Reliability of Wireless Networks in Smart Grid Environment
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Presentation Outline

1. Motivation

2. Modeling of electricity distribution and communication networks

3. Fault cases and results

4. Conclusions

Motivation

- Interdependency of electricity distribution and mobile communication networks has increased due to automation and remote control.

- Interdependencies between these networks have been little studied / simulated.

- The research work was focused on suburban and rural areas in the southern and northern parts of Finland.

Modeling of Networks

- **Environment**
  - Terrain height information
  - Clutter information

- **Electricity distribution network**
  - Primary substations
  - Feeders
  - Disconnectors
  - Secondary substations

- **2G/3G network**
  - GSM-900 base stations
  - UMTS-900 base stations
  - Different types of terminals
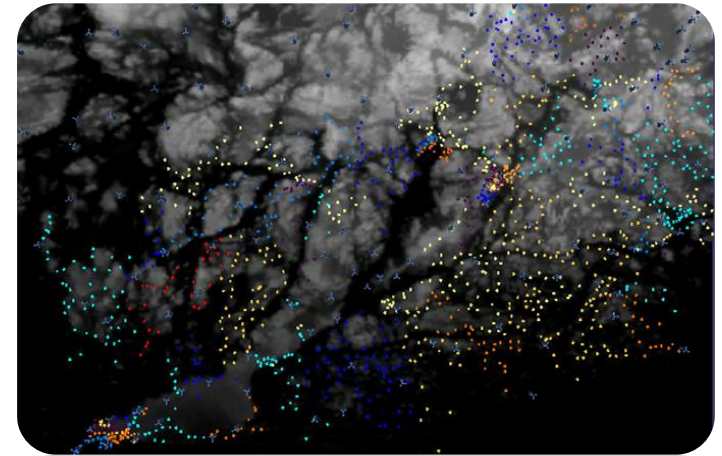
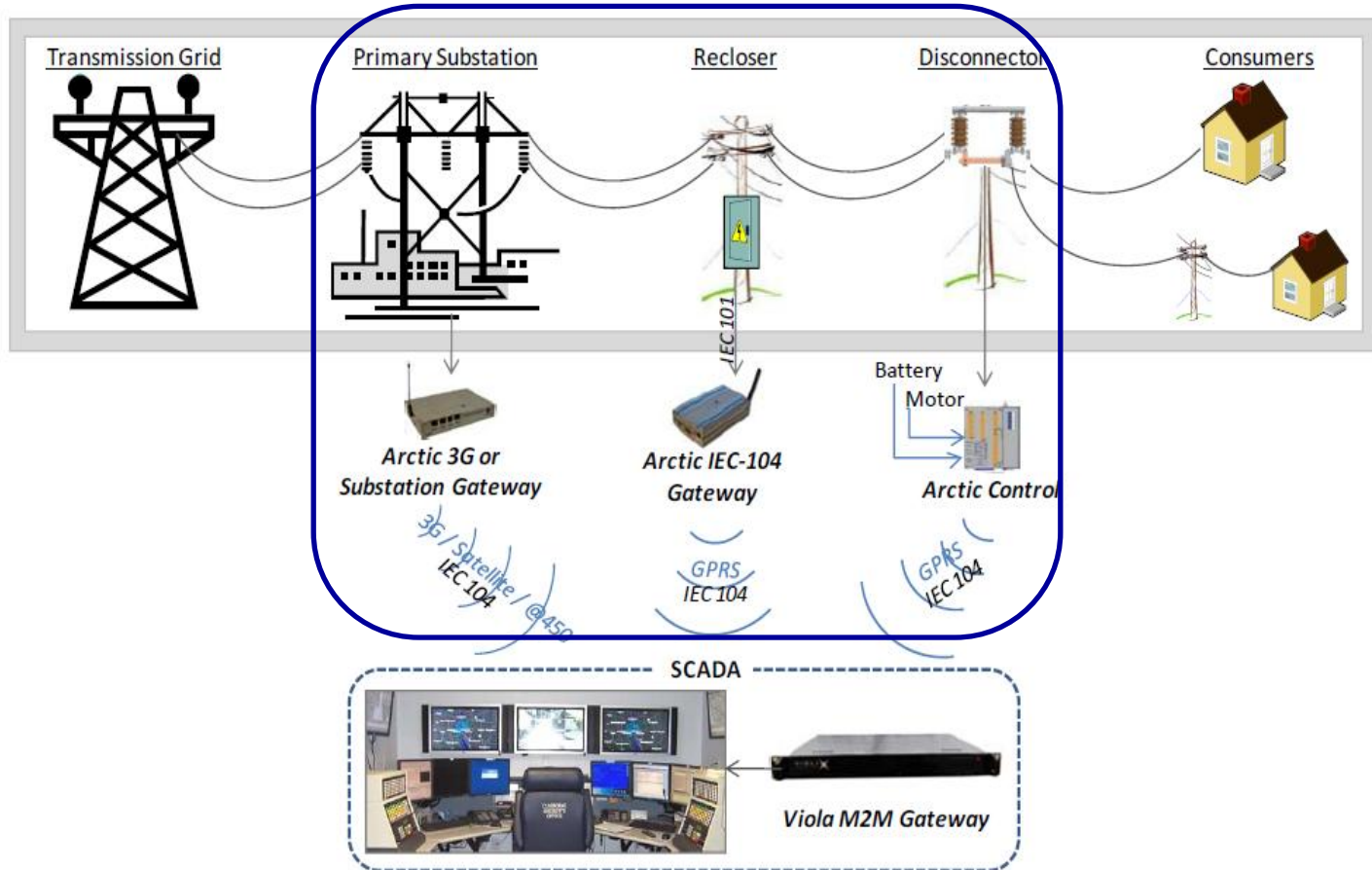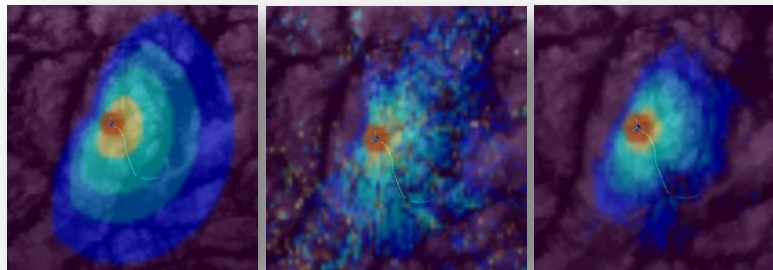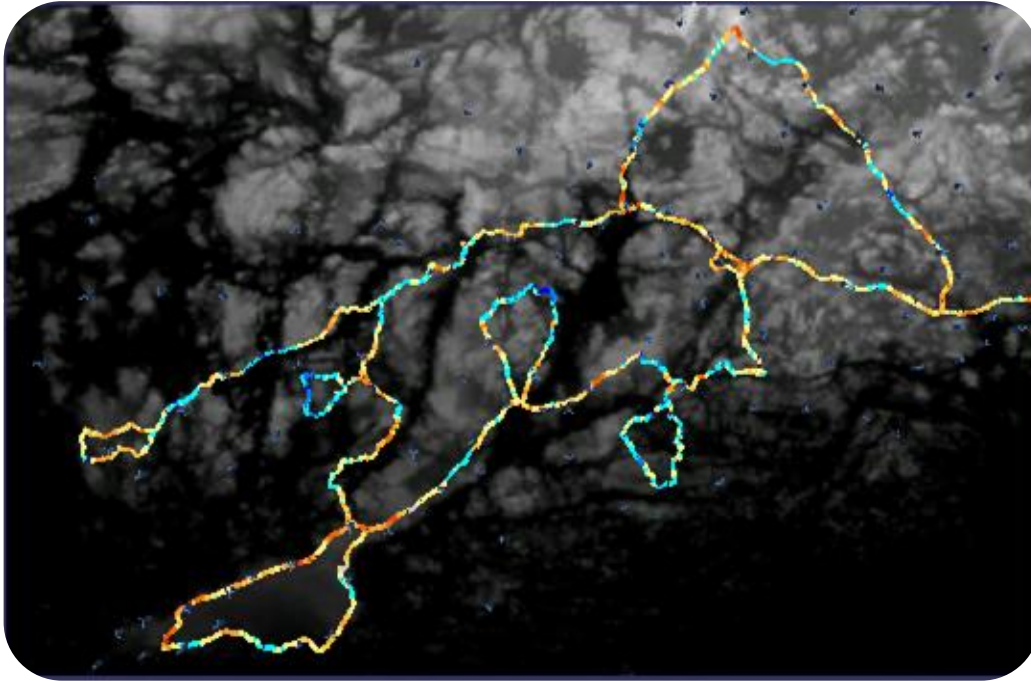# Scope of Electricity Distribution Network

