

DATA MANAGEMENT AND

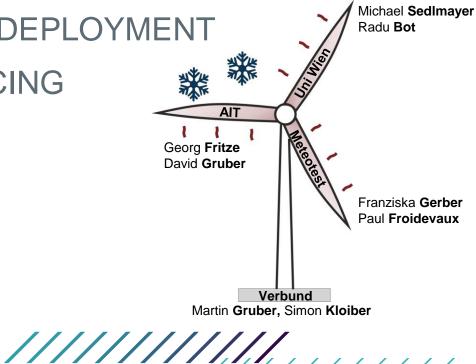
REAL-TIME ALGORITHM DEPLOYMENT

FOR ADVANCING ANTI-ICING

ROTOR BLADE HEATING

IN WIND TURBINES

Georg Fritze





CONTENT

Introduction SOWINDIC

Challenges

Data processing

- Execution Environment
- Retransmission Strategy
- Data Availability

Deployment

- Dataflow Architecture
- Validation Challenge

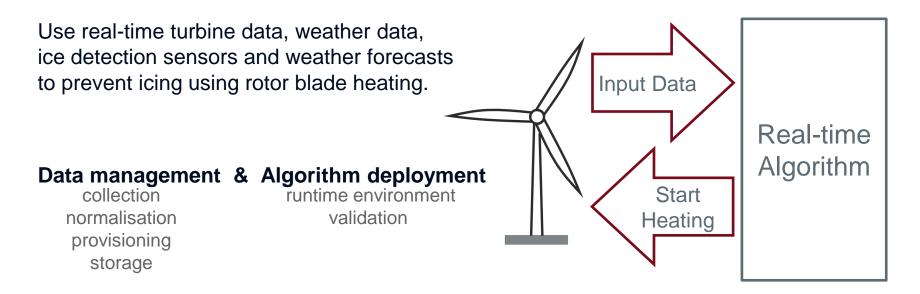
Summary & Outlook





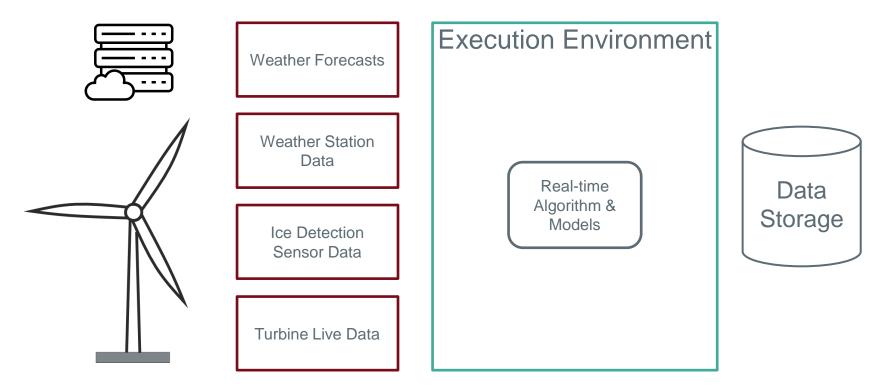
SOWINDIC

Smart Operation of Wind Turbines under Icing Conditions





SYSTEM ENVIRONMENT





PRACTICAL CHALLENGES

Hardware constraints

- Blade heating supported during standstill & operation?
- How to control rotor blade heating externally?

Regulatory restrictions

- Is blade heating during operation allowed?
- Is automatic blade heating allowed at all?



DATA HANDLING CHALLENGES

Data collection

- Interface data sources with different technologies
- Normalise different data formats: "2023-11-15T10:00:04", "2023-11-15 10:00:04", 1700038804

Data pre-processing

- Data interpolation: Super/sub-sample time series with different update rates
- Provide suitable data sub-sets for different algorithms of multiple developers

Data storage

- Overlapping timestamps in weather forecasts
- Handle connection losses
- Sensor failure or replacement
- Retransmit missed data points



