AALBORG UNIVERSITY

Investigating Wind Farm Control over Different Communication Network Technologies

EnergieInformatik2015

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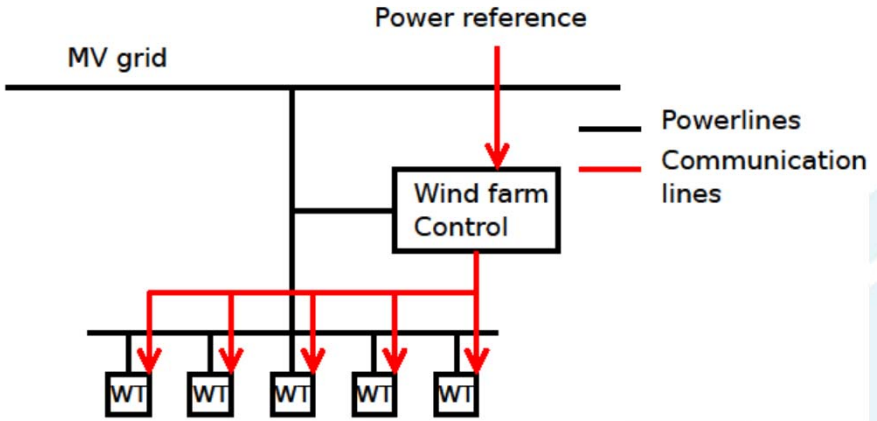
Problem statement

- Wind farm connected to MV grid
- Central control of distributed assets

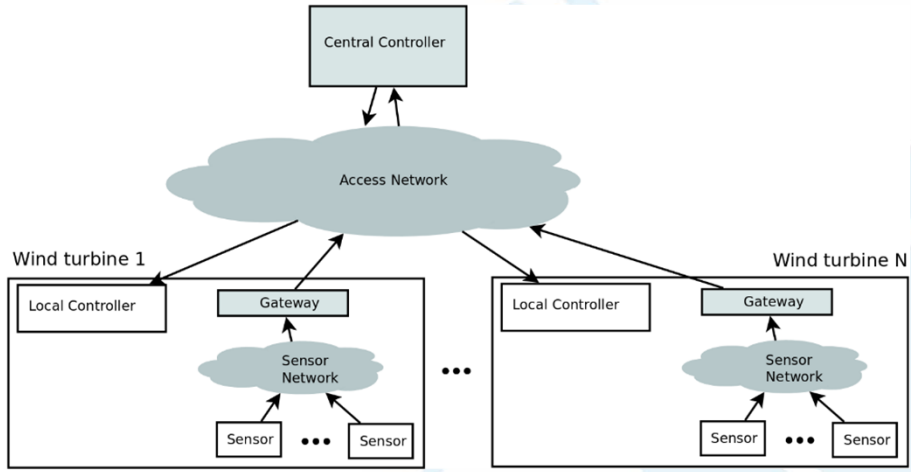
❖ How does communication network affect controller performance?

❖ Which communication technologies are feasible?



System description I
Communication network architecture

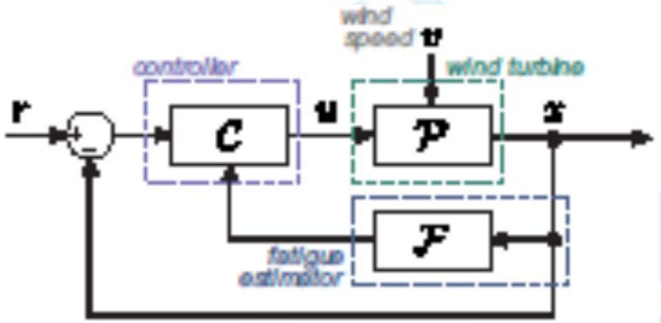
- Central controller
  - Communicates over Access Network
- Local controller on wind turbine
  - Acts on set-points from central controller
- Sensors
  - Periodically send measurements
- Gateway
  - Forwards sensor information



System description 2
Controller description

- Control of a wind-farm from a central controller
  - Maintain a power reference
  - Reduce damage wind turbine sustains during operation
- Performance metric is accumulated damage

- Controller acts periodically every150 ms
- Wind turbine state to estimate fatigue/damage

