Redundancy Strategies for Distribution Protection

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Outline

- Background

- Redundancy practices

  – Breaker failure

  – Distribution substation

  – Distribution feeder

- Challenges with not designing for redundancy

- Solutions

- Conclusions

Redundancy is less common for distribution

Historical paradigms

- Less system impact for uncleared faults

- Many more circuits to protect

- Radial operation allows upstream backup

New realities

- Greater focus on reliability to individual loads

- Higher consequences for delayed clearing

- Scarce resources to perform detailed coordination

- Significantly reduced costs with multifunction relays

Redundancy practices

- Transformer zone

  Typically redundant

- Bus zone

  Sometimes redundant

- Feeder zone

  Practices vary

  Focus of the paper
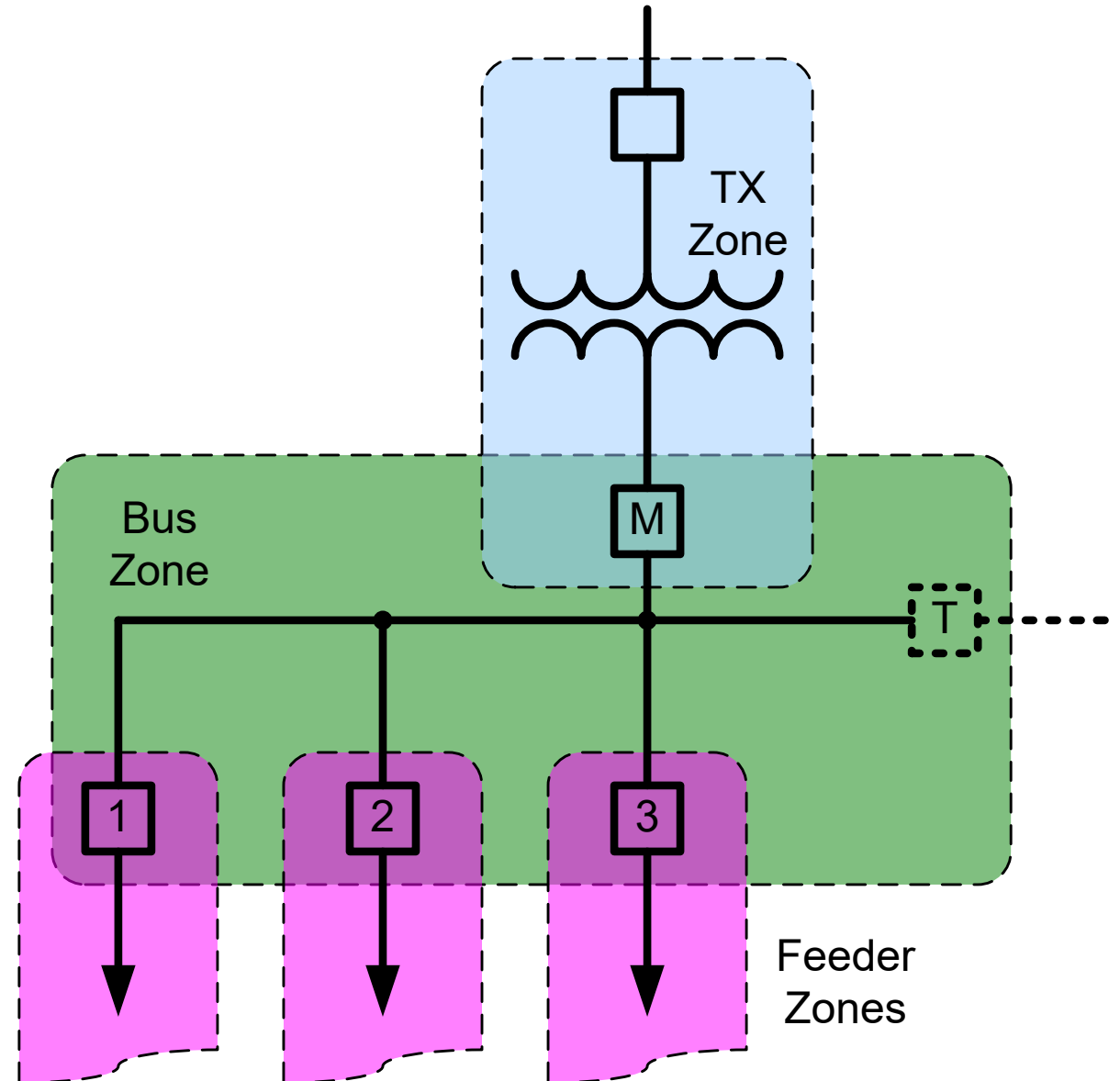
Breaker failure

- Redundant protection makes fault detection dependable

- Breaker failure makes fault clearing dependable

- Upstream backup is no longer relied upon

- Breaker failure is available in multifunction relays
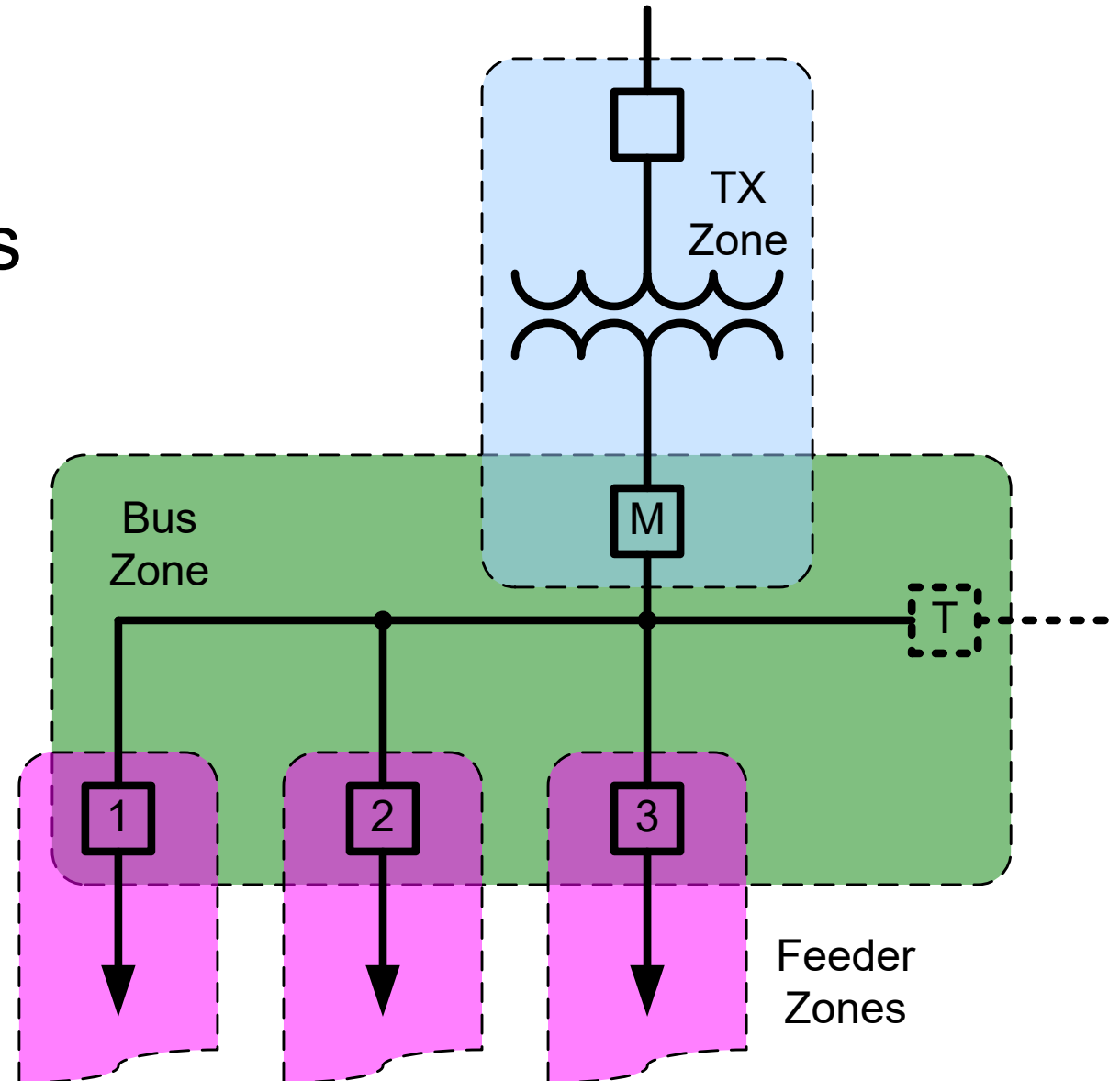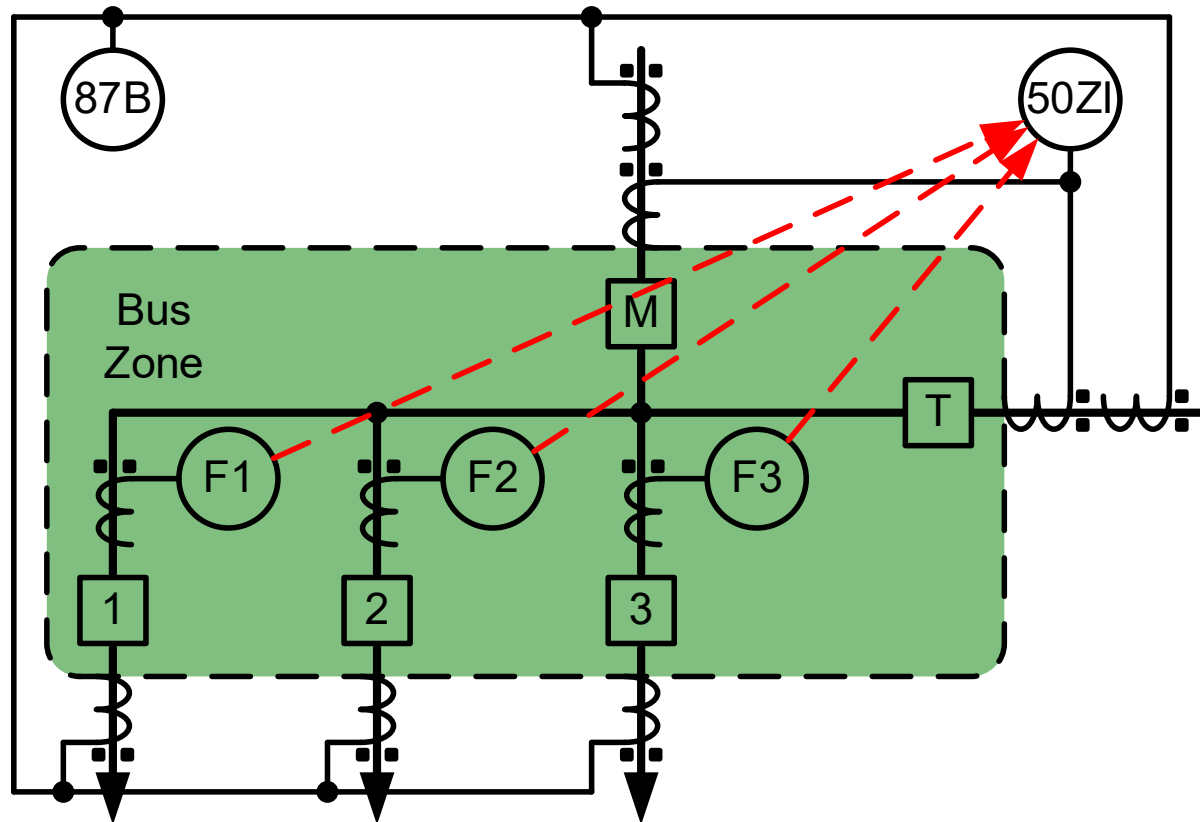
Transformer zone