Figure from Viola Systems' 'Case Vattenfall: Automating the Distribution Network' report

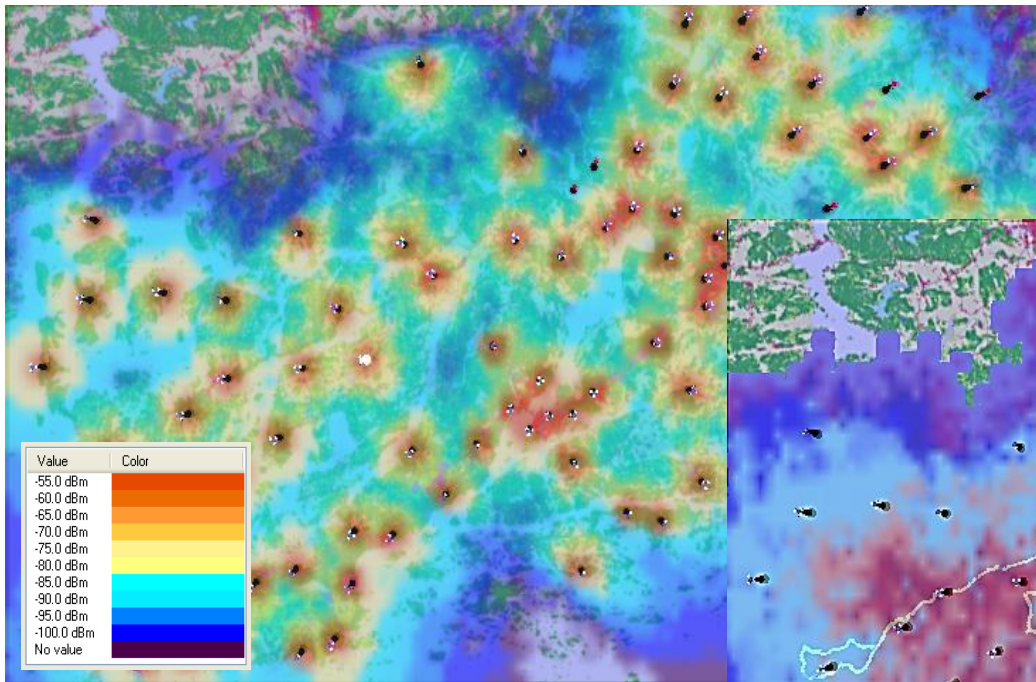# Raasepori Field Measurements

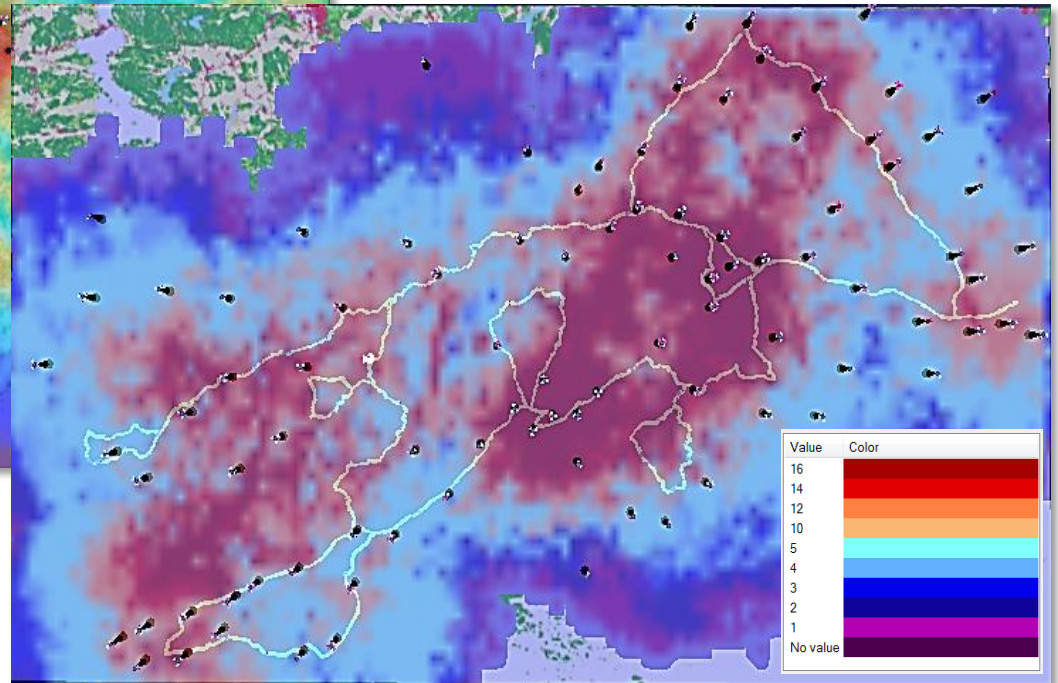

Viola Arctic
2G/3G

Nemo
Handy

Samsung
Nexus

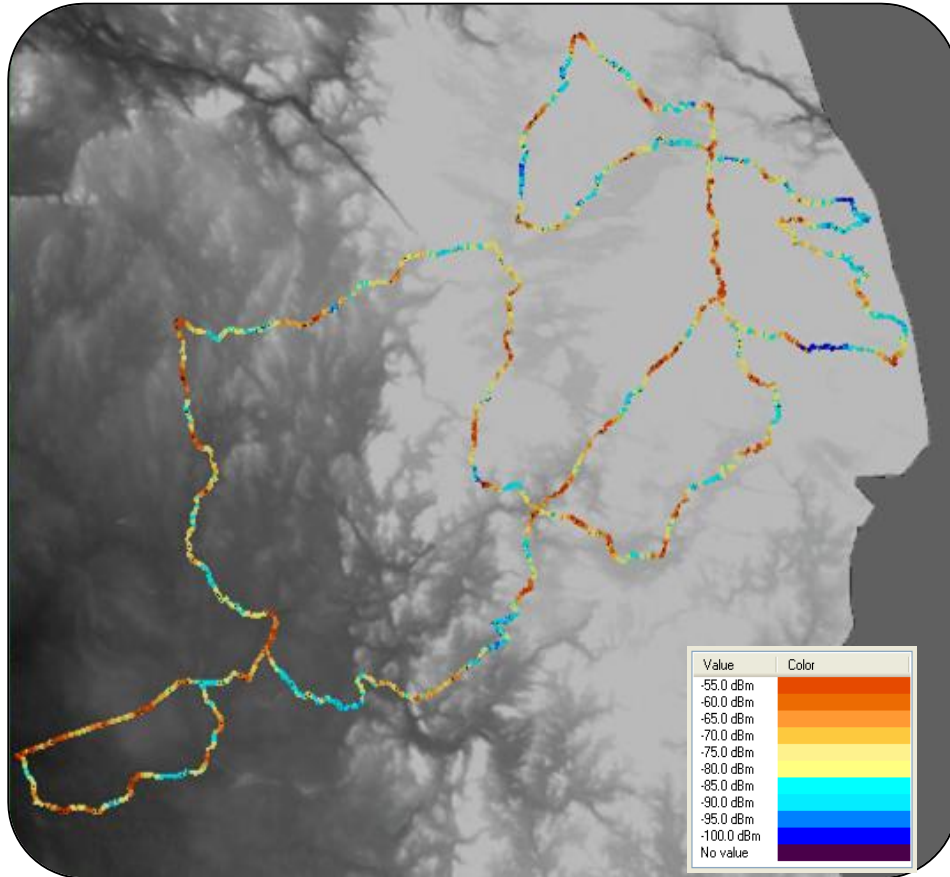# Raasepori Redundancy Calculations

