

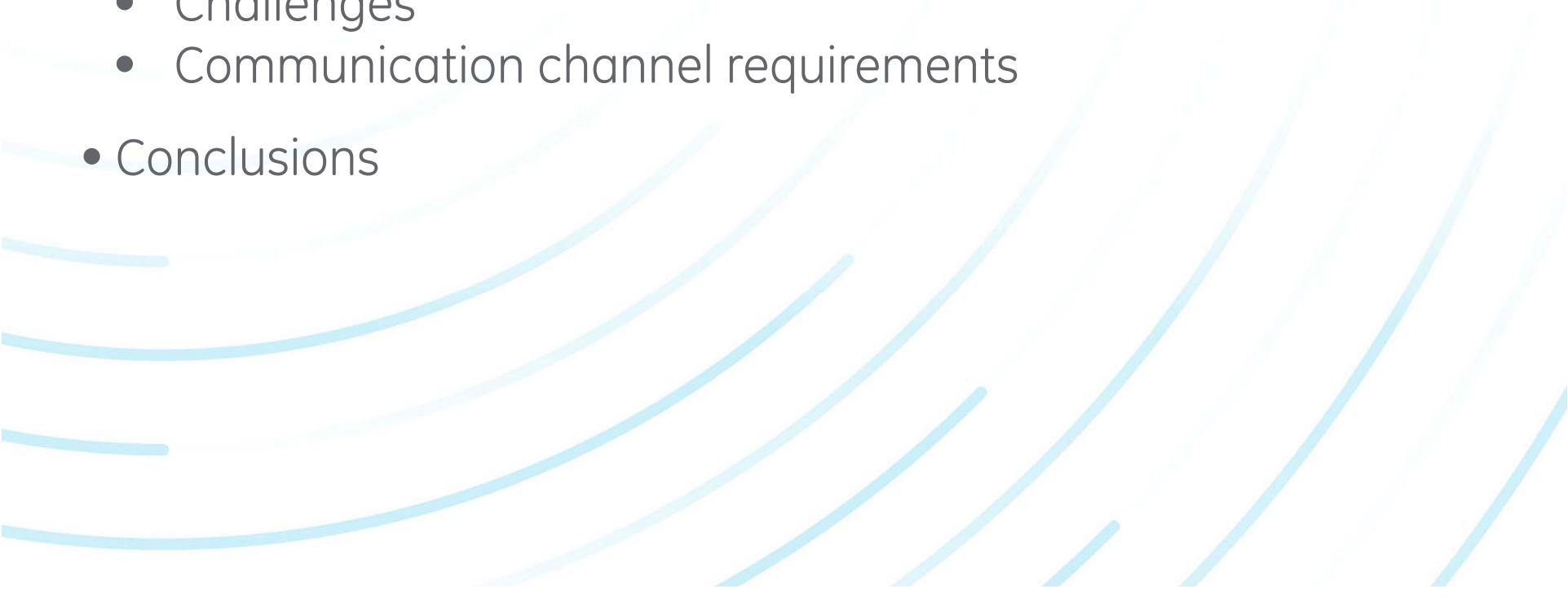
# Distribution Network Protection: What Can We Learn from Transmission Protection

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2017 Minnesota Power Systems Conference

# Agenda

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- Fundamental differences between transmission and distribution networks
  - Characteristics of traditional T & D protection
  - Transmission protection techniques applied to distribution
    - Challenges
    - Communication channel requirements
  - Conclusions
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# Fundamental differences between T & D networks

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- Transmission network characteristics
  - 2 or 3 terminals
  - Homogeneous conductor sizing
  - Minimal reconfiguration
  - Tapped loads are known (and limited)
  - End-of-Line is known
- Distribution network characteristics
  - Numerous terminals
  - Varying conductor sizes and methods
  - Reconfigurable at will (minimal remote intelligence)
  - Many laterals and hundreds of tapped loads
  - End-of-Line unknown