Typically redundant

- System A, 87T
- System B, 50/51 AND 63SPR or second 87T
- Separate 86 tripping relays

Remote backup not possible

- Ground relays blocked by delta windings
- Phase relays blocked by impedance
- Transformers require high sensitivity

Bus zone

- Typical selective high-speed schemes
  - 87B, differential
  - 50ZI, zone interlock
  - 50AF, arc-flash
- Dual 87B is often not possible
- Time-delayed backup common
- New schemes make redundancy possible

Feeder zone (focus of paper)

- Operational and maintenance considerations
- Organizational considerations
- Challenges of relying on upstream backup
- Functions that should be redundant
- Economical methods to provide redundancy

Operational considerations

- Circuits must be removed from service for
  - A relay failure
  - Periodic maintenance
- Alternate feeds may not be available or may require extensive switching
- Urgency can lead to human performance issues
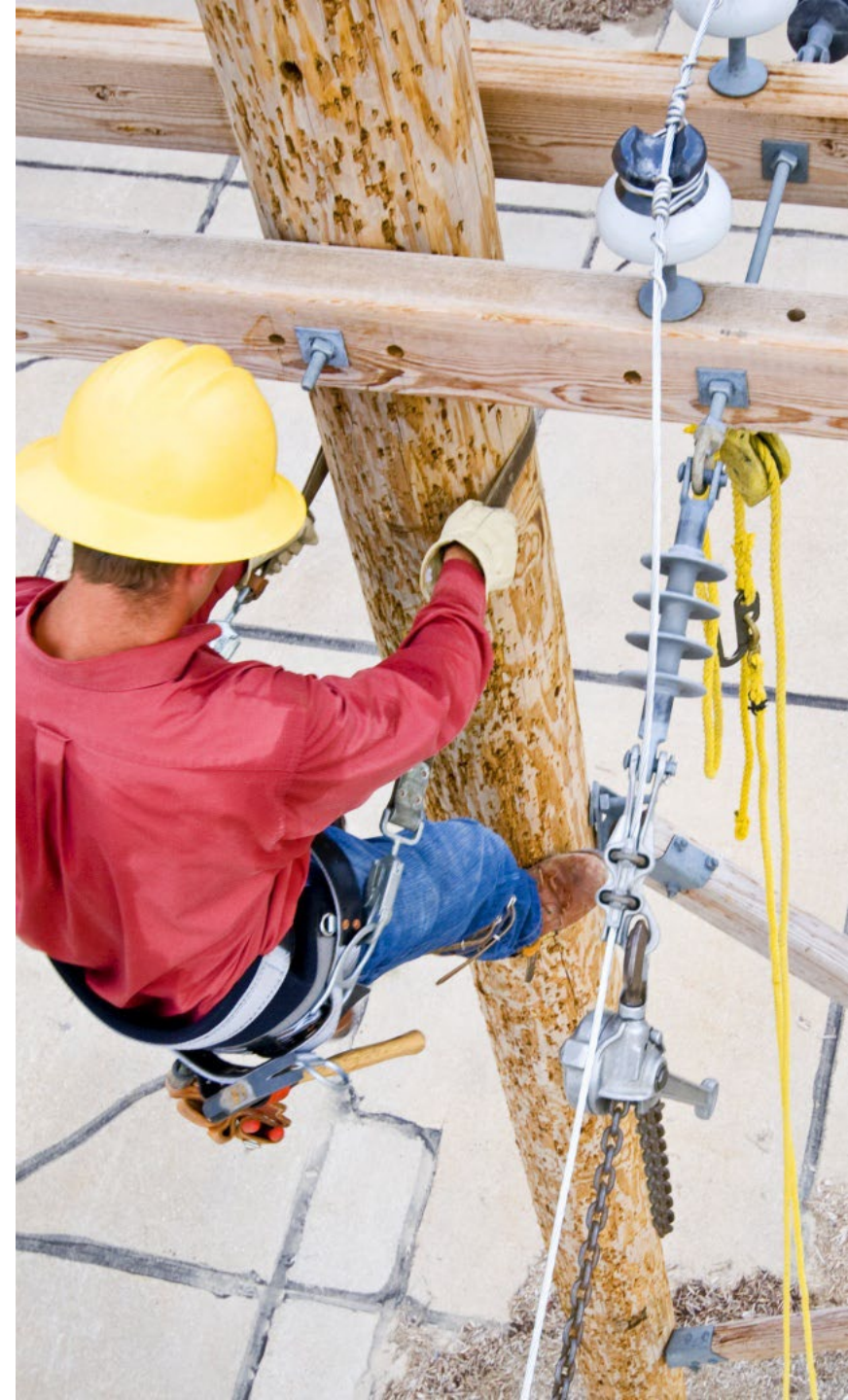
Organizational considerations

- Boundaries of responsibility
  - Substation engineers
  - Distribution engineers
- Relying on bus main to back up feeders makes cross-boundary communication critical
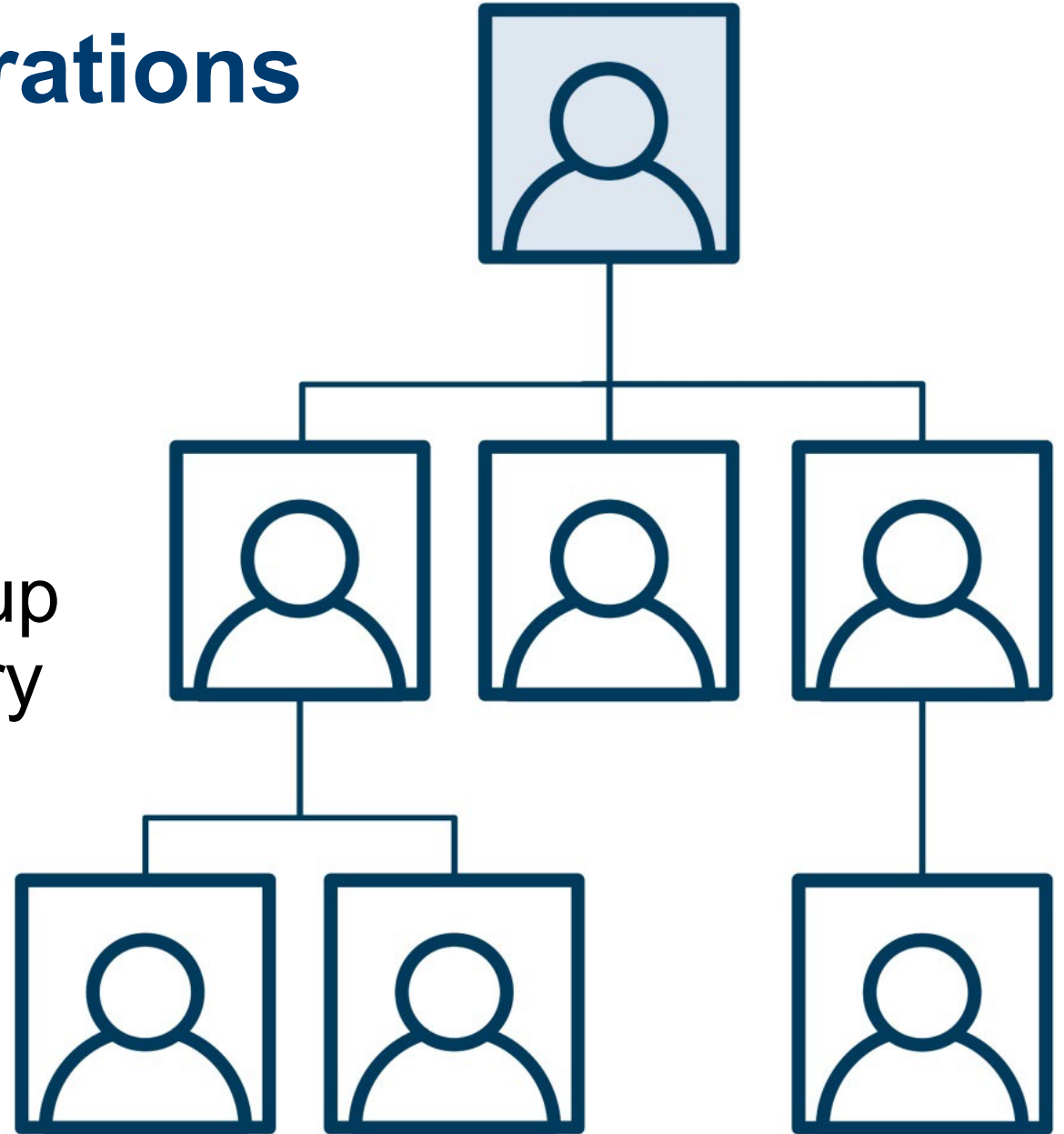
Challenges of relying on upstream backup