Downlink 2G coverage raster

Downlink 2G redundancy raster

Koillismaa Field Measurements

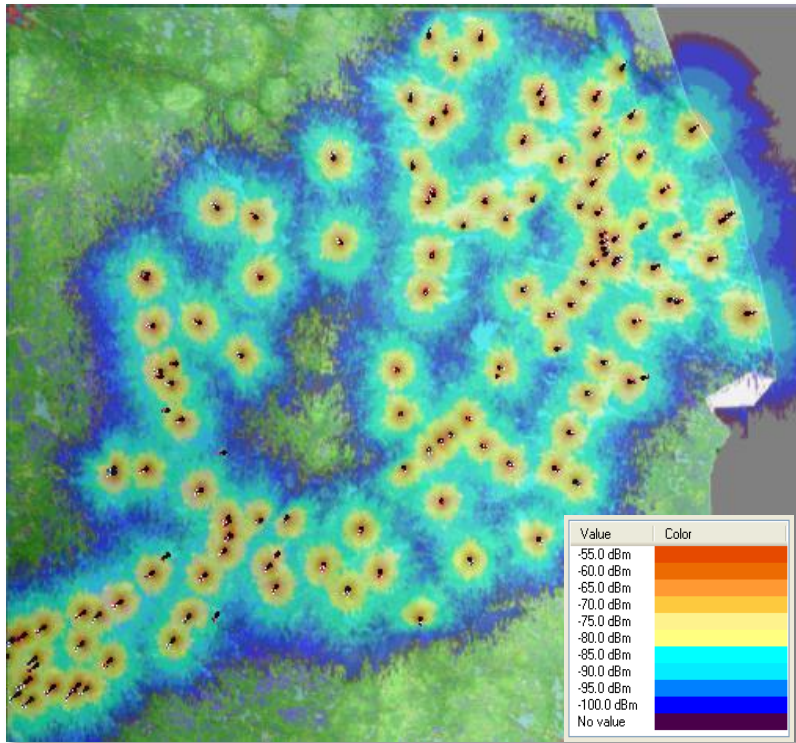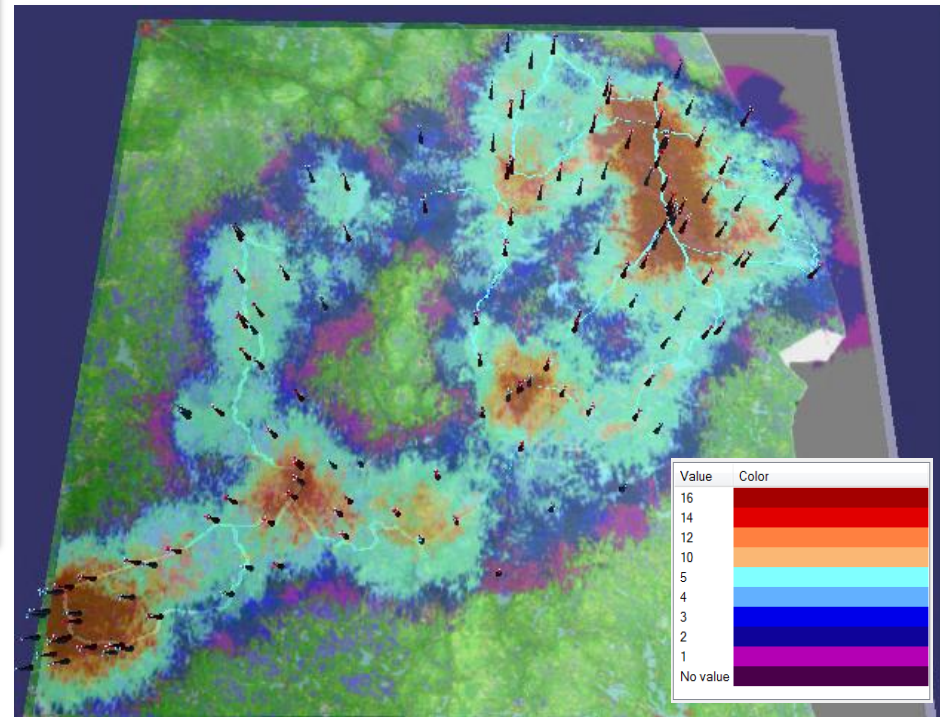| Value	Color
-55.0 dBm	
-60.0 dBm	
-65.0 dBm	
-70.0 dBm	
-75.0 dBm	
-80.0 dBm	
-85.0 dBm	
-90.0 dBm	
-95.0 dBm	
-100.0 dBm	
No value	