# Characteristics of traditional T & D protection

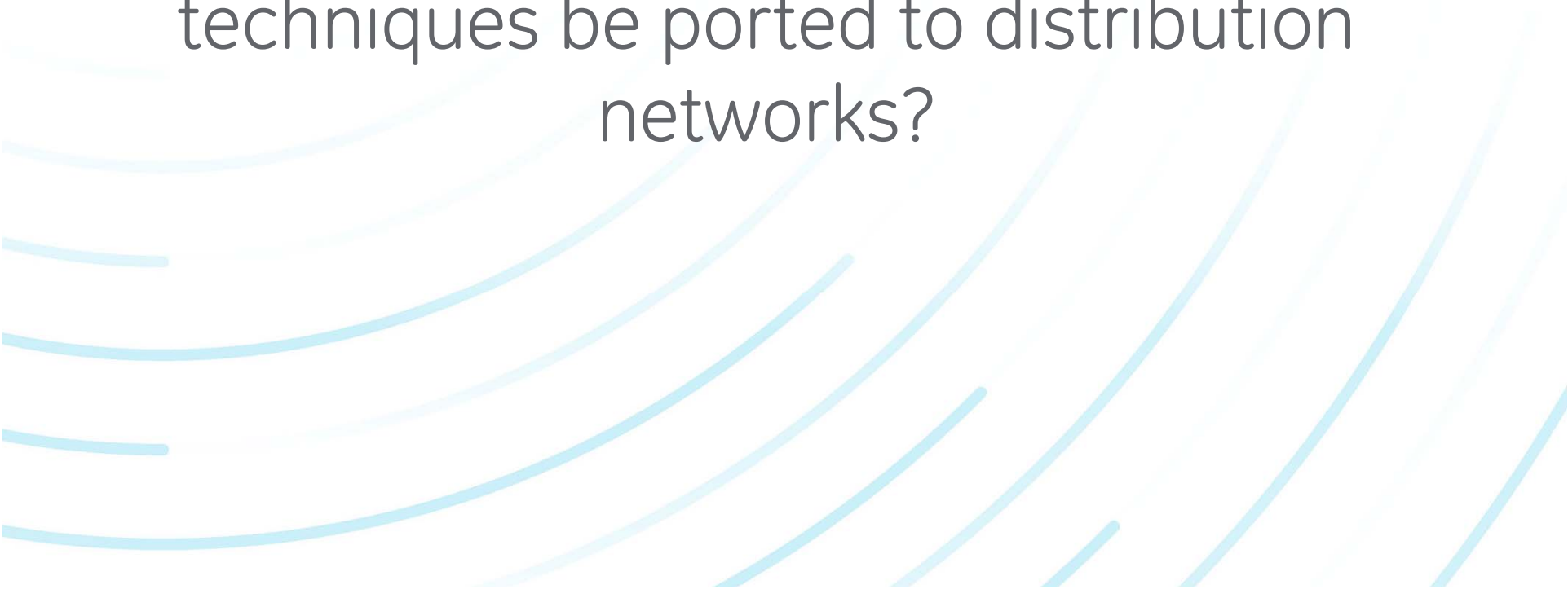
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- Transmission network protection FDIR
  - High speed
  - Highly selective
  - Non-adaptive to network changes
  - Intelligent reclosing
- Distribution network traditional protection FDIR
  - Variable speed
  - Poor selectivity
  - Forgiving of network changes (non-adaptive)
  - Uses reclosing for selectivity

# Transmission protection techniques applied to distribution

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Can transmission network protection techniques be ported to distribution networks?



# Transmission protection techniques applied to distribution

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- Over-current protection challenges
  - Reconfiguration changes fault current availability
  - DR cause direction changes in fault current distribution
    - California's goal of 100% renewable by 2050
  - Negative and zero sequence voltage profiles vary greatly
    - Challenging for directional element polarizing
- Over-current protection communication needs
  - Narrow bandwidth, high speed
    - Directional comparison schemes
    - Zone selective interlocking

# Transmission protection techniques applied to distribution

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- Distance protection challenges
  - Varying conductor sizes creates non-homogeneous impedance
  - Reconfiguration changes impedance to end-of-line
  - Laterals create parallel impedance paths to multiple end-of-lines
  - Tapped loads and DR create apparent impedance
- Distance protection communication needs
  - Narrow bandwidth, high speed
    - Directional comparison schemes

# Transmission protection techniques applied to distribution

- Line differential challenges
  - Reconfiguration requires dynamic terminal reassignment
  - Tapped loads and DR create sensitivity challenges
  - Is there a practical limit to the number of terminals?
- Line differential communication needs
  - Wide bandwidth, high speed
    - Are the speed requirements the same for T & D?
    - Standardized data formats to allow plug-and-play with DR devices
      - Could we use type “P” synchro-phasors rather than sampled values to reduce bandwidth requirement?