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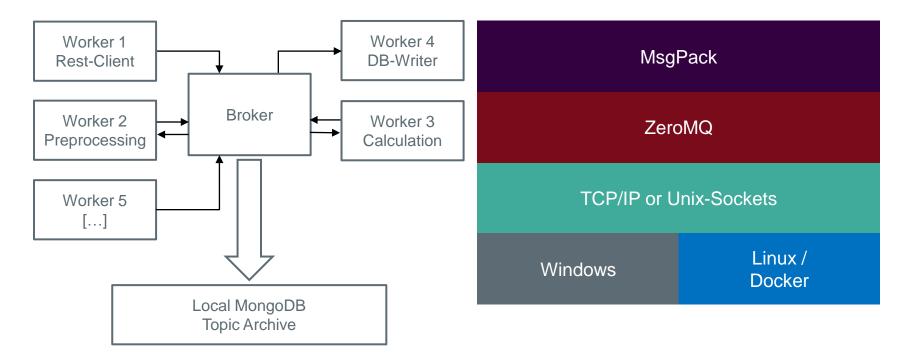
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COMMUNICATION FRAMEWORK: C++ DATA EXCHANGE SYSTEM







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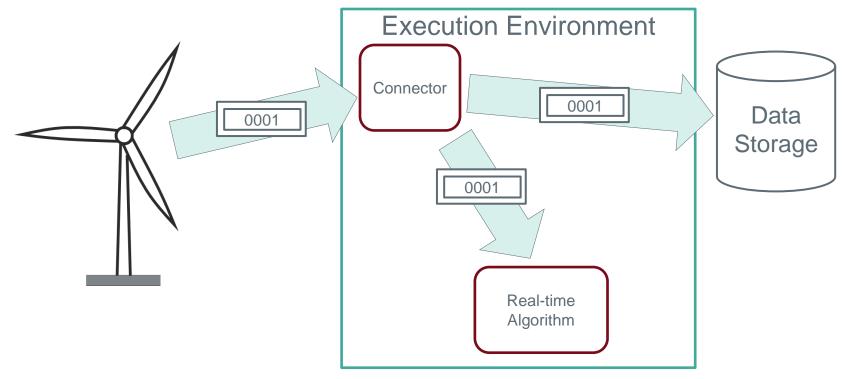
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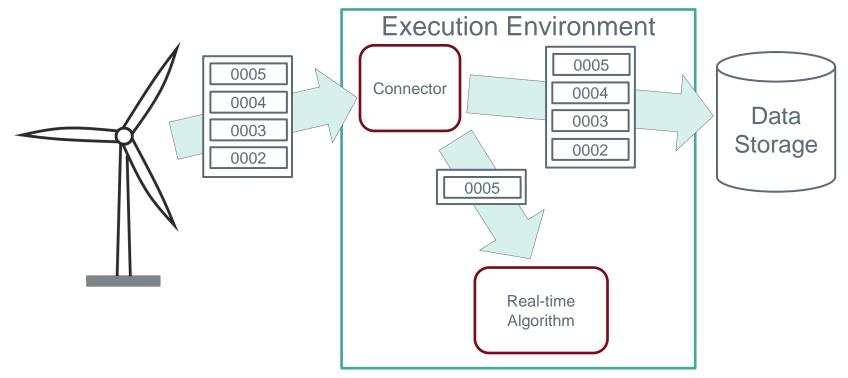


