

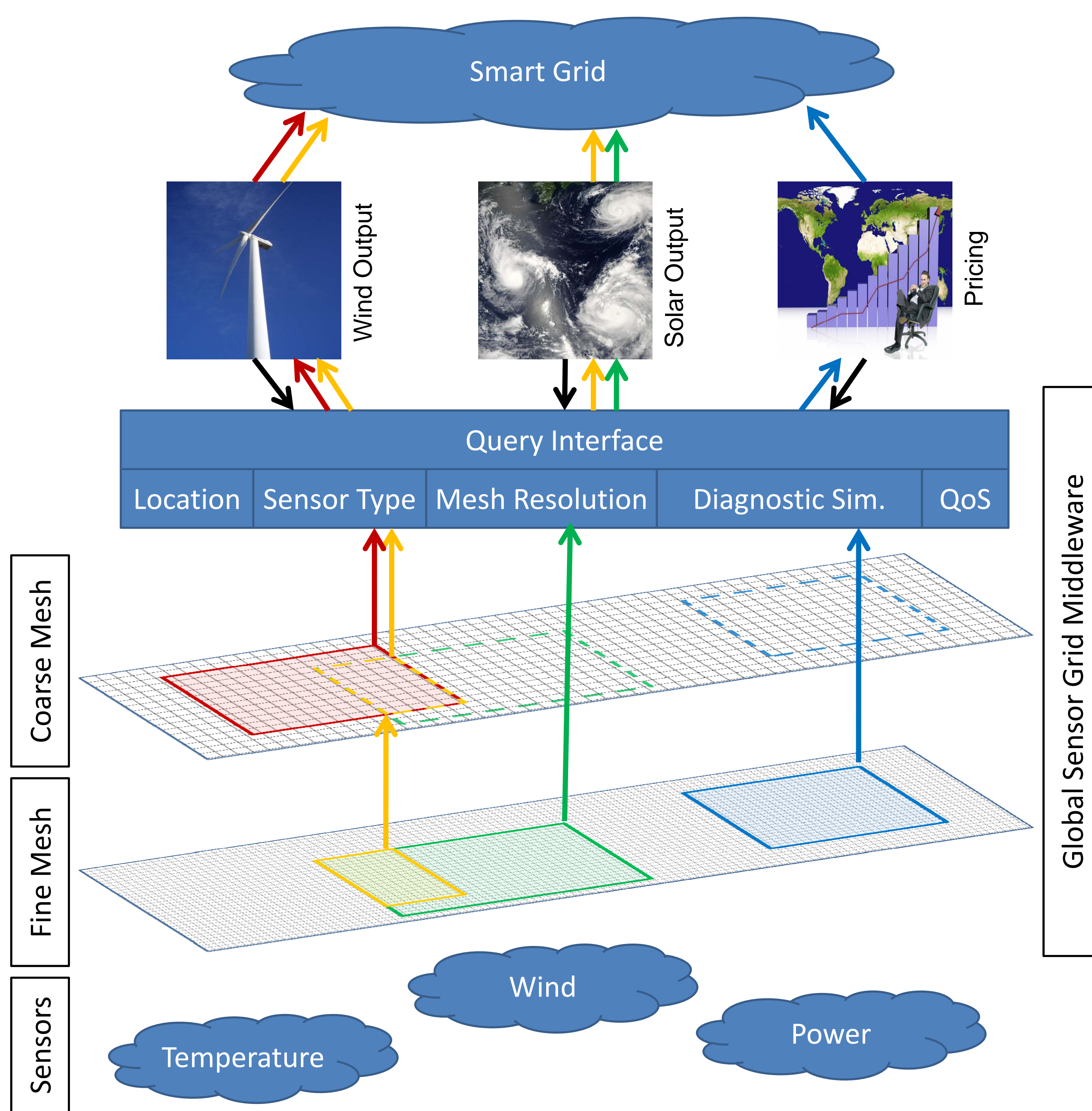
Distributed Diagnostic Simulations for the Smart Grid

Introduction

With the increasing deployment of renewable energy sources their power output strongly depends on the current wind and light conditions. Up to now, the required atmospheric data has been mostly provided by weather forecasts. Such forecasts involve very complex simulations and therefore take a long time to provide the required data. We propose a Global Sensor Grid which provides real-time data by tightly integrating and distributing so-called diagnostic simulations.

