DaWaK 2012

MIRABEL DW: MANAGING COMPLEX ENERGY DATA IN A SMART GRID

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OUTLINE

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1 CONTEXT
- Problems with renewable energy
- The MIRABEL project

2 CONTRIBUTIONS

3 MIRABEL DW SCHEMA
- Actors of European Electricity Market
- Timeseries
- Flexibility objects

4 ALTERNATIVE SCHEMA DESIGNS
- Experimental evaluation

5 RESEARCH DIRECTIONS

6 CONCLUSION

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CONTEXT

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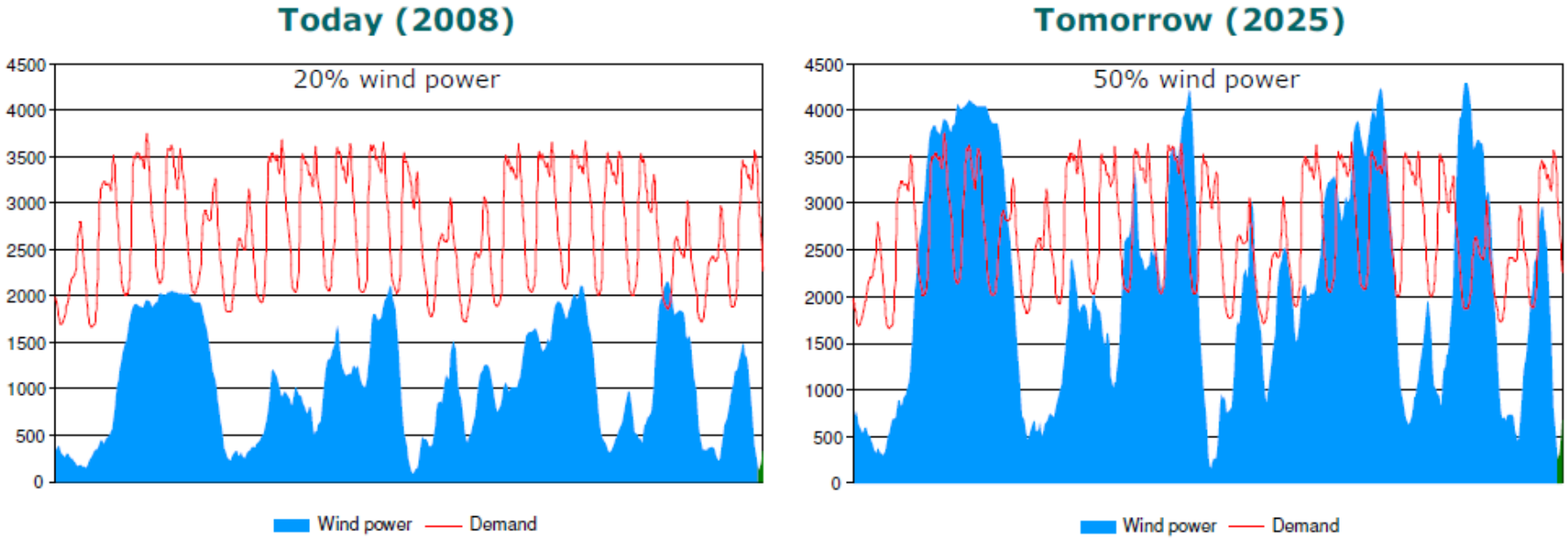
Renewable Energy

- More and more energy is produced from renewable energy sources, e.g., windmills
- The integration of renewable energy is challenging



MIRABEL project

- Design and prototype EDMS to balance supply and demand with the help of demand flexibilities

