CENTER FOR DATA-INTENSIVE CYBER-PHYSICAL SYSTEMS

Storing and Querying Big Energy Time Series

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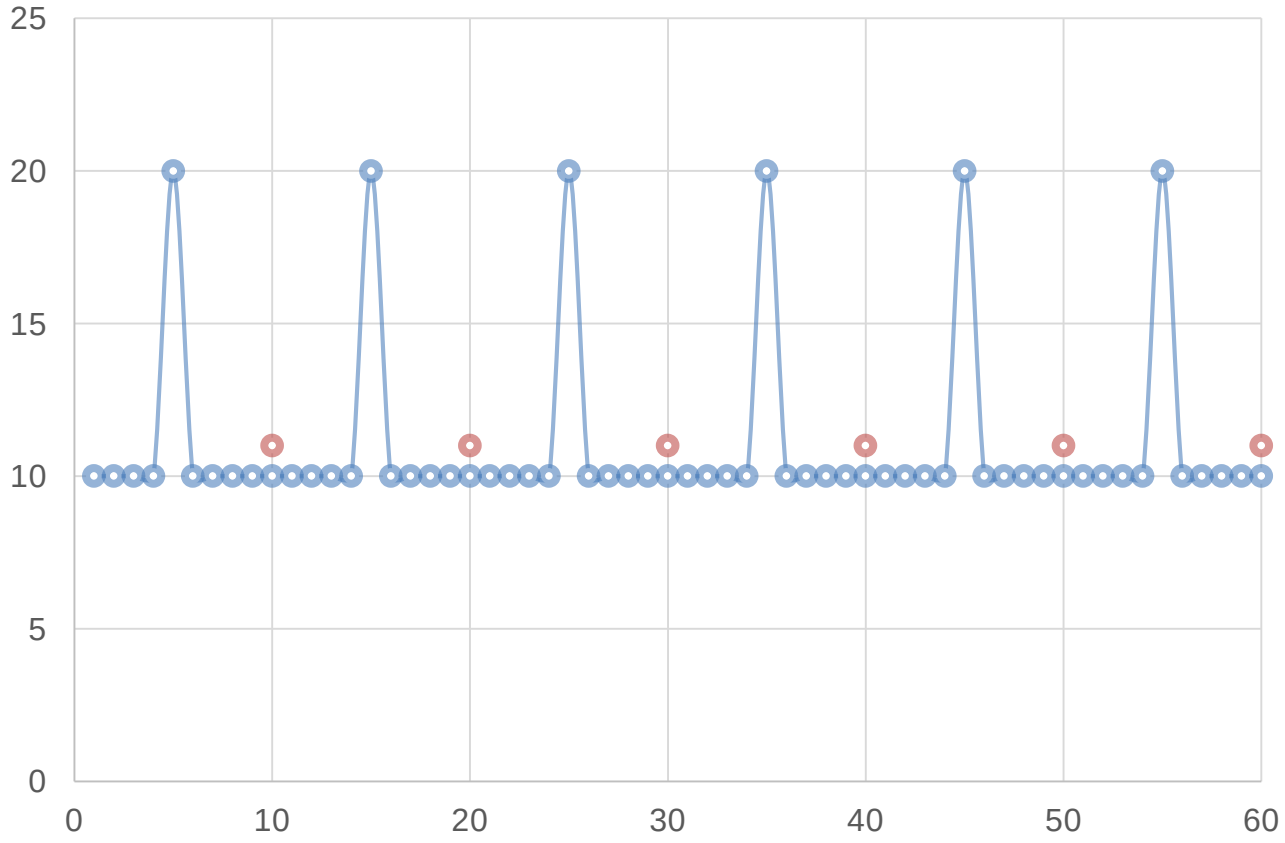
The challenge

- Wind turbines and solar panels have a lot of sensors that can deliver data values several times per second
  - A modern wind turbine has up to 15,000 streams
- This generates a lot of data
  - 10 reads/second, 4 bytes, 15000 streams ➔ ~50 GiB per day from one wind turbine

The current situation

- The available information is currently not exploited or stored
- Many monitoring solutions consider few (~100) sensor streams and store only a single value for every *x* minutes (e.g., the average)
  - *x* is typically ½, 1, 2, 5, or 10
- Important things might not be seen