REAL-TIME DATA





RETRANSMIT DATA





DATA AVAILABILITY 18.11.2023 - 8.2.2024

Data Availability Plot Data available from 18.11.2023 00:00:29 to 8.2.2024 09:12:44 No Data available												
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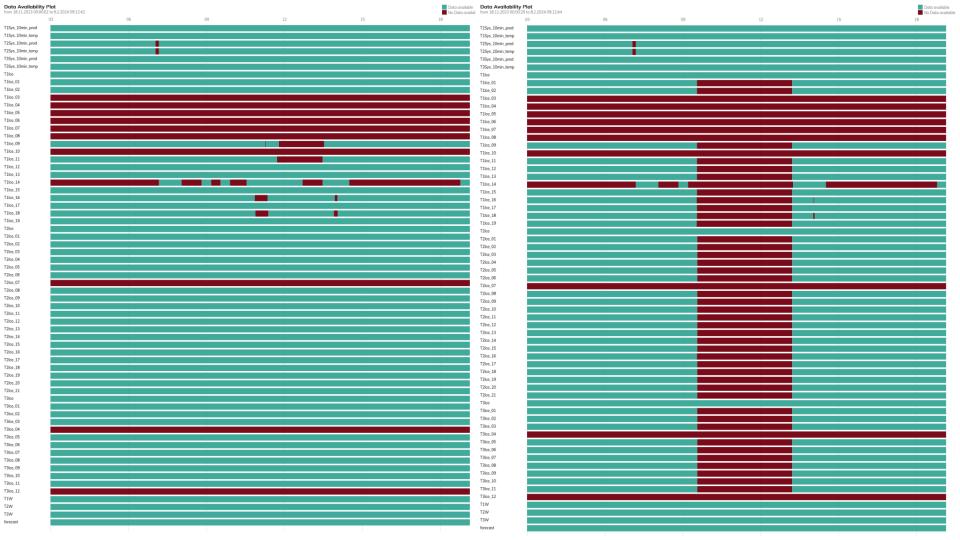
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	T3Sys_10min_temp						
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T1lce_06	T1ice_06						
T1lce_07	T1lce_07						
T1Ice_08	T1lce_08						
T1Ice_09	T1lce_09						
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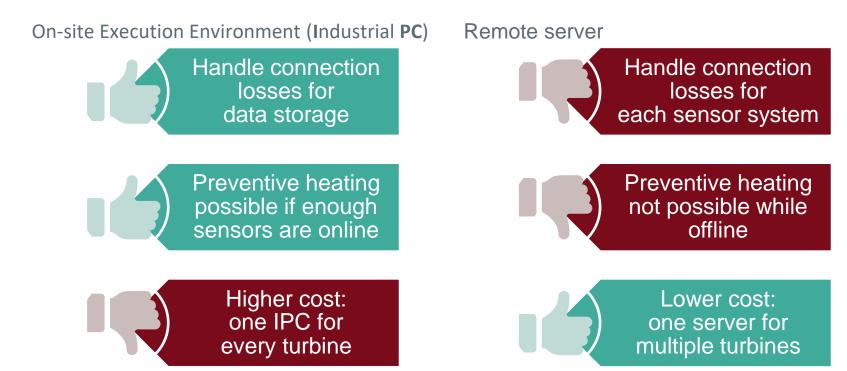


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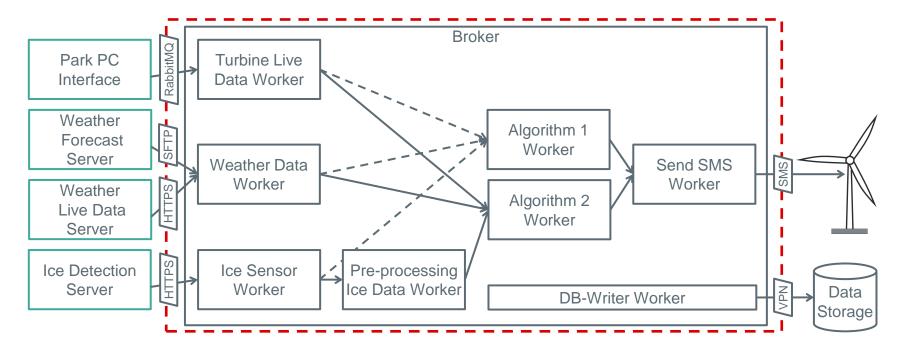