- Increased complexity
  - Setting bus main requires knowledge of feeder topology
  - Coordination is critical
  - Loadability must be addressed
- Poor performance
  - Slow clearing and reduced dependability
  - Increased stress to transformers
  - Loss of service to healthy feeders
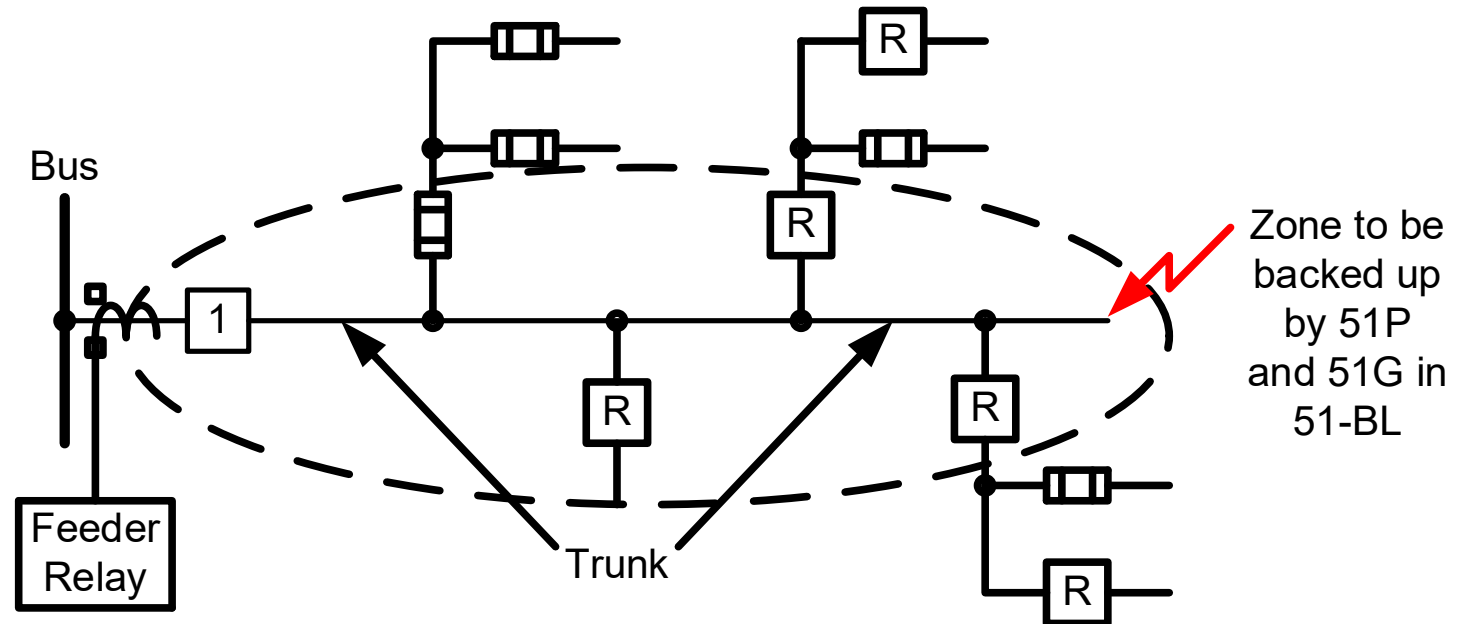
Functions that should be redundant