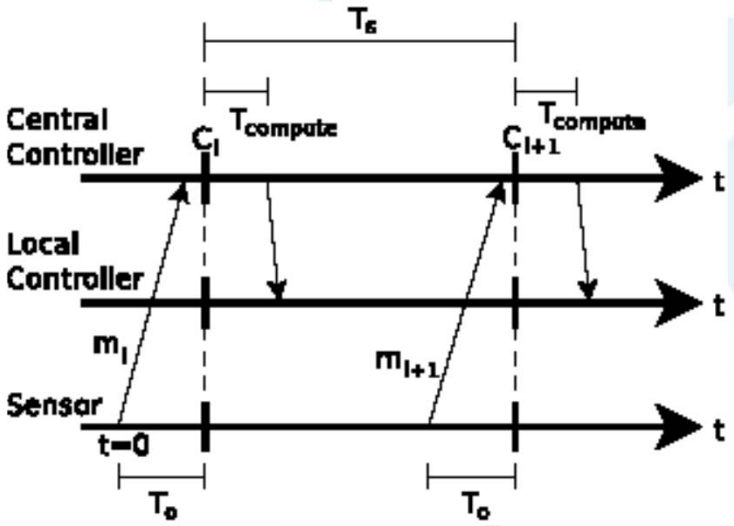


System description 3
Communication overview

- Message sequence diagram
  - T_s: Control period (150 ms)
  - $T_{compute}$: computation time (50 ms)
  - T_o: offset
  - C_i: Computation instant

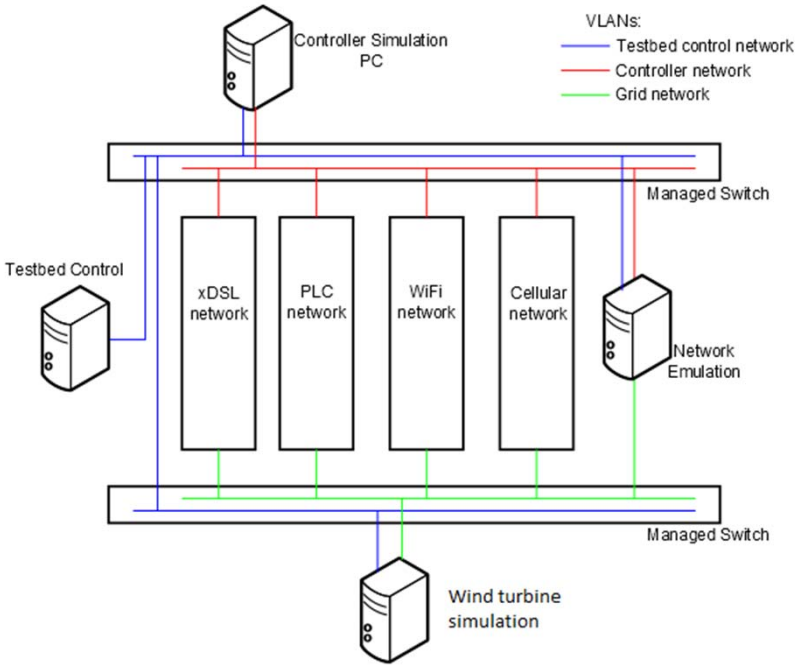
Tradeoff: Larger T_o

- Gives better chance of reaching C_i in time
- Larger risk of wind turbine state changing significantly