Viola Arctic 2G/3G

Nemo Outdoor

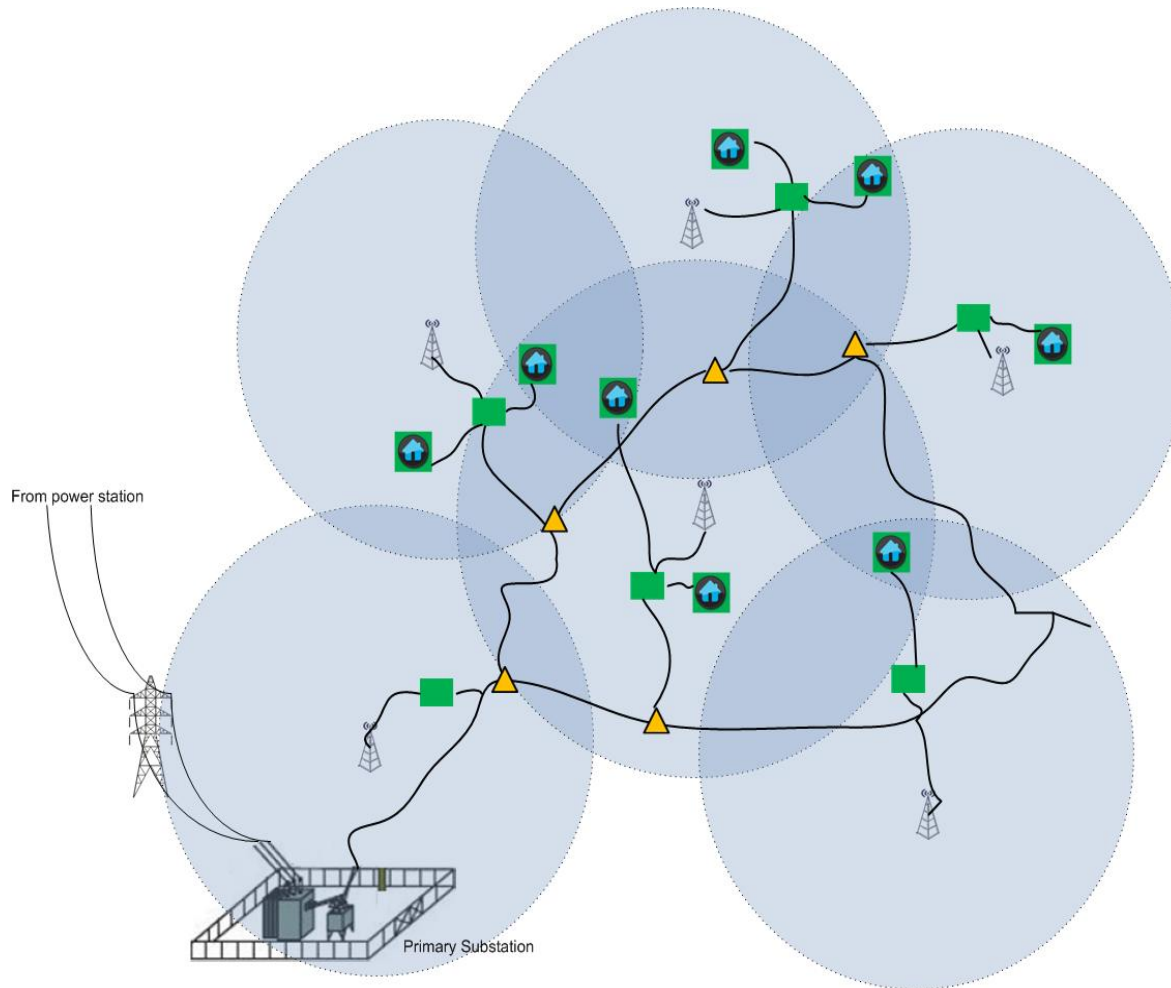# Koillismaa Redundancy Calculations

Downlink 2G coverage raster

Downlink 2G redundancy raster
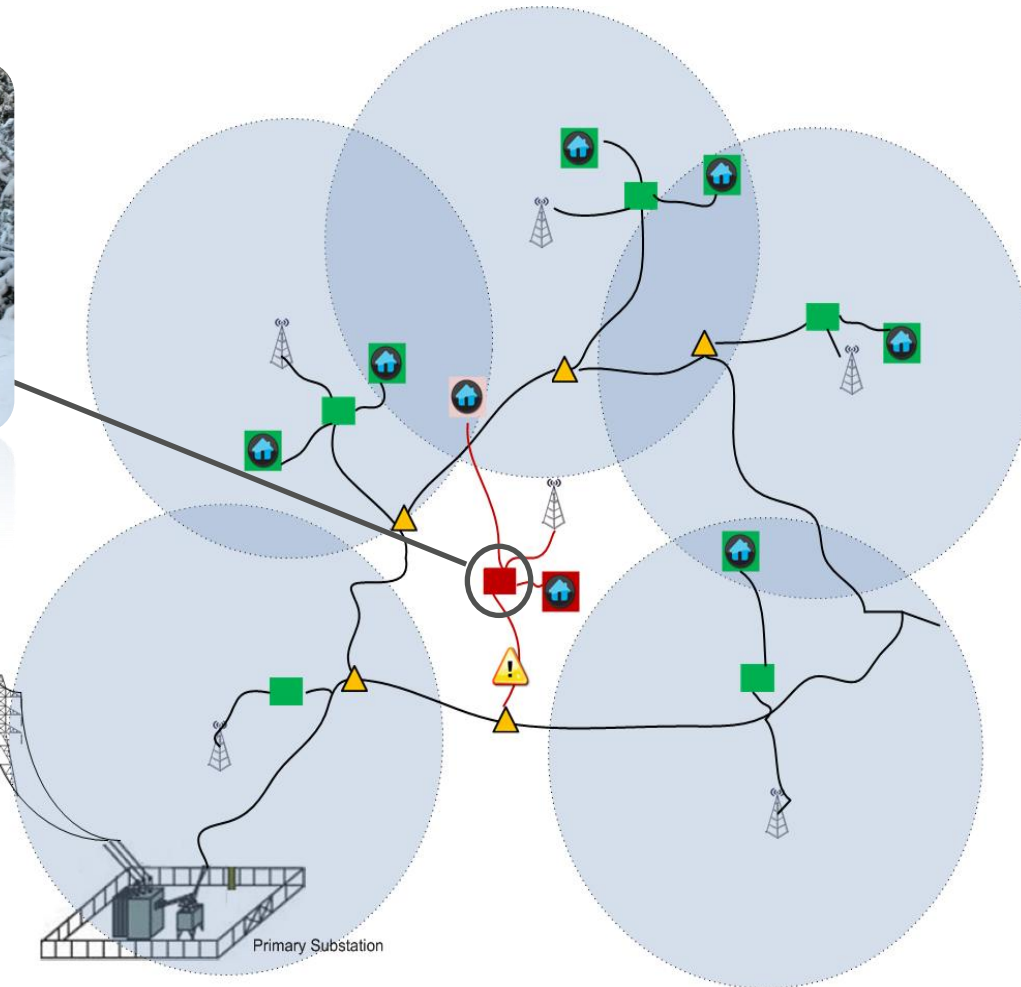
Interdependency of Networks (Normal)