# Transmission protection techniques applied to distribution

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What about transfer trip?



# Transmission protection techniques applied to distribution

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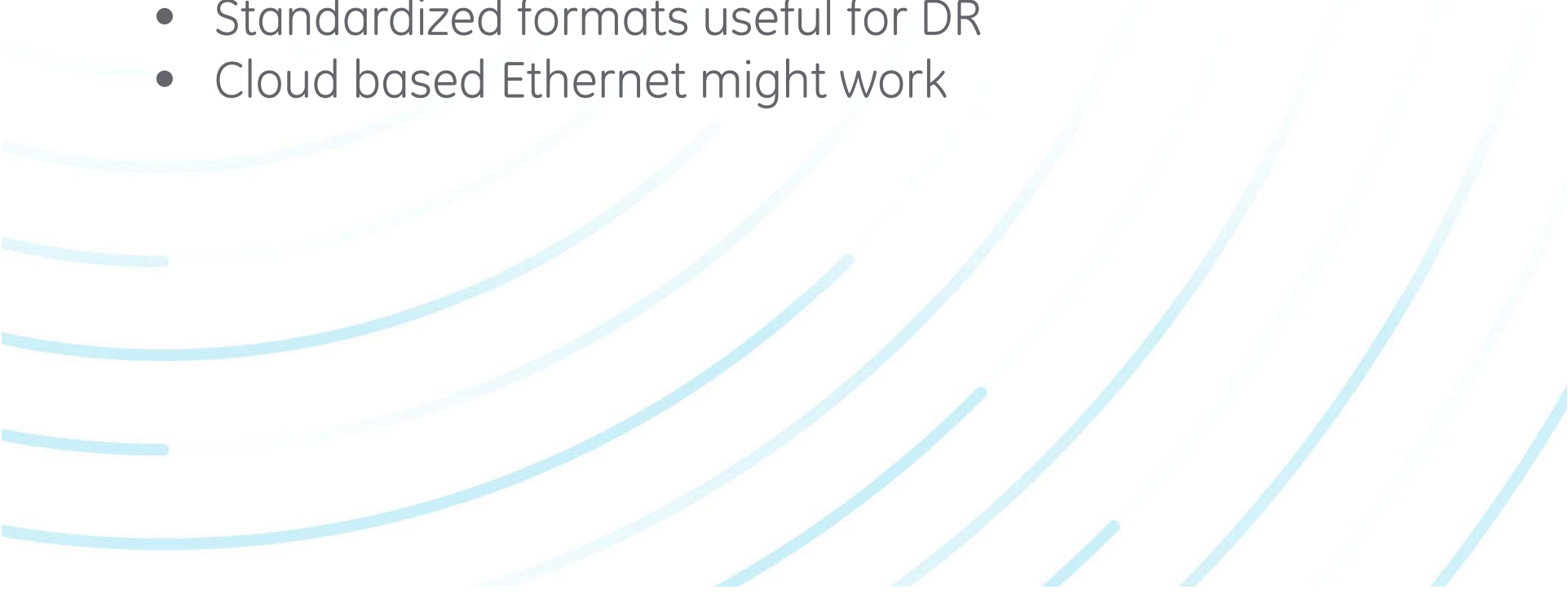
Could we use public cloud based Ethernet solutions?

Security?

Reliability?

# Conclusions

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- Transmission protection concepts can be applied
    - Significant challenges
    - Best for static networks
    - Might not be flexible enough for large DR penetration
  - Unique communication system requirements
    - Speed requirements are not the same for T & D
    - Standardized formats useful for DR
    - Cloud based Ethernet might work
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Thank You

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