Communication Requirements of Distributed Energy Management Algorithms in Smart Grids

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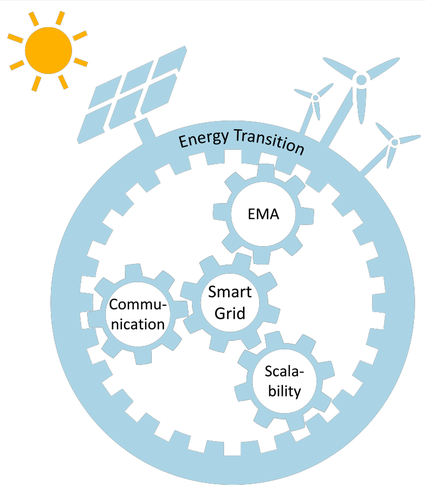
Introduction

- Different Energy Management Algorithms (EMAs)
  - COHDA
  - PowerMatcher
  - PrivADE
  - etc.
- Different scenarios
  - Varying communication technology
  - Varying number of participants

⇒ **How to analyse, which algorithm is suitable for which scenario?**



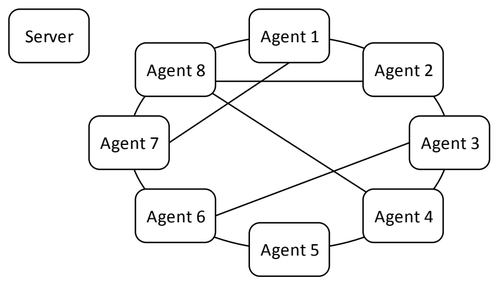
COHDA

Characteristics:

- Fully distributed approach
- Each agent maintains a knowledge base
- Agents can communicate in parallel

Procedure:

- Server publishes global goal to one agent
- If a household receives new information, it tries to find a better configuration
- If a household finds a better configuration, information will be published to its neighbours



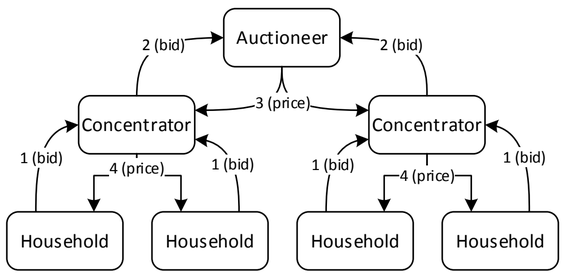
PowerMatcher

Characteristics:

- Centralised cost-based approach
- Central unit chooses energy price that leads to a desired consumption

Procedure:

1. Send bid to concentrator
2. Aggregate and transmit bid to auctioneer
3. Find price and send it to concentrators
4. Forward price to households



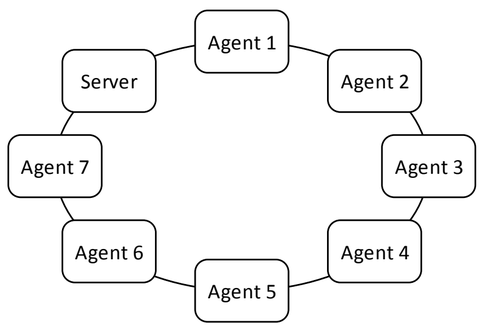
PrivADE

Characteristics:

- Round-based privacy preserving approach
- Needs a variing number of rounds to converge

Procedure:

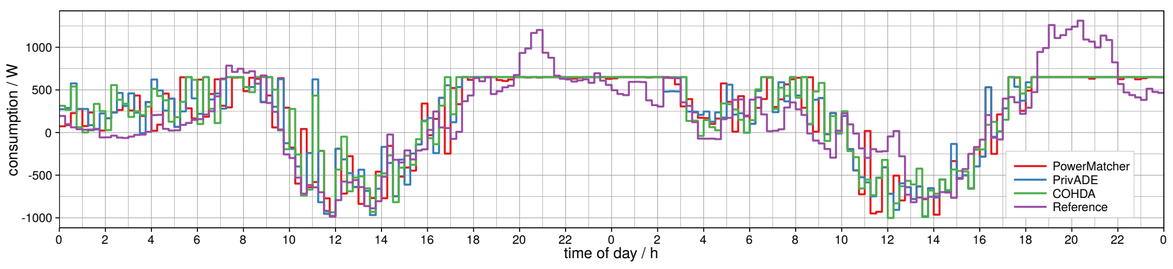
1. Gather switchable categories and adaption potential of the Agents
2. Publish categories and parameters for scheduling
3+. Max-min fairness scheduling continues until target reached



Key features of our Simulation Environment

- Bottom up event-based simulator
- Simulates energy consumption
- Communication simulation with several communication technologies
- Heat simulation based on VDI 4655
- Variable step size (1 minute to 1 hour)
- Solar irradiation and real temperature data
- Adjustable duration (one minute up to three years)
- Numerous statistical data and behaviour models
- Proven simulated base consumption
- Selectable and configurable EMAs
- Statistical and graphical evaluation of simulations results