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DEMAND IN A HOUSEHOLD

Non-flexible

- Lamp
- TV
- Computer
- Cooking Stove

Flexible

- Refrigerator
- Air conditioner
- Dishwasher
- Electric vehicle

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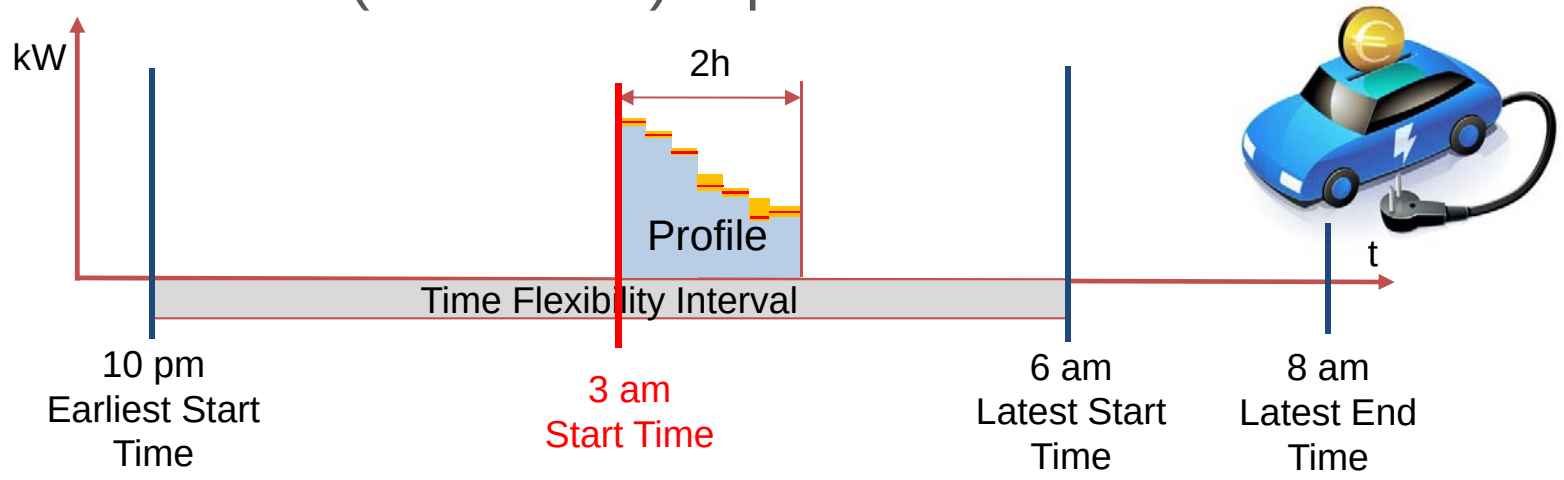
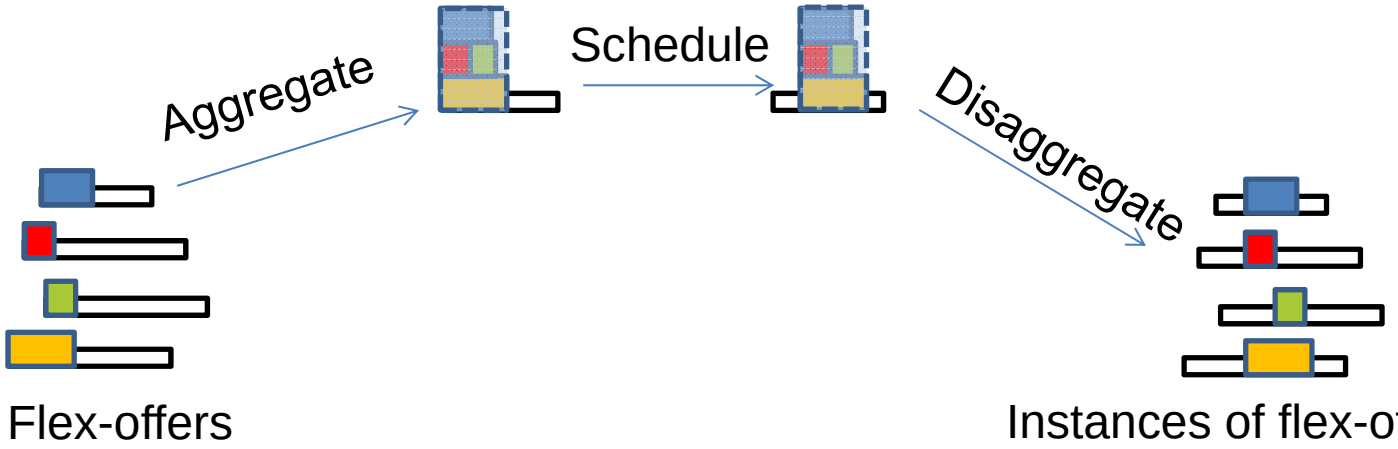
MIRABEL use-case

- Flexible offers (flex-offers) represent a flexible demand



- Flex-offers are aggregated and scheduled to utilize renewable energy more efficiently



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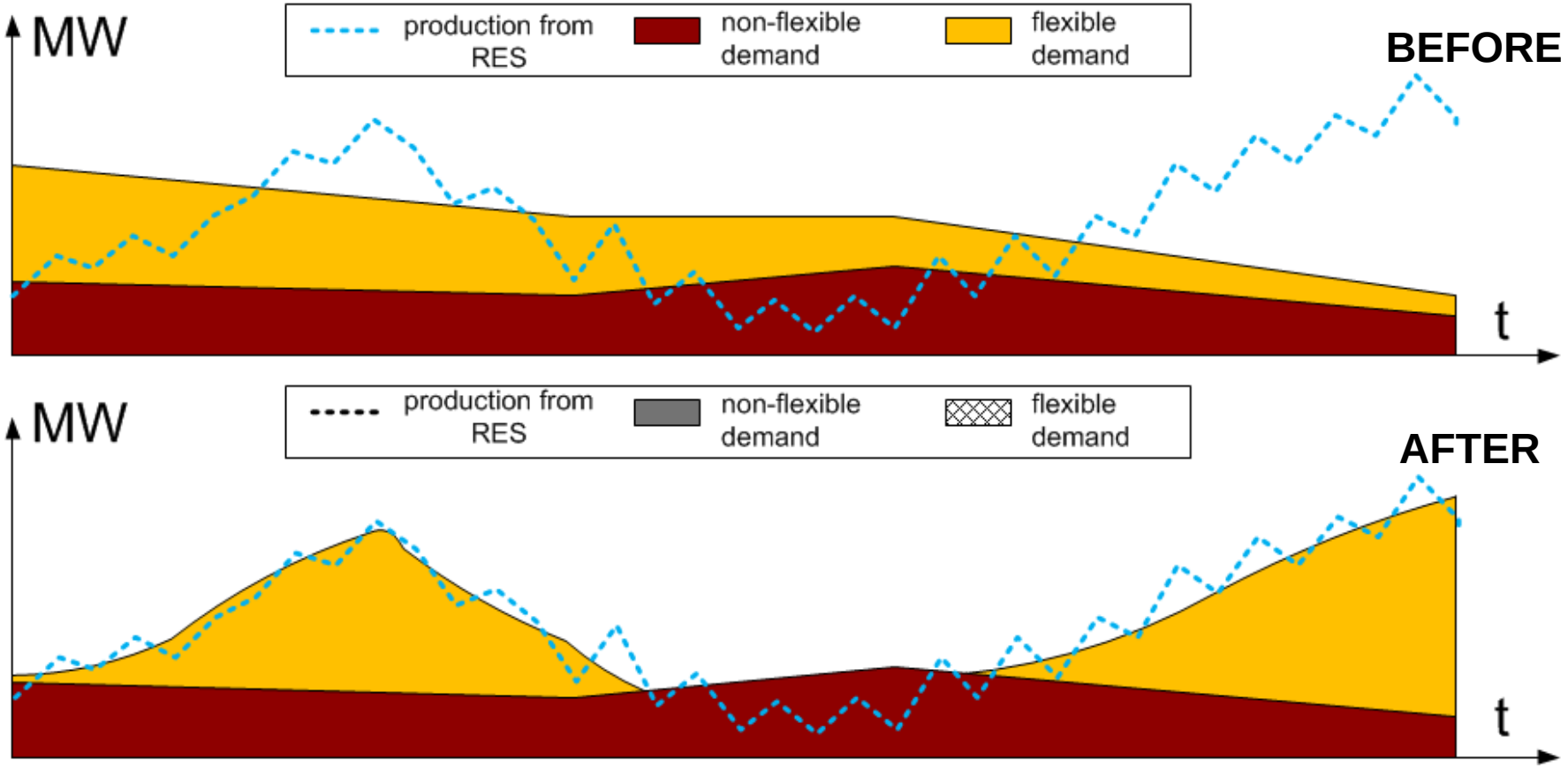
MIRABEL use-case