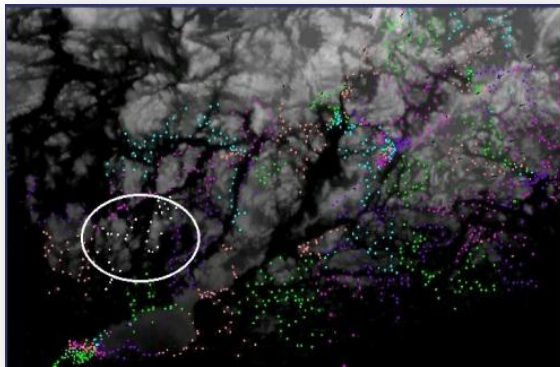
Interdependency of Networks (Abnormal)

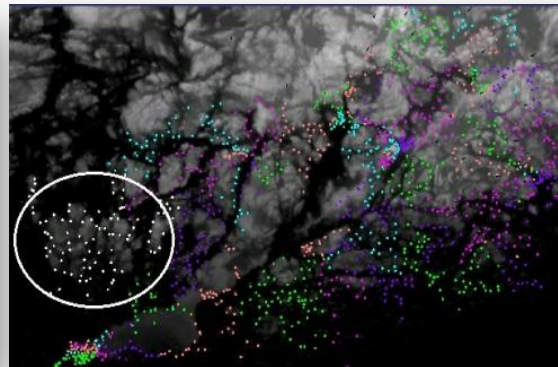Kuva: Olli Pihlajamaa

From power station

Primary Substation
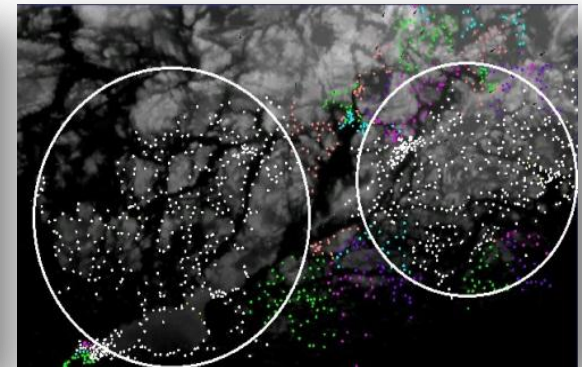
Analysis of Device Related Failures (1 / 2)