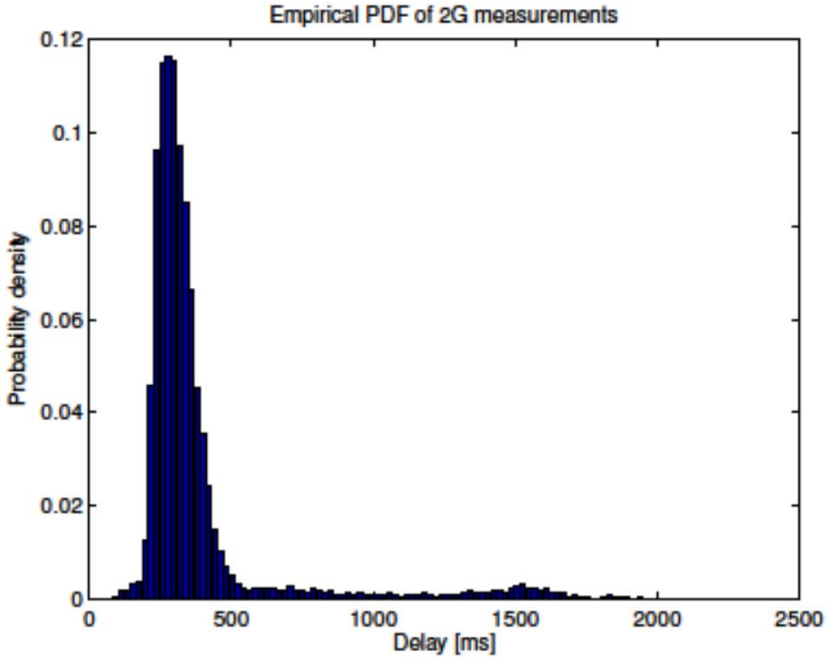


Testbed measurement steup

- 10 wind turbines with 3 sensors
- 1 ping message every 150 ms
- Four different communication technolgies measured
  - 2G/3G base station located on top of nearby building, modem located inside office building near window
  - WLAN in an office-like enviroment
  - Narrow-band PLC over 1m powerline
- Measure RTT and packet loss
  - No losses except in PLC case