Diagnostic Simulations for the Smart Grid

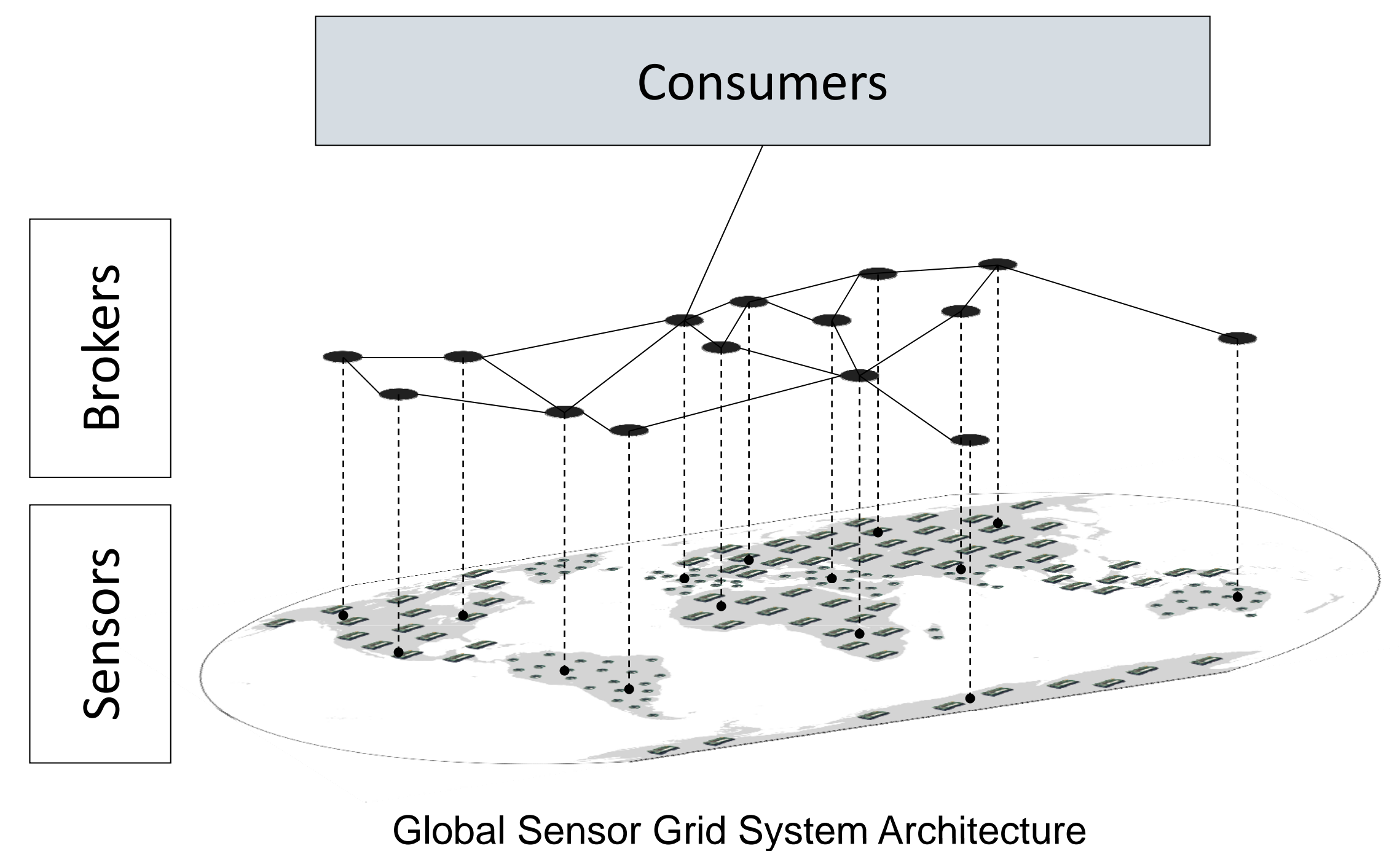
- Provide power predictions for the smart grid with access to measurements
 - Full availability of data despite low sensor coverage
 - Higher quality of data than raw interpolation or just measurements
- Support real-time access to time-lagging sensors