- Before and after the MIRABEL system balances the grid



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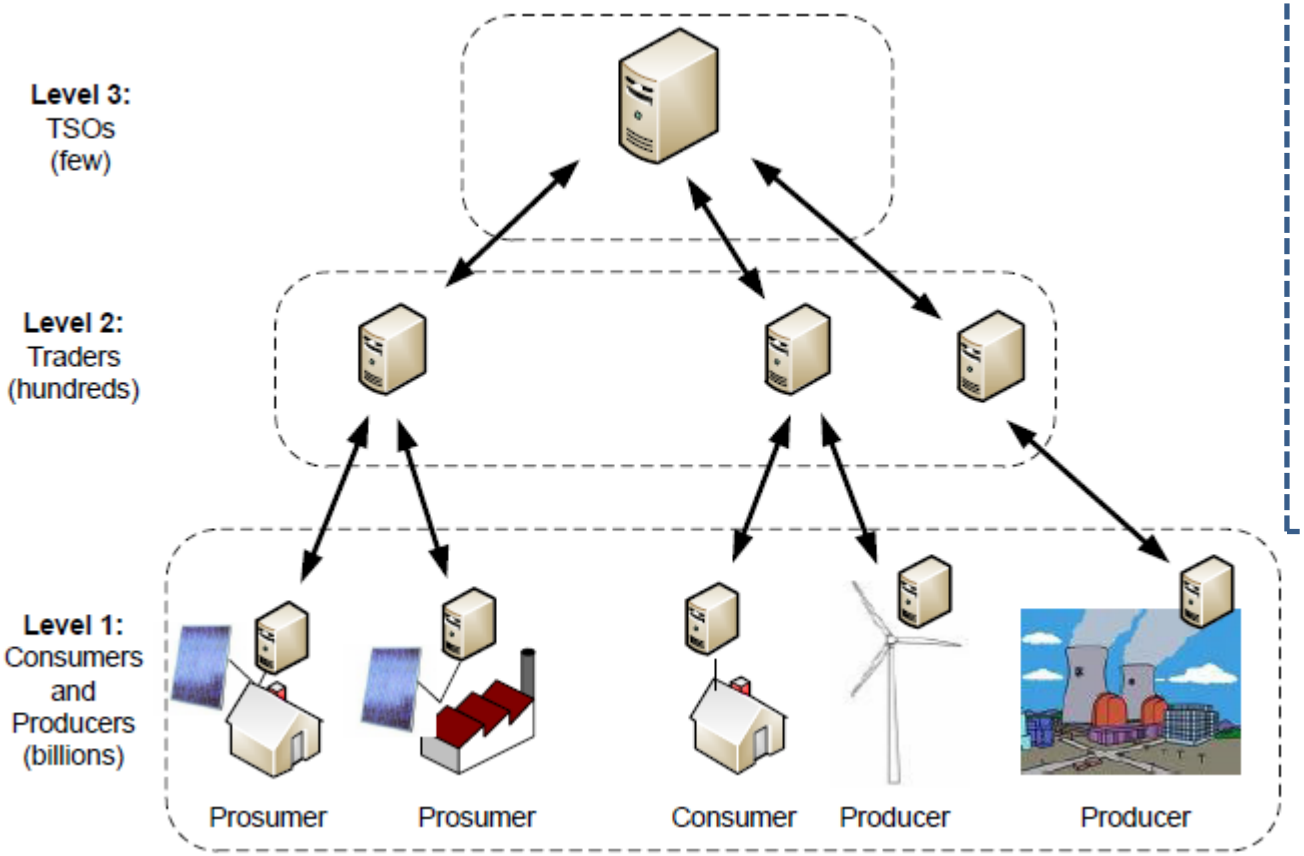
Hierarchical Energy Data Management System (EDMS)