Recommended

- Fault detection, 51P/G and high-set 50P/G

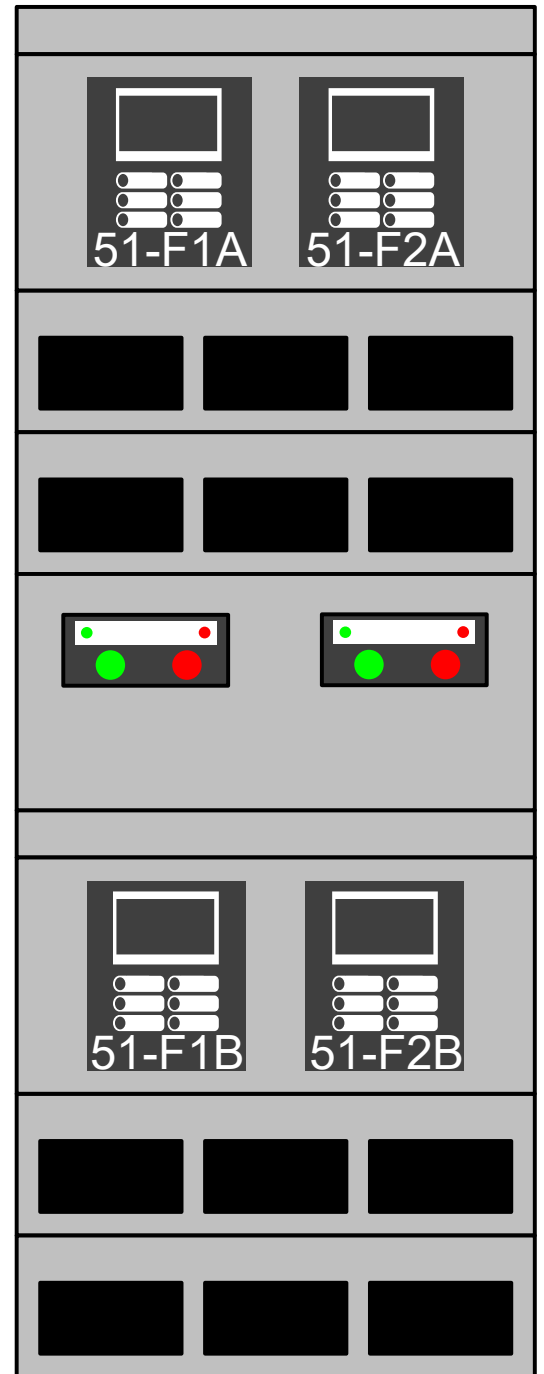- Hot-line tag enabled elements

- Manual control

Optional

- Reclosing

- Fuse-saving scheme

Feeder redundancy options

- Apply two multifunction feeder relays
  - Simplest option
  - No compromises
  - Requires twice as many relays and more panel space
- Apply multirestraint 87B relay for bus zone
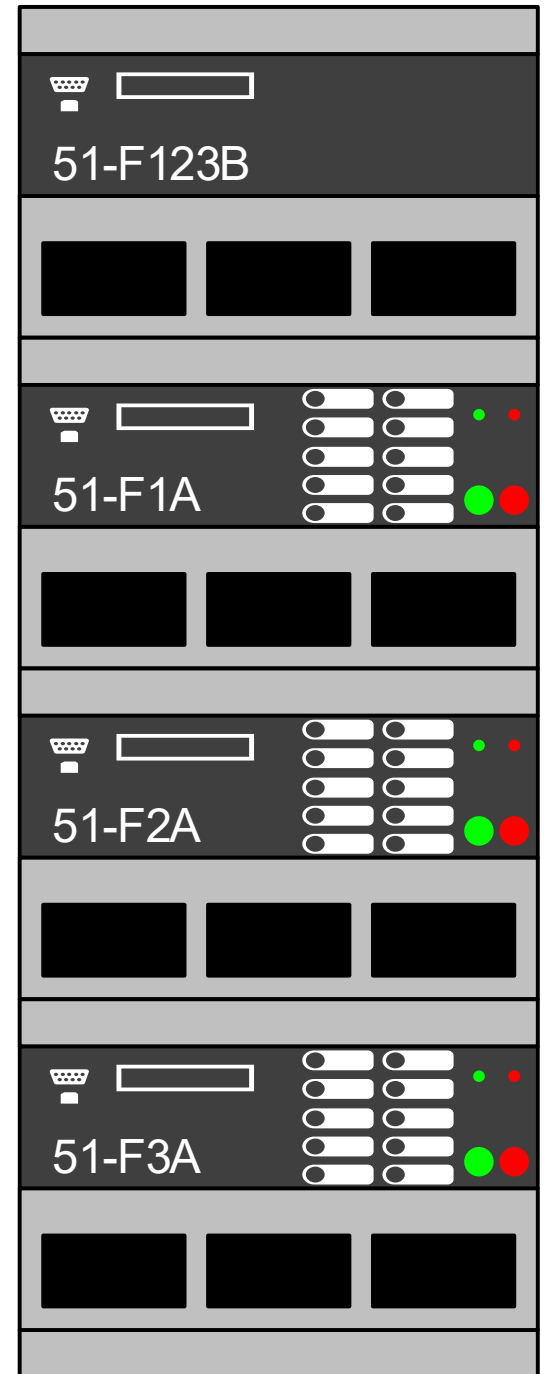- Apply a multifeeder redundant relay to each panel