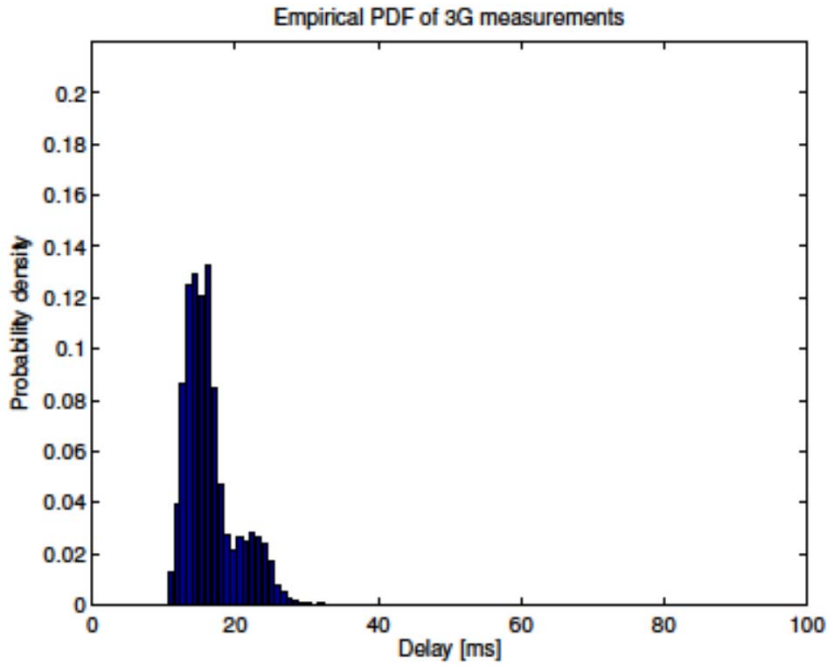


RTT delay results of cellular 2G



- Min delay: 84.5 ms
- Mean delay: 385.2 ms
- Max delay: 2131 ms

RTT delay results of cellular 3G

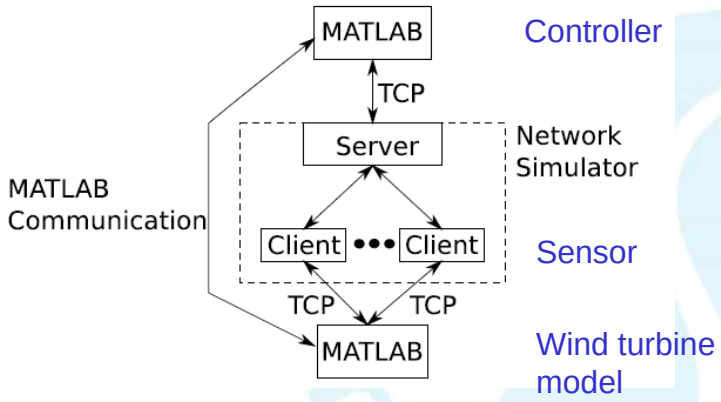


- Min delay: 10.5 ms
- Mean delay: 16.7 ms
- Max delay: 98.5 ms

Co-simulation framework

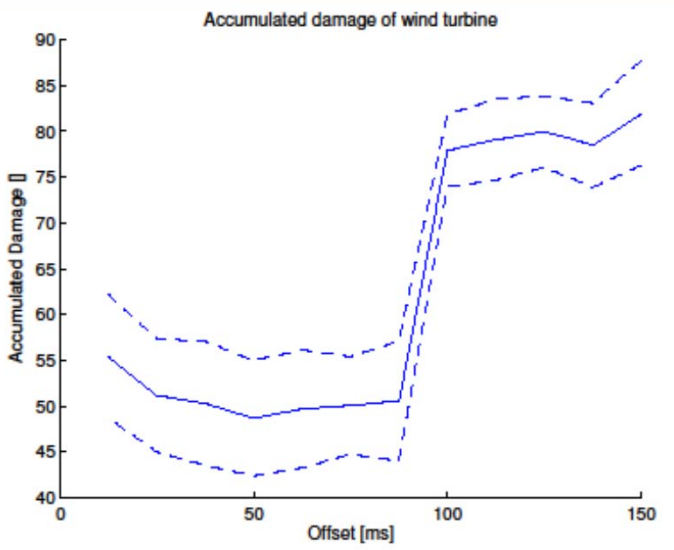
- Controller simulated via MATLAB
- Network simulated via OMNeT++
- Measurement traces used as packet delays

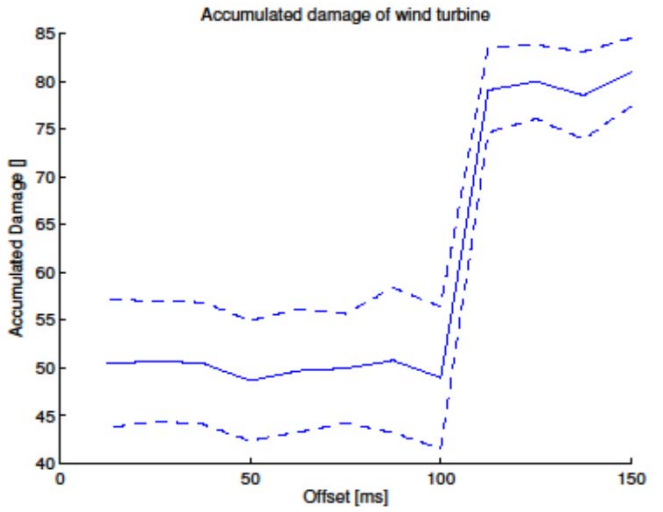
- OMNeT++ to OMNeT++ Interface
- OMNeT++ to MATLAB Interface
- MATLAB to MATLAB Interface



Controller performance results

- 3G trace: accumulated damage
  - Mean RTT delay of 16.7 ms
- Ideal network: accumulated damage
  - 0 delay
  - WLAN similar behaviour to ideal network
    - Not shown here
    - Mean delay of 5.4 ms

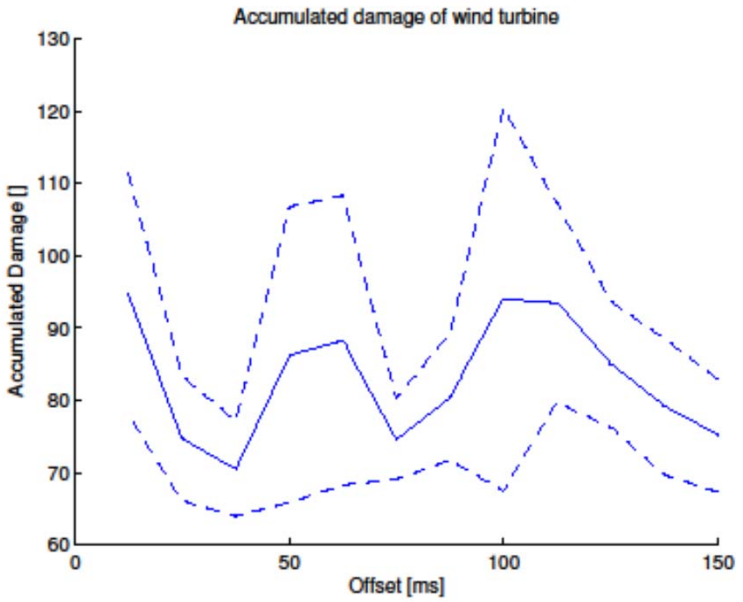




Controller performance results

- 2G trace: accumulated damage
  - Mean RTT delay of 385.2 ms
  - Messages are on average one control period old

➢ Cannot determine optimal offset within one control period



Summary

- We investigated the impact of different OTS communication technologies on controller performance
- Communication network delays impact performance
  - 3G and WLAN showed capable of handling the communication requirements
  - 2G showed delays that were too long to be of use to determine an optimal offset
  - PLC was not simulated as the testbed measurements showed too low throughput
- Access strategy optimization
  - 3G optimal offset shown to be in the interval [25 ms, 87.5 ms]
  - WLAN optimal offset shown to be in the interval [12.5 ms, 87.5 ms]

Thank you for your attention

QUESTIONS?