Exemplary simulation of two days



A online version of SiENA is available at http://siena.hs-osnabrueck.de/

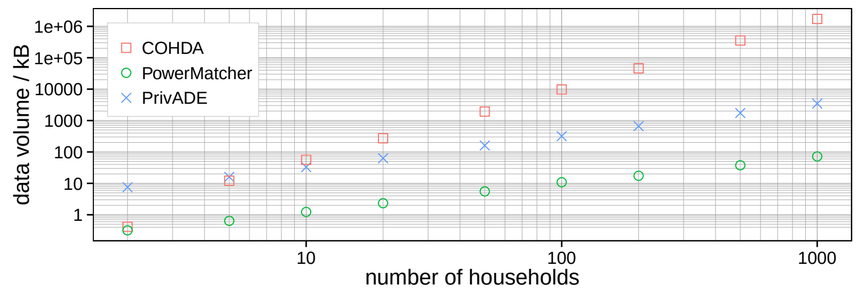
Evaluation

- Analysis of convergence time and required data amount
- Shorter convergence times enable advanced possibilities of the algorithms
- Lower data amounts allow the use of inexpensive communication technology

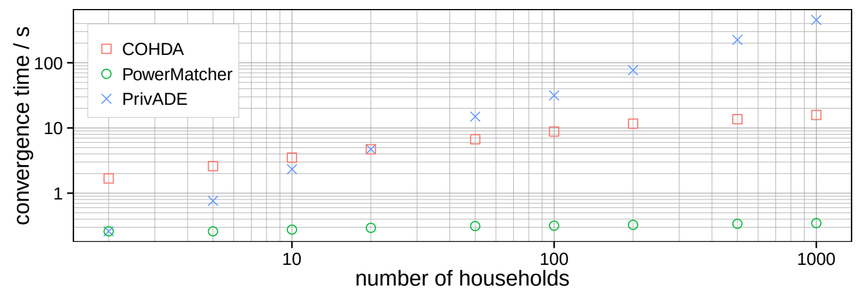
Scalability

- Variation of the number of participants (In this case households)
- Use of 5 Mbps DSL-technology and 20 ms delay per household
- Approximation of simulation results in the $\mathcal{O}$-Notation

Total data amount:



Convergence time:

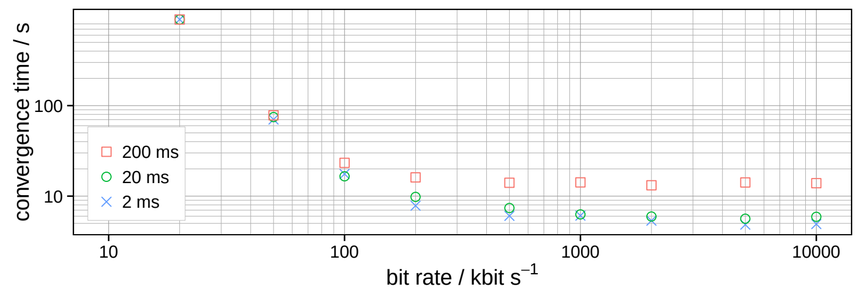


	Total data amount	Convergence time
COHDA	$\mathcal{O}(\lvert H\rvert^2 \log \lvert H\rvert)$	$\mathcal{O}(\log \lvert H\rvert)$
PowerMatcher	$\mathcal{O}(\lvert H\rvert)$	$\mathcal{O}(1)$
PrivADE	$< \mathcal{O}(\lvert H\rvert \log\log \lvert H\rvert)$	$\sim \mathcal{O}(\lvert H\rvert \log\log \lvert H\rvert)$

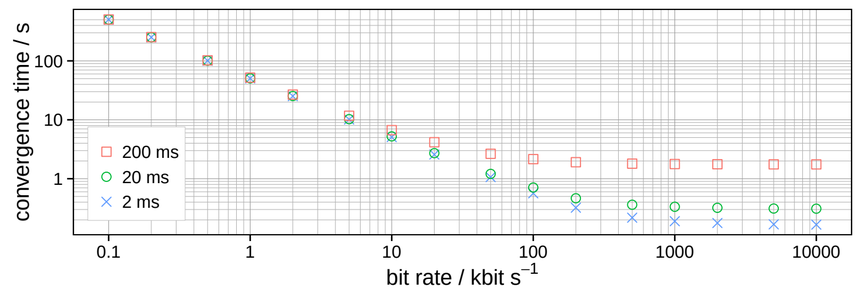
Comunication Limitations

- Variation of households data rate and latency
- Simulations with 50 households

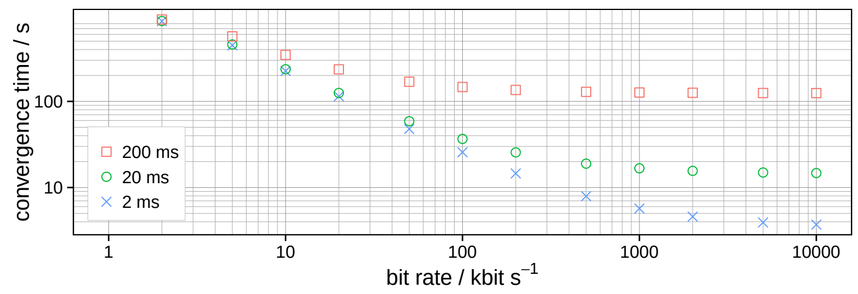
COHDA:



PowerMatcher:



PrivADE:



Conclusion

COHDA

Communication technology must enable high parallel transmissions, insensitive to high latencies, robust against node failures, moderate scalability, server only necessary for initiation

PowerMatcher

Low bit rate and latency requirements to the communication technology, fast convergence, good scalability, auctioneer and at least one concentrator necessary, sensitie on node failures

PrivADE

Requires communication technology with low latencies, good for shared medium technology, moderate scalability, privacy preserving, multiple server interaction per execution necessary

The Consortium

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