Apply multirestraint 87B

- 50/51 elements in bus relay provide redundancy for fault detection

- Scalability limited to buses with five feeders
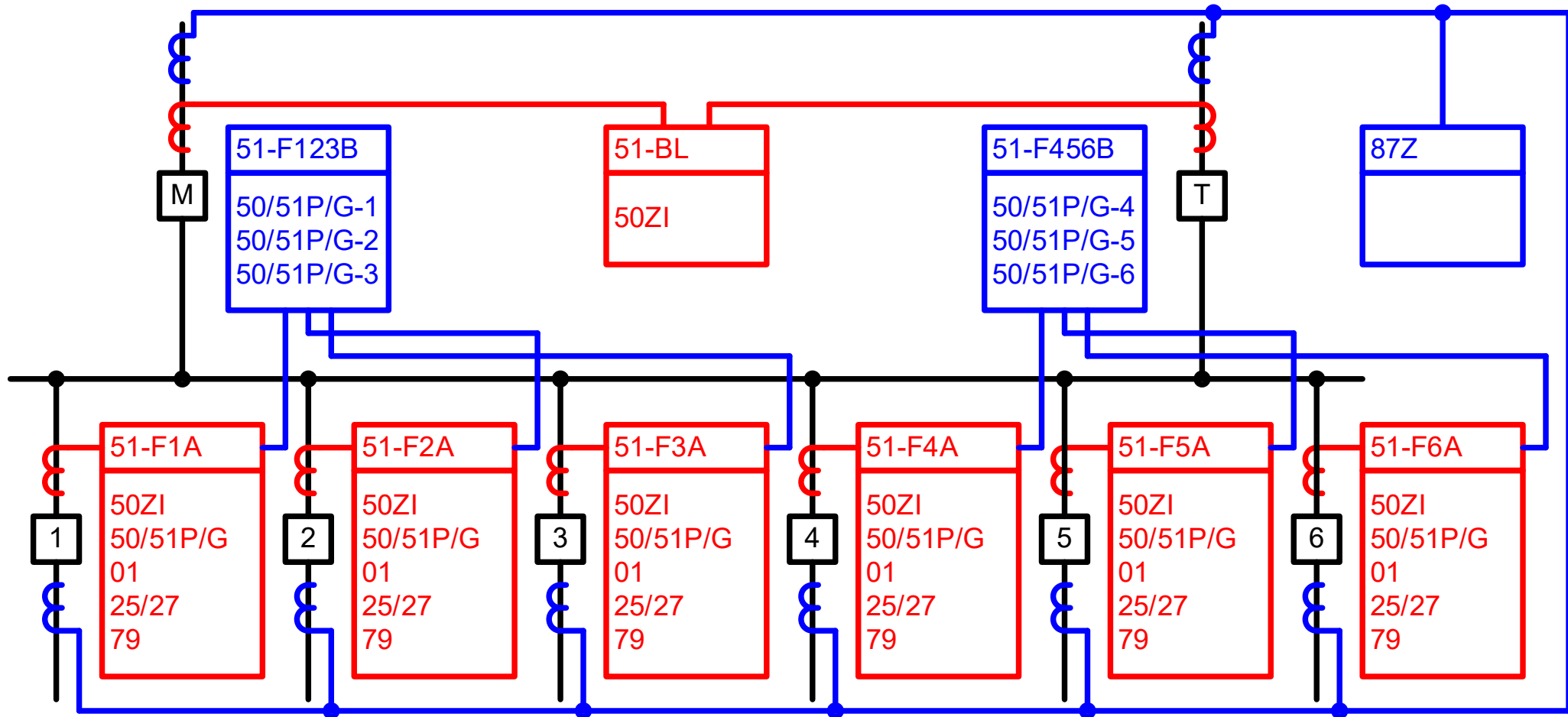
- No additional relays required
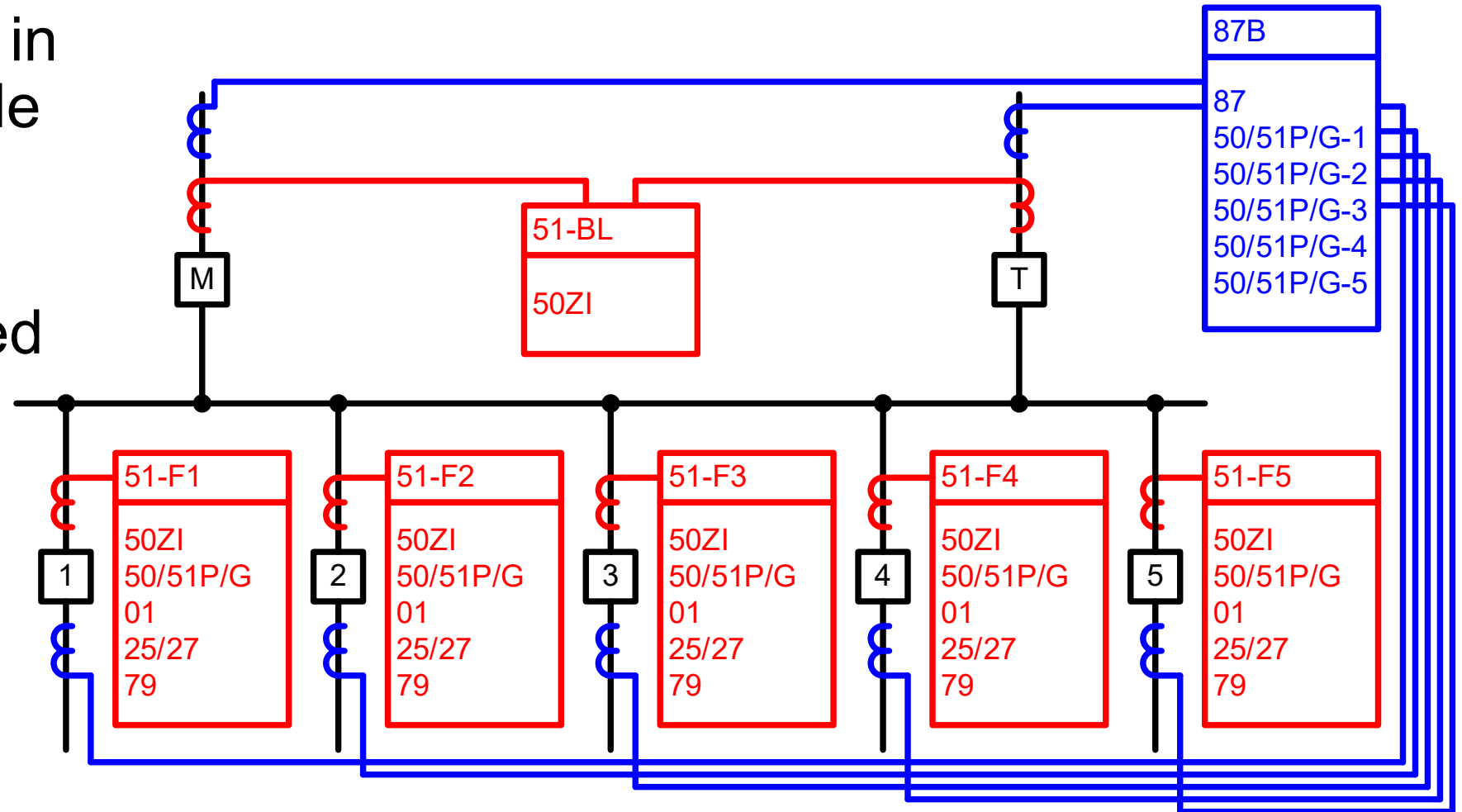
Apply a multifeeder redundant relay to each panel

- Multirestraint differential relay – 50/51 protection for three circuits

- Redundancy for fault detection

- Scalable to as many feeders as needed

- Economical – Only one additional relay for up to three feeders is required

Apply a multifeeder relay to each panel

Conclusions

- Historical paradigms not fully relevant today
- Distribution system reliability is critical for individual consumers
- Distribution is much messier than transmission
- Relying on upstream backup is
  - More complex
  - Lower performance
  - Less reliable
- Designing for redundancy solves many problems
- Barriers to applying breaker failure at all voltage levels are gone

Conclusions

- Paper provides ideas for implementing redundant bus protection
  - 50ZI schemes require no added relays
  - 50AF schemes can also be a second high-speed selective system
- Paper provides ideas for implementing redundant feeder protection
  - Using dual feeder relays
  - Using protection in bus relay requires no added relays
  - Using a multifeeder redundant relay requires few added relays
- Paper has two informative appendixes
  - Methods to improve loadability of phase overcurrent relays
  - Methods to implement 51G elements in a bus relay

Questions?