Example of ”missing the point” :-)



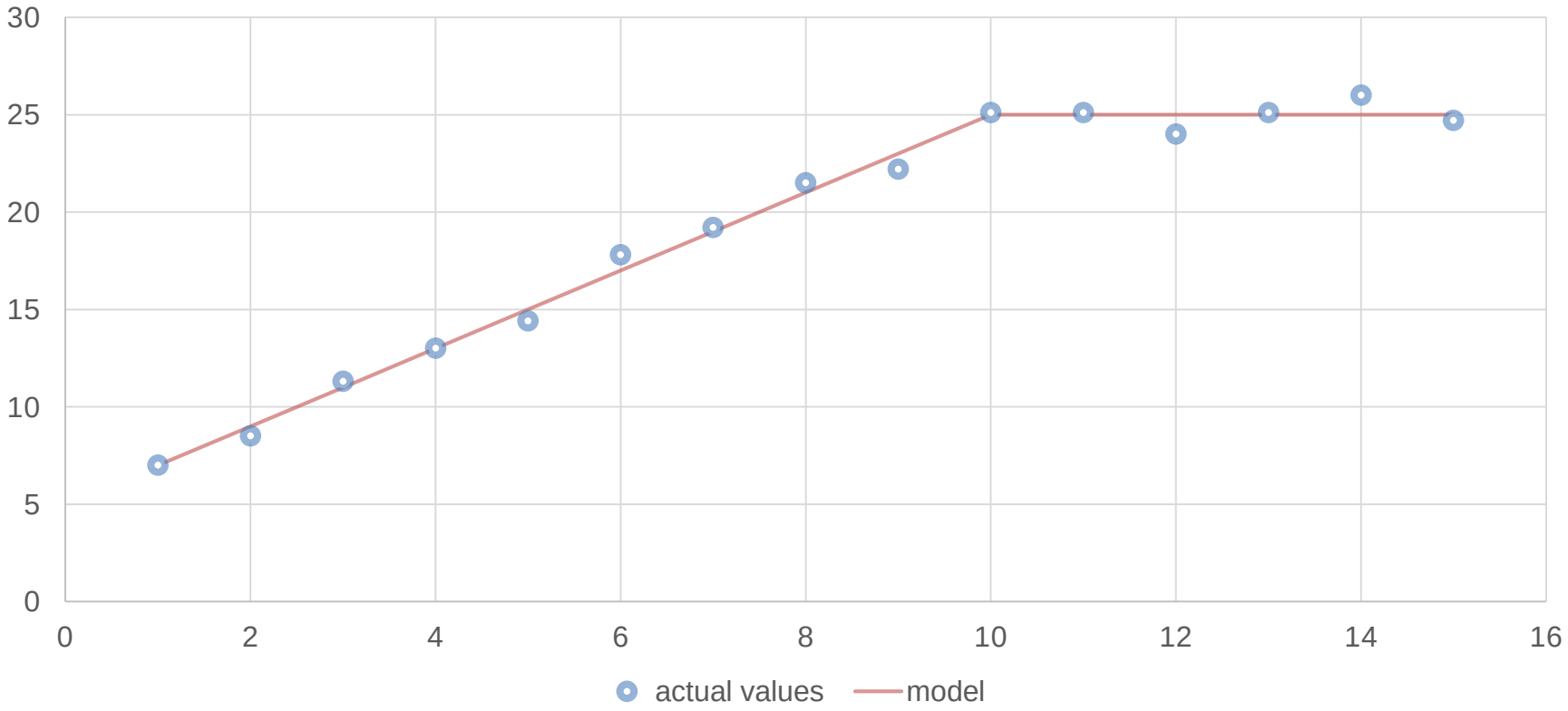
What we want to do…

- Store and use all available sensor data
- Support efficient aggregate queries on historical data
- Support analysis of data while it is being ingested
  - Detect underperformance and other problems immediately
  - Enable predictive maintenance
  - For example, detect and fix a problem before the wind turbine breaks

How we want to do it

- Time-series can contain millions of points
- An efficient way to store and process them is to represent them by models
- We use a model-based approach for the time-series data
- A (user-defined) error can be allowed
  - For example 5%, 1%, or 0%