ON-SITE VS. REMOTE DEPLOYMENT





DATAFLOW ARCHITECTURE





THE VALIDATION PROBLEM



Validation is only possible with real operation on a turbine

A proper comparison can only be made after several years of operation



SUMMARY: DATA QUALITY



Handle connection losses and sensor replacements

Deploy IPC on-site to ensure best data availability



OUTLOOK

Validation

- Additional locations
- Other turbine types

Long-term tests

- Algorithm fine tuning & adaptions
- Quantification of efficiency

ACKNOWLEDGEMENT



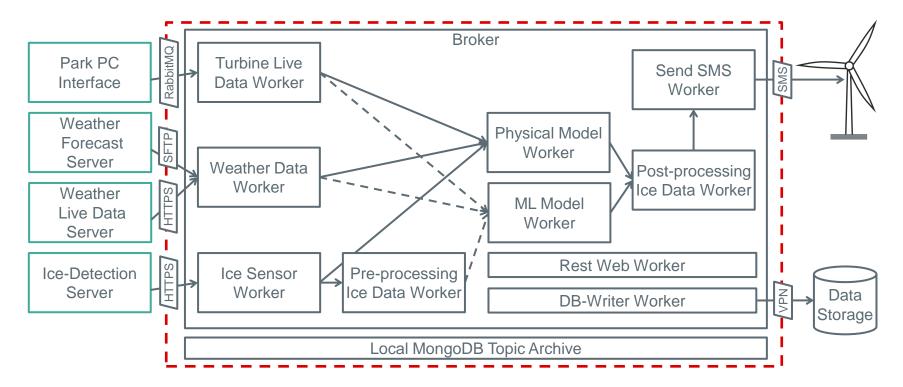


This work was partially funded by the "Energy Research" programme of the Austrian Federal Ministry for Climate Action, Environment, Energy, Mobility, Innovation and Technology (Grant No. 38160077)