One feeder down

One substation down

Several substations down

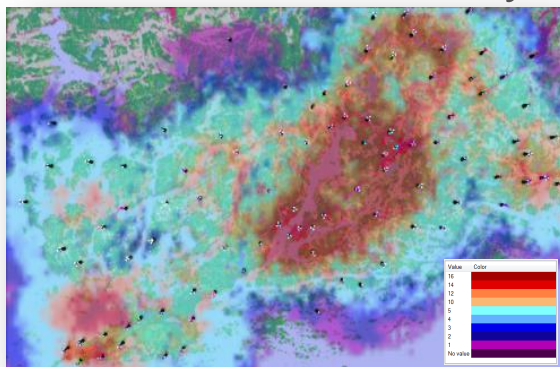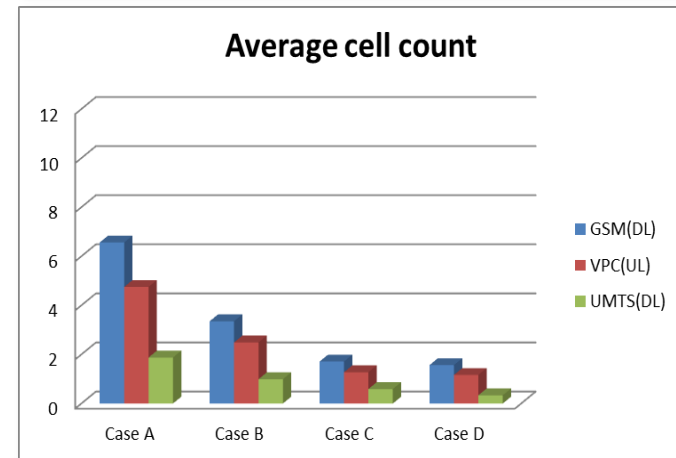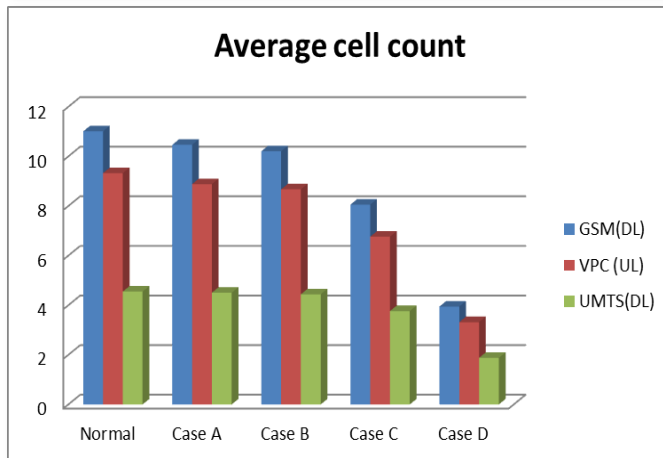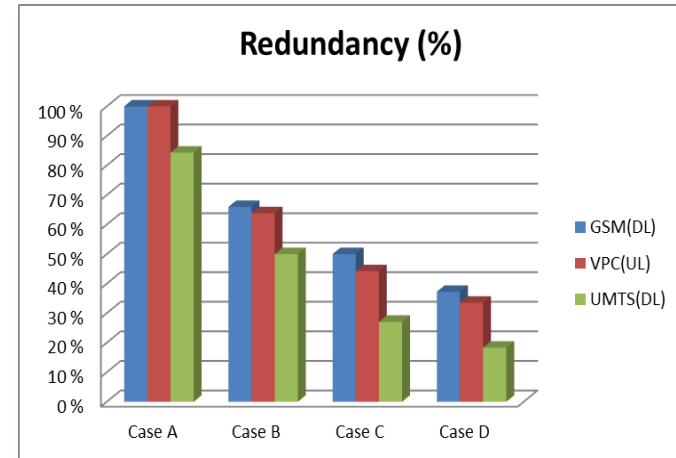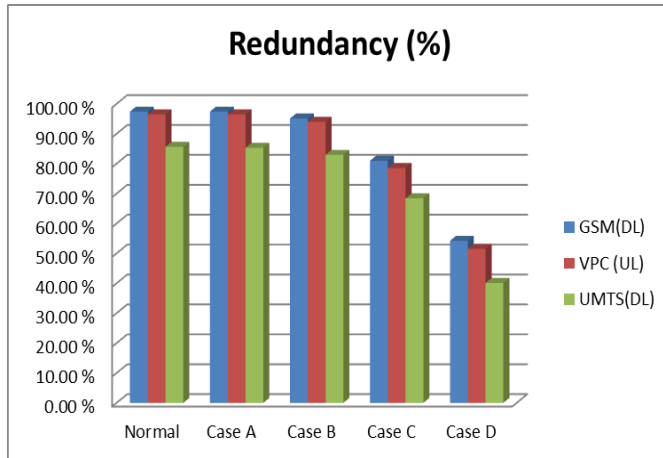*) Gray indicates network entities without electricity.

