizes representative of size of each Optimization Problem

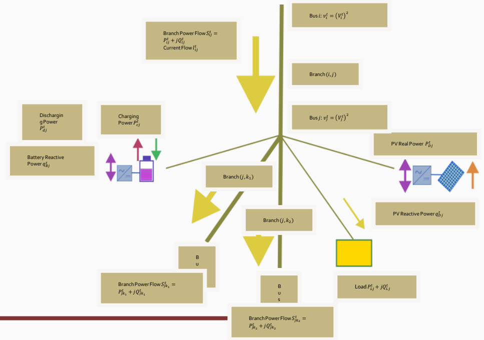
For nonlinear optimization problems, computational burden increases *superlinearly* with size!

Introduction and Motivation

Why Decomposition Approach?

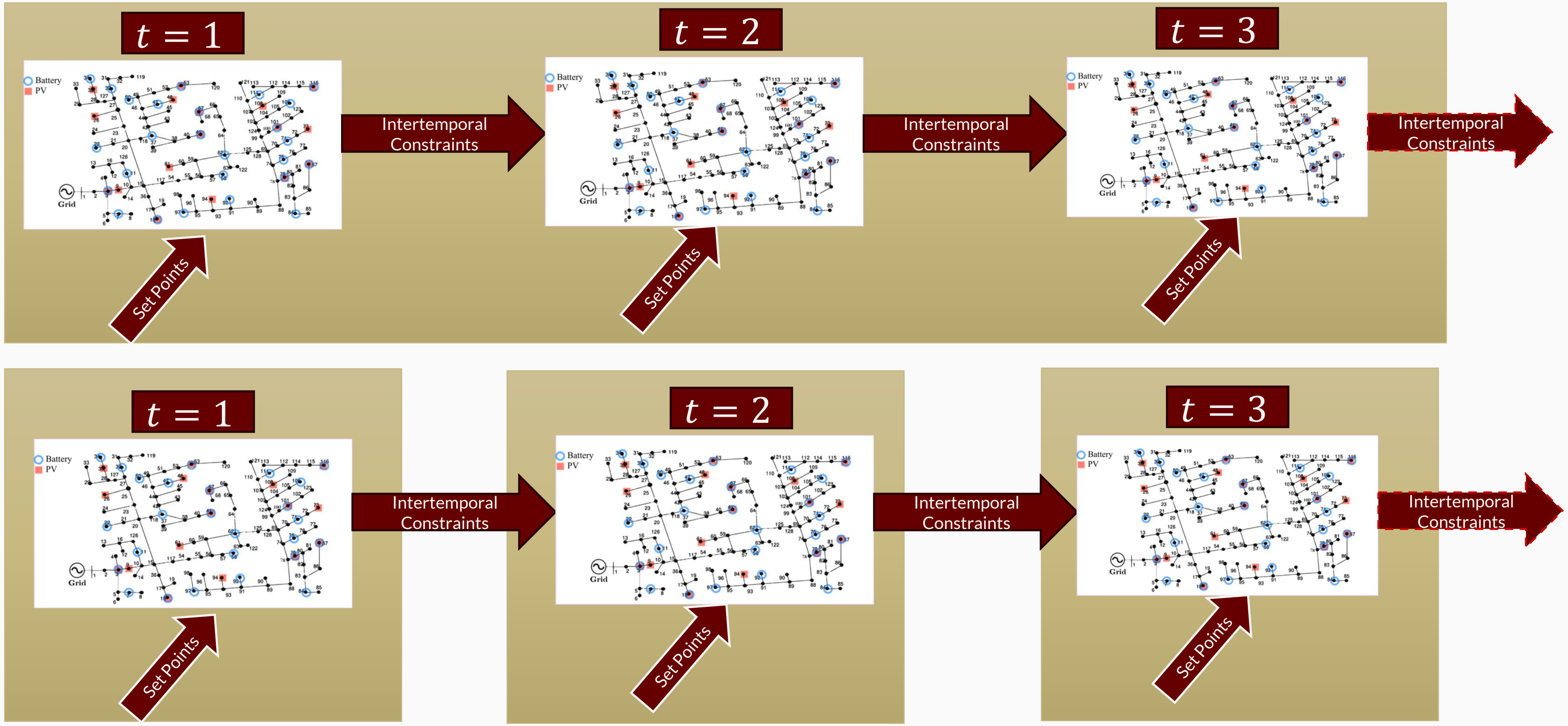
- Previously techniques like Successive Linearization [usmain] or Two-stage hierarchical optimization [Nawaf2018] have been employed for MPOPF which can miss global optimum
- Realistic modelling often requires **nonlinear** distribution system representations
  - But these are computationally expensive
- **Decomposition-based algorithms** can break MPOPF into **smaller, parallelizable subproblems**
- This enables:
  - Scalability to larger feeders and larger timescales
  - Faster or near real-time solutions
  - **Adoption by DSOs** when GED coordination becomes operationally necessary

Accurate modelling* + *Scalable Decomposition* *is the key to enabling future grid operations



Introduction and Motivation

Why Decomposition Approach? Visual



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Introduction and Motivation

Intended Contributions of my PhD

- A **framework for** solving the **MPOPF** problem…
  - Which has a **systematic procedure to model** components of power distribution system in a manner faithful to their behaviour yet computationally efficient to solve for
  - That **employs** tailored **decomposition algorithms** which can exploit model’s properties to come up with an even faster solution
  - Which has **provision for comparison of output** solution **with** those of **trusted softwares**, say OpenDSS
  - Whose **procedure** may be **theoretically justified**

An example of

Decomposition Algorithms Implemented

1. **MPDOPF - Spatial Decomposition** Algorithm
2. **tADMM - Temporal Decomposition** Algorithm
3. **DDP - Temporal Decomposition** Algorithm
4. Future Works