Global Sensor Grid Architecture

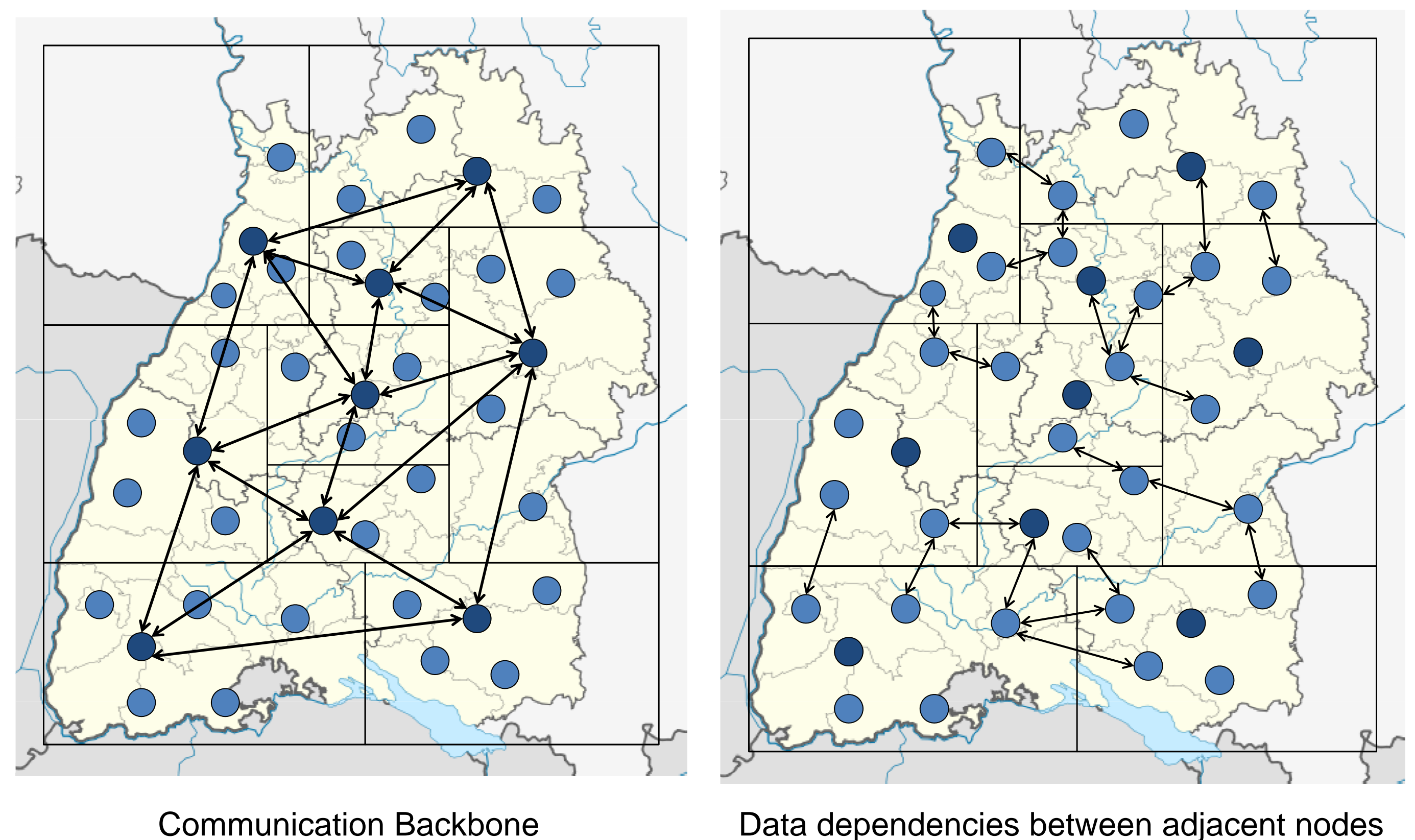
The Global Sensor Grid includes the following three main parts:

- Brokers provide computation and communication backbone
- Sensor nodes are assigned to brokers according to management areas and might also lack persistent power supply (wireless sensor networks)
- Continuous queries are used by applications to specify the geographic region of interest with spatial and temporal resolution



Distribution of Diagnostic Simulations

- Integration of the diagnostic simulation into the Global Sensor Grid
 - Partitioning of simulation and mapping to communication backbone
 - Equal distribution of load among brokers
 - Rearrangement of partitioning with changing load situations
 - Routing of queries from and results to consumers
- Synchronization between brokers required
 - Exchange of boundary conditions for higher accuracy
 - Alignment of simulation grids for better performance
 - Data dependencies between adjacent nodes have to be met



Applications Key Challenges

- Huge amount of data has to be processed and transmitted
 - High density query results from high number of consumers
 - Synchronization of boundary conditions between brokers
 - Common approaches for in network processing unsuitable
 - New mechanisms for data reduction based on reuse of results required
- Increasing number of data sources has to be managed and indexed
 - Efficient lookup of sensor nodes and sources for reuse required
 - Smart meters, weather stations, and running queries
 - Horizontal dependencies of data producers on the base level
- Provision of low latency to the consumers
 - Spatial distribution entails increased number of hops and signal delay
 - Tradeoff between low latency and bandwidth conservation
 - Extension of predictors from WSN to multi-hop operation in GSG

Current and Future Work

- GSG is under evaluation of distributed wind field calculation
 - Challenges in real application scenarios
 - Projects in the SimTech cluster of excellence
- Wind fields are used for multiple simulations
 - Dispersion of substances in the atmosphere
 - Prediction of wind energy output for efficient adaptation of power grids