Denmark

1 TSO

~100 traders

~$3 \cdot 10^6$ households

↔ Exchange of

- Measurements
- Flex-offers
- Prices
- …

- Reflect the harmonized model of European Electricity Market

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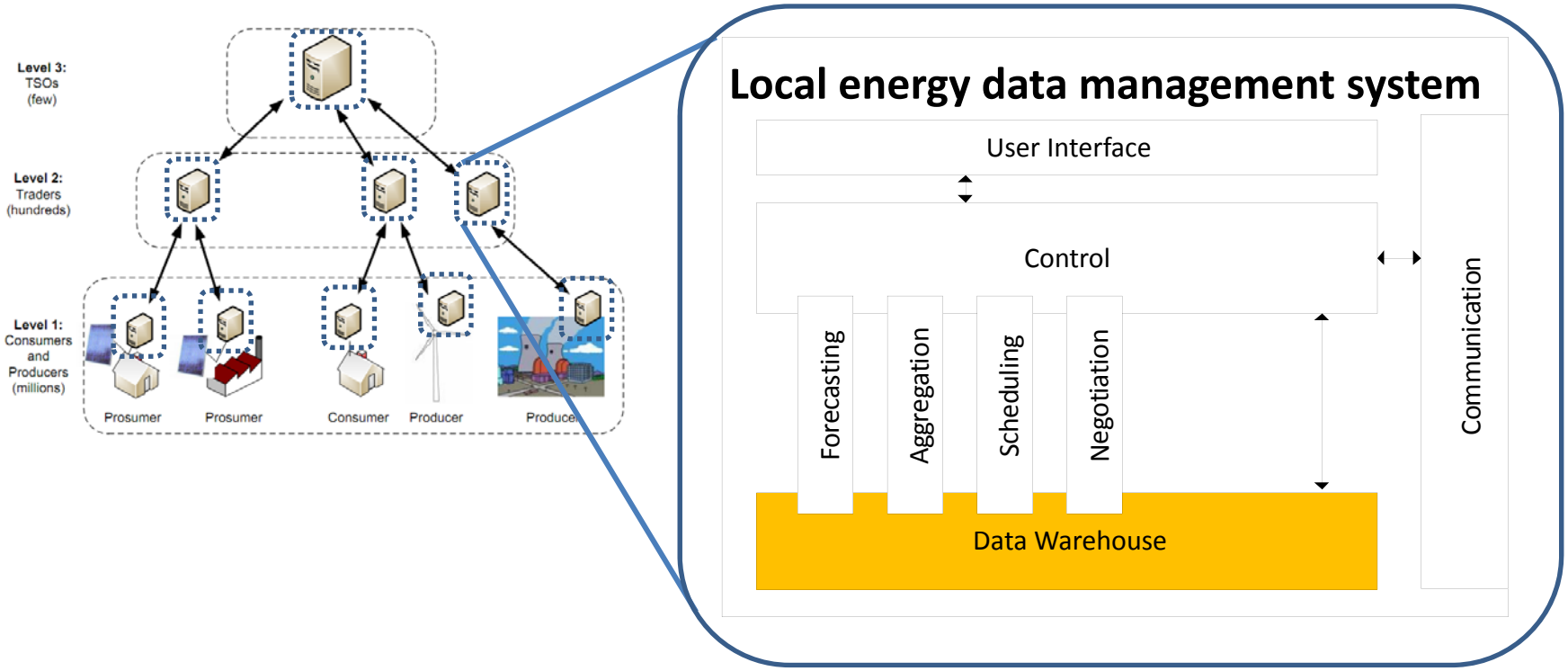
EDMS NODE ARCHITECTURE



- A suitable DW schema is need for efficient data management!

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CONTRIBUTIONS

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In our paper we:

- Present a generic DW schema supporting all levels of the EDMS hierarchy
- Discuss the complexities of the schema compared to traditional DW schemas
- Discuss alternative data modeling strategies
- Evaluate schema alternatives using typical queries from the MIRABEL project

- More on the MIRABEL EDMS: “Data Management in the MIRABEL Smart Grid System”, EnDM 2012
- More on the MIRABEL DW: “Real-time Business Intelligence in the MIRABEL Smart Grid System”, BIRTE 2012

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MIRABEL DW schema

- Based on the MIRABEL data model
  - Common information model (CIM) by IEC
    - Represent major objects in an electric utility enterprise
  - Harmonized Electricity Market Role Model by ebIX®, EFET and ENTSO-E
    - Define administrative data internally interchanged between European electricity markets

  None of the existing models focus on storage of energy-related entities
- Schema is complete for the prototype of the MIRABEL system
- Types of data represented:
  - Actors and roles defined by the “Harmonized Electricity Market Role Model”
  - Flex-offers and time series

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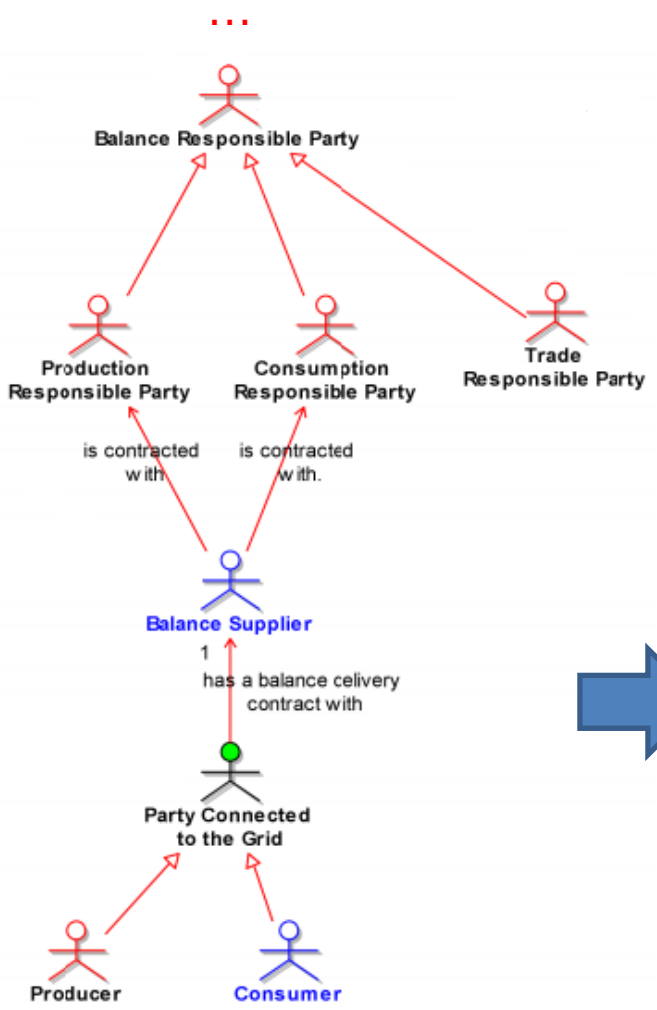
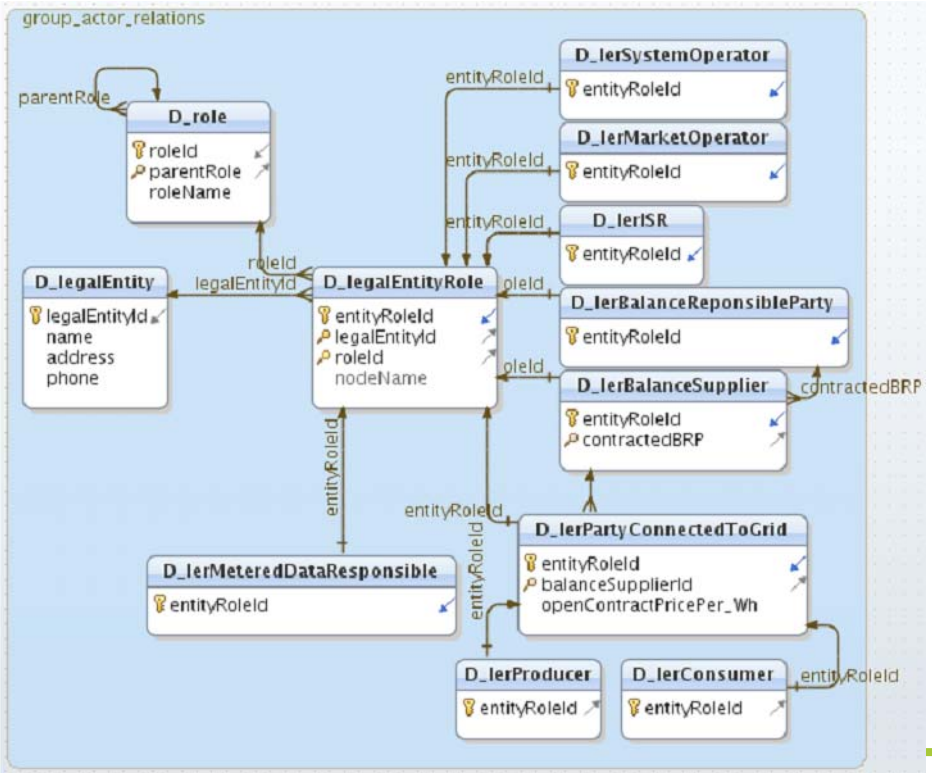
Actors and roles