Downlink redundancy rasters
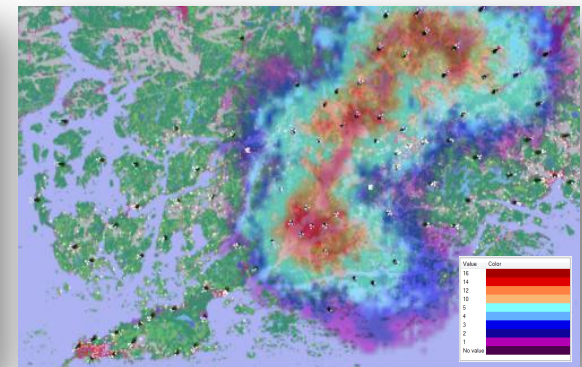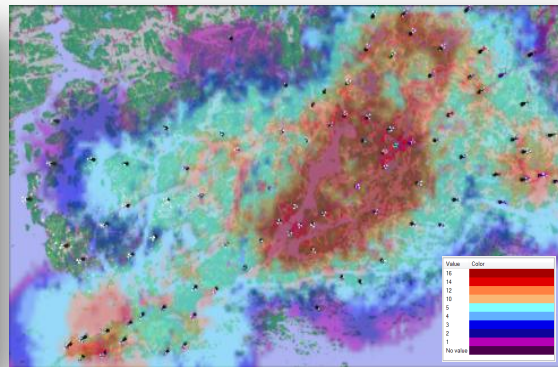
*) Color indicates the redundancy of 2G networks

Analysis of Device Related Failures (2 / 2)

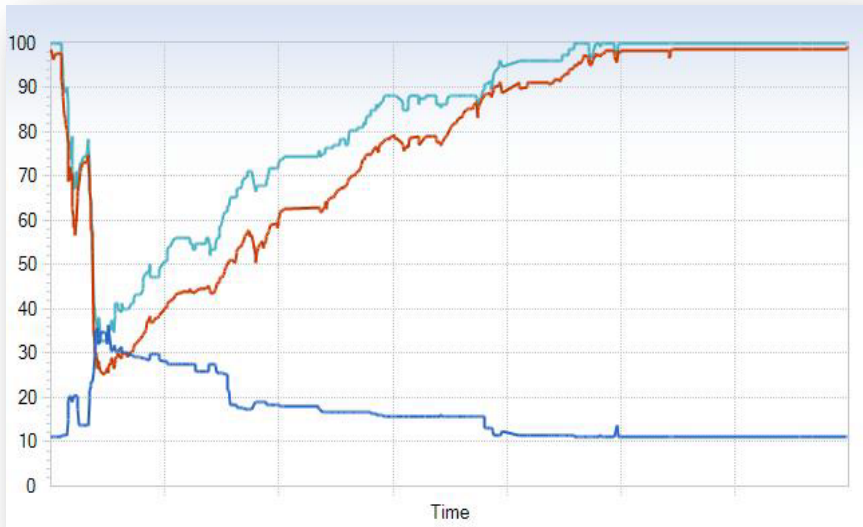Redundancy percentage and average cell counts including all distribution network entities.
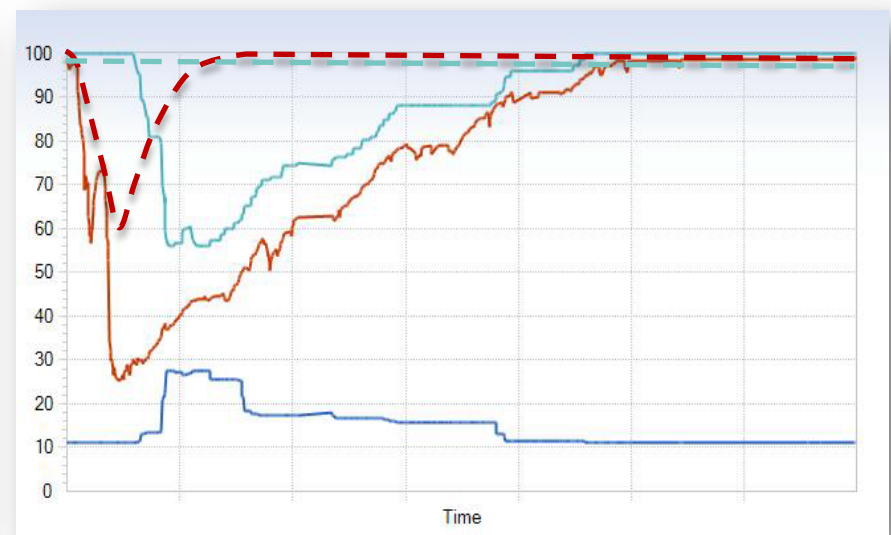
Redundancy percentage and average cell counts including de-energized distribution network entities.

Analysis of Storm Related Failures

No battery backup

12 hour battery backup

- **Red**   - Operational secondary substations %
- **Light blue**   - Operational masts %
- **Dark blue**   - No coverage area %

Conclusions

- The simulation tool enables analysis of interdependencies between electricity distribution and mobile communication networks
  - Detailed information from both networks are needed
  - Field measurements for fine-tuning and validation

- 2G and 3G networks have good redundancy and can tolerate small and medium size faults in suburban and rural areas
  - Large-scale faults cause coverage gaps especially near the coast

- Results indicated that there are no significant differences between networks in the Southern and Northern parts of Finland
  - Both networks are dense in residential areas and along main roads

- Fault reports from storms were found very essential for failure and recovery analysis of both networks
  - Detection of critical network entities
  - Comparison of pre-emptive techniques