Simple example – linear models



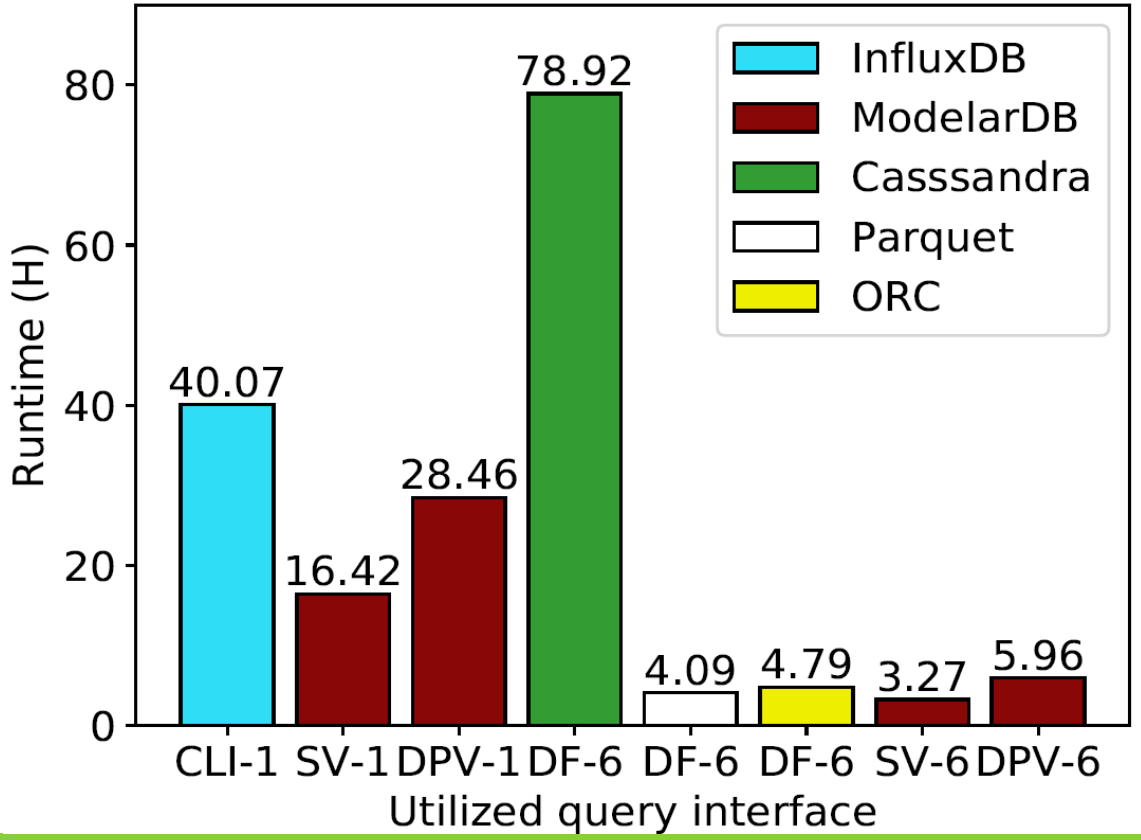
ModelarDB

- We have developed ***ModelarDB*** which uses models to store time series data
- Time series-specific functionality implemented in a system-agnostic library
- We have implemented some model types and the user can optionally add more. ModelarDB will automatically pick the best
- Query processing and storage from existing systems (we have used Spark & Cassandra)

Storage requirements for a real-world data set from the energy domain

Storage Method	Size in GB
CSV files	617.52
PostgreSQL 10.1	782.87
InfluxDB 1.4.2	4.34 – 4.44
Apache Parquet files	106.94
Apache ORC files	13.50
Apache Cassandra 3.9	111.89
ModelarDB	2.43 – 2.86

Performance example for large aggregate queries



Performance summary

- ModelarDB provides support for fast ingestion, good compression, and fast large aggregate queries
- ModelarDB remains competitive for small aggregate and point/range queries
- Other systems are good for *one* of these, but not both

Conclusion and future work

- ModelarDB provides novel model-based compression within an error bound
- Good performance
- Integrated with Spark and Cassandra
- Future directions
  - Indexing to increase query performance further
  - Represent correlated streams together