Roles from Harmonized Role Model

- Actors plays one or more roles
- Roles may have specializations and/or interact with/reference other roles
- Schema represents actors



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MIRABEL DW SCHEMA

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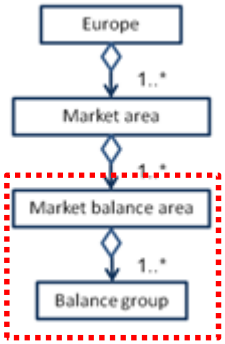
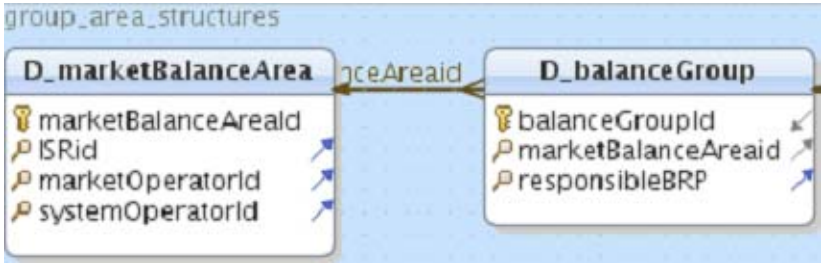
- An actor, for each role,
  - **Belongs** to one of the areas





  - **Warehouses** proprietary energy data
    - Energy, power, prices, flex-offers
    - Non-aggregated/aggregated
    - Measured/forecasted

Represent in our schema

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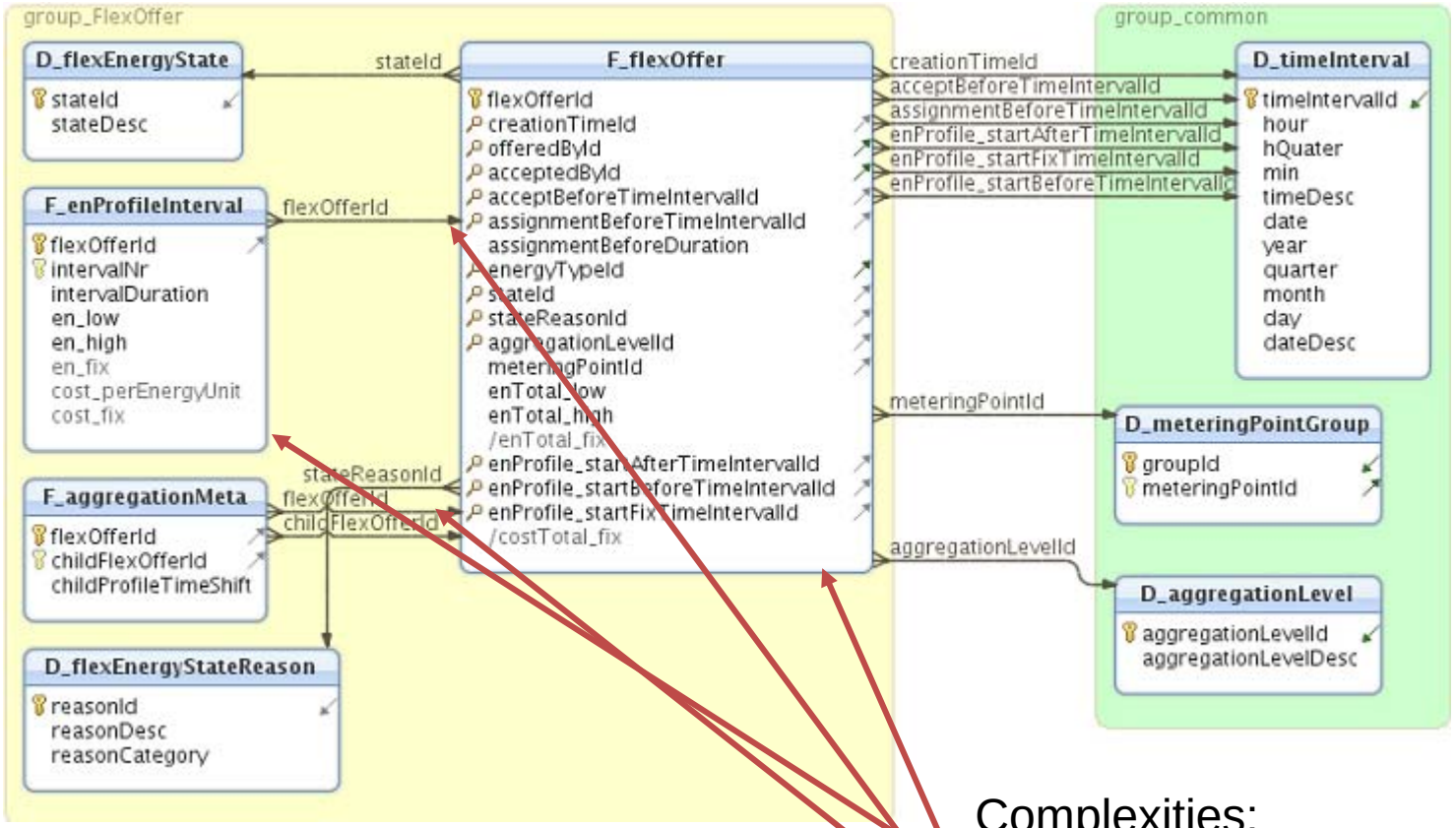
Flex-offers