DATAFLOW ARCHITECTURE





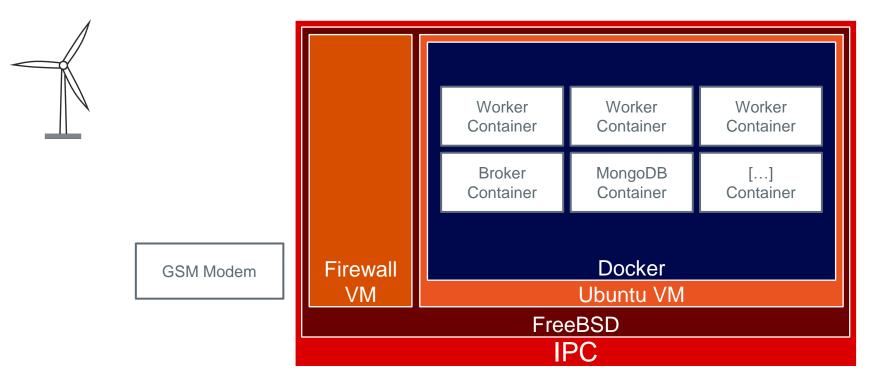
DETAILED DATA VIEW



13/03/2024

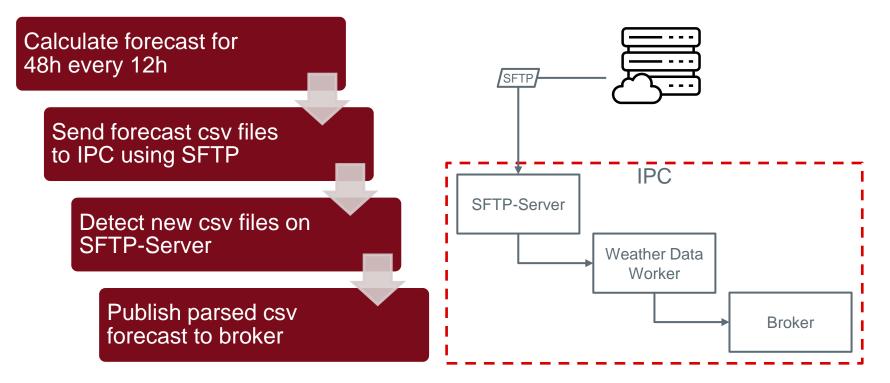


SYSTEM ARCHITECTURE



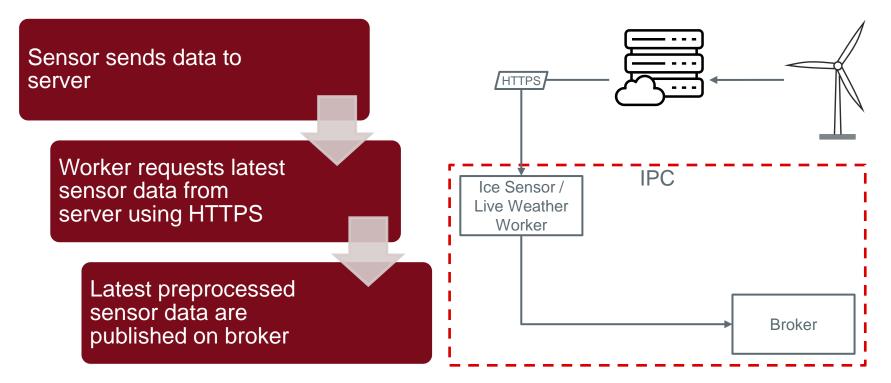


WEATHER FORECASTS



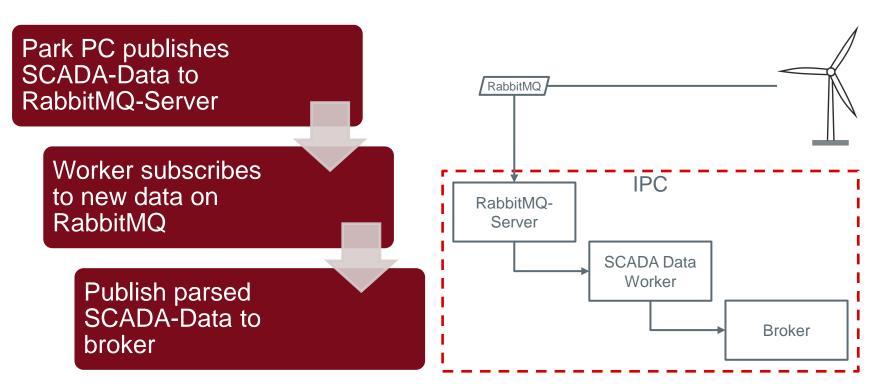


ICE-DETECTION, WEATHER STATION DATA



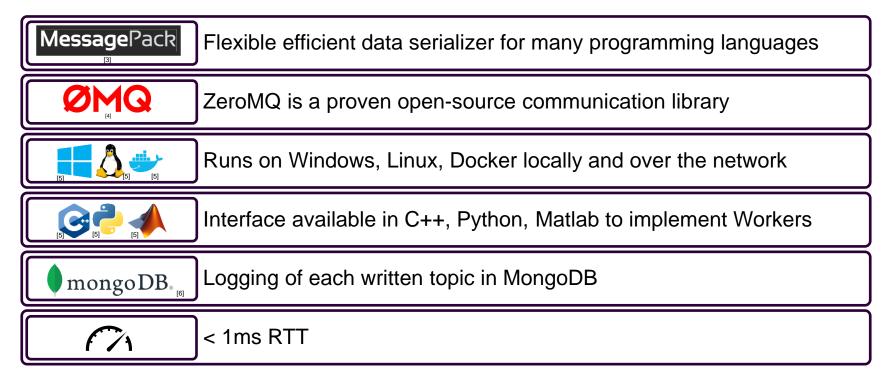


TURBINE LIVE DATA



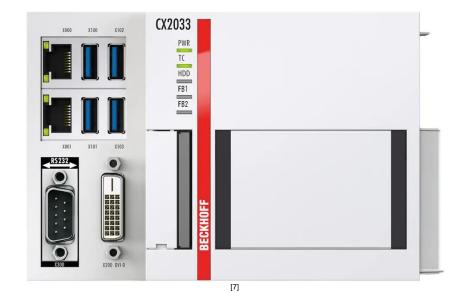


C++ DATA EXCHANGE SYSTEM



IPC BECKHOFF CX2033





MODEM TELTONIKA RUTX14







PICTORIAL SOURCES

- 1. Verbund AG
- 2. ffg.at
- 3. msgpack.org
- 4. zeromq.org
- 5. wikimedia.org
- 6. mongodb.com
- 7. beckhoff.com
- 8. teltonika-networks.com