- Time is discretized
- Flex-offers of different aggregation levels
- Instances of flex-offers represented

Complexities:

- Non-atomic composed facts
- Facts about facts

Alternative designs are considered

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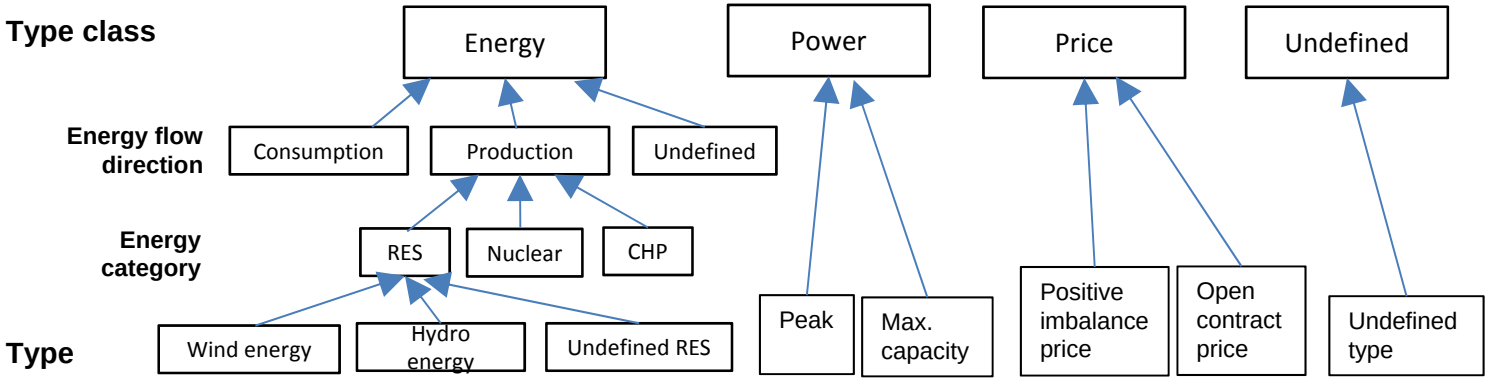
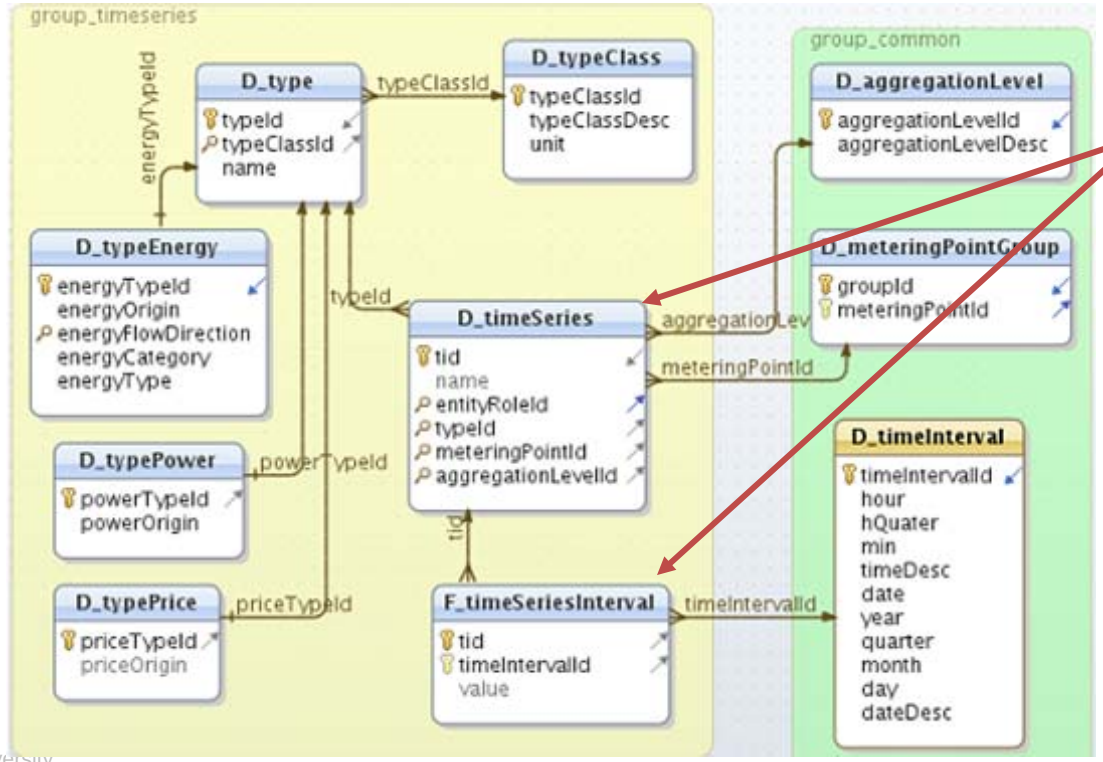
Timeseries





Complexities:

- Composite facts

Alternative designs are considered

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MIRABEL DW SCHEMA

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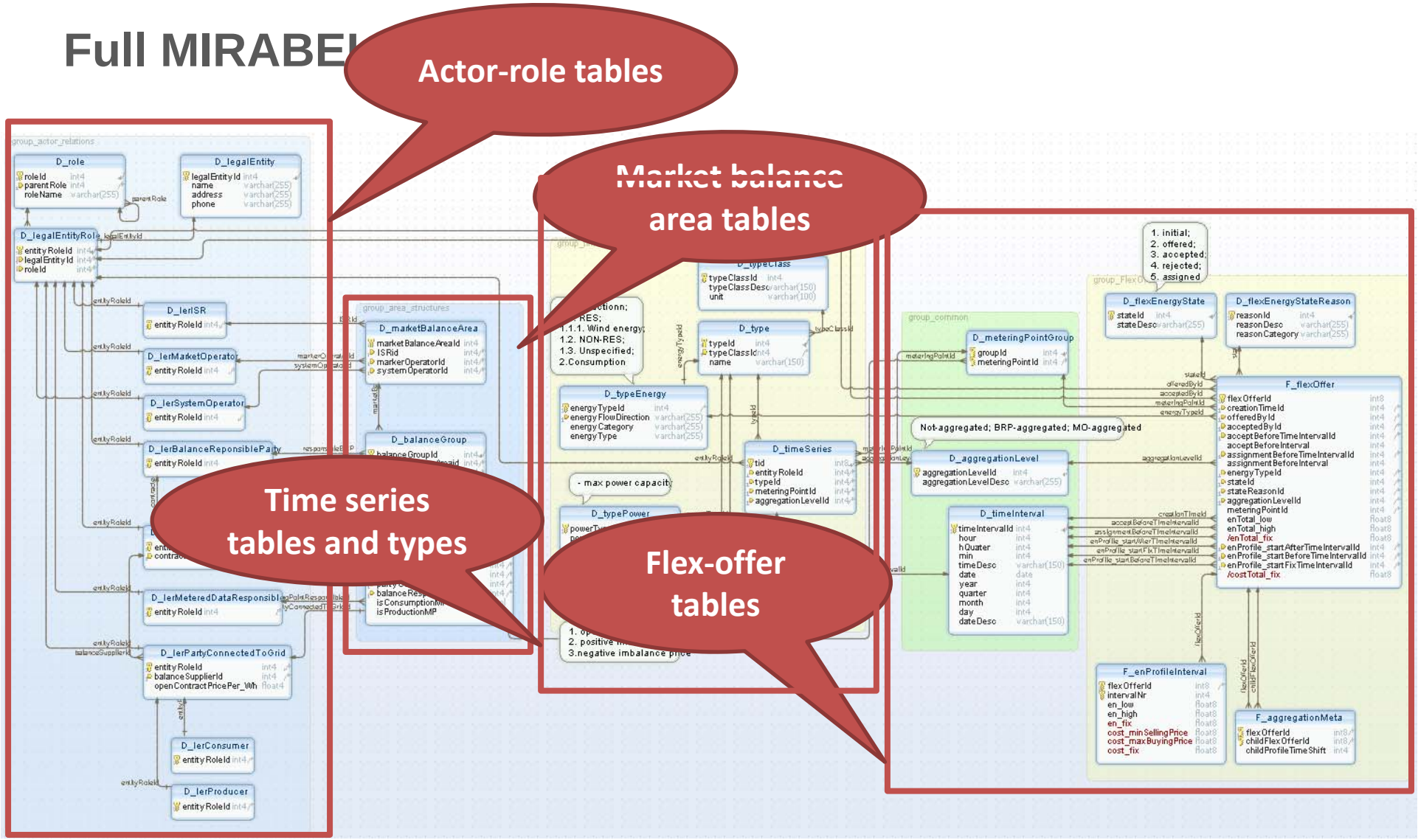
Full MIRABEL



ALTERNATIVE DESIGNS

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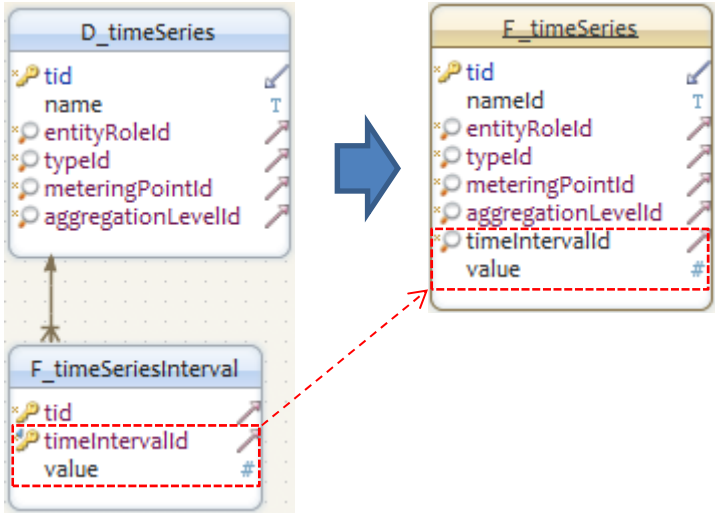
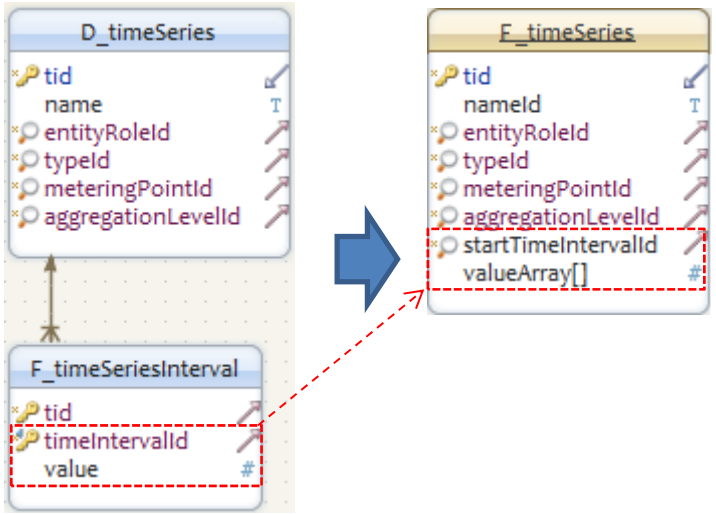
- **Objective:** optimize the schema for typical queries
- **Approach:** implement alternative schemas and run typical queries to evaluate them on realistic data
- **Schema alternatives:** flex-offer and time series design variants:
  - Denormalized
  - Array-based





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Experiment setup

- Real energy consumption data: 963 time series, 32.1M values (MeRegio),
- Synthetically generated 3.1M flex-offers
- Linux server with 16 GB RAM, 2x Intel Xeon CPUs, 4 SATA 7200RPM disks
- PostgreSQL 9.1, tables are “fully vacuumed”
- Queries executed in round-robin fashion 5 times

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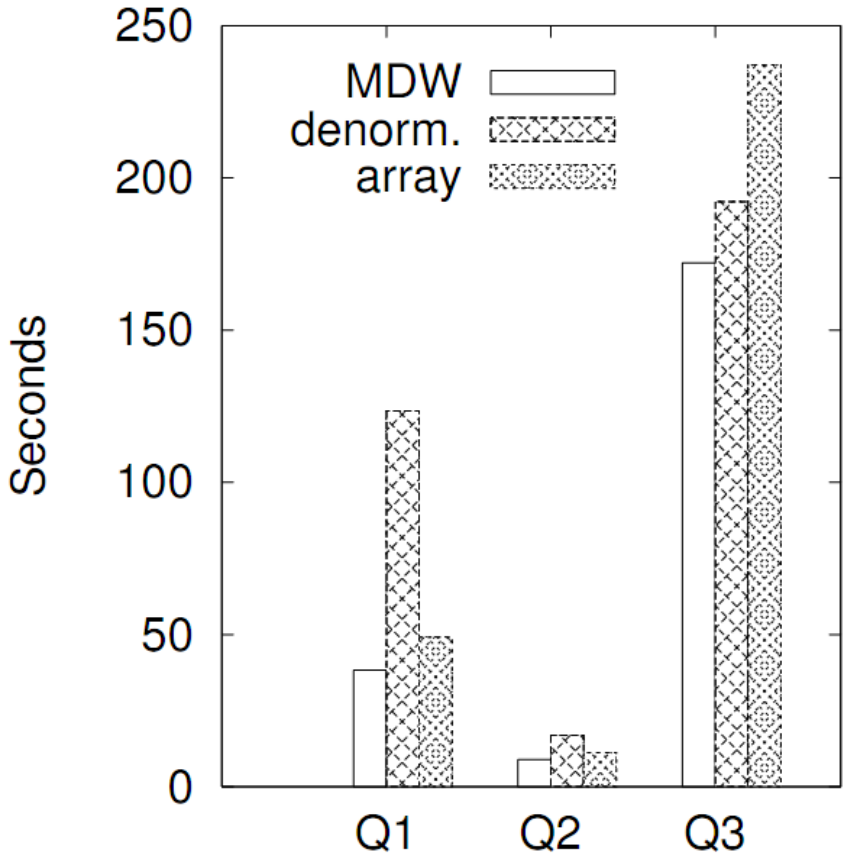
Experiments with flex-offer schema variants

Flex-offer queries

- Q1: Compute total flexibility per flex-offer
- Q2: Compute sum of all scheduled (fixed) energy
- Q3: Builds a time series that represents amounts of fixed energy

Results

- MDW variant is the fastest
- MDW variant uses optimal amount of space



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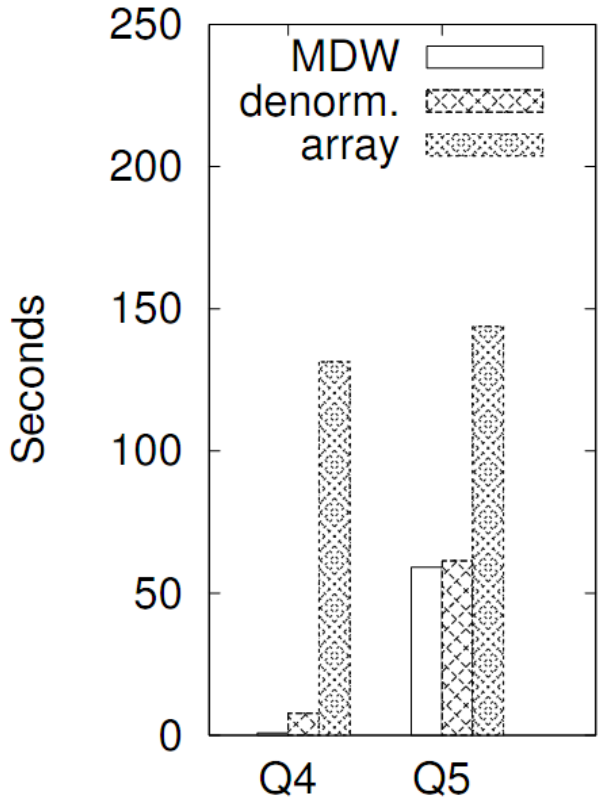
Experiments with timeseries schema variants

Time series queries

- Q4:Compute energy balance for 24h considering total demand and supply
- Q5: Find time series with average energy exceeding an average time series by 25%

Results

- MDW variant is the fastest
- MDW variant uses optimal amount of space



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RESEARCH DIRECTIONS

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- (Future) distribution of DW
  - The schema will be replicated on all nodes of EDMS
  - Node holds only relevant data and of specific granularity

- Challenges
  - Propagation of data through the hierarchy, caching
  - Specialized versions of the schema for different types of nodes such that queries formulated on generic schema can be translated to the specialized schemas

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CONCLUSIONS

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- Designed a generic DW schema for complex energy data
- The schema has a number of interesting complexities
  - Facts about facts
  - Composed non-atomic facts
- The schema can be used by a different nodes of hierarchical system
- Evaluated different alternatives (denormalization, arrays)

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Thank you!

QUESTIONS?

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