LUNDS UNIVERSITET

District Heating Control and Digitalization

A Whirlwind Tour

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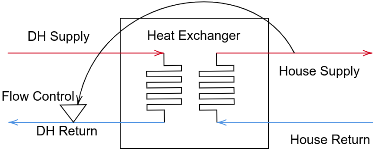
Outline

- *Traditional DH*
  - *Existing Control*
  - *What's left to do?*
- *4th gen. DH*
  - *How do they work*
  - *Challenges*
  - *How are they new*
- *Department Challenges*

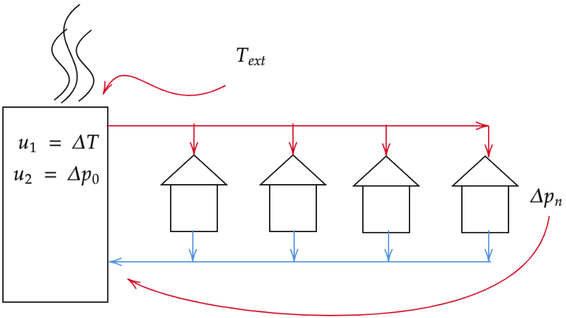
Traditional House Control

- DH water flows through heat exchanger
- Desired house supply temperature sets flow
- PI(D)-controlled



Traditional Plant Control

- Goal to match supply and demand
- Temperature control to counteract outdoor temperature
- Pump control to ensure good lowest Δp.



What's left to do?

- Load shifting
- Pre loading
- Weakest point in the grid
- (Automated fault detection)

Traditional DH Summary

Control leverages:

- Internal building controls flow
- Plant pump control sets grid pressure
- Plant sets supply temperature

Control challenges:

- Match supply and demand
- Load shift - shave peaks
- Support weakest grid points
- Fault detection

4th gen. DH

- Examples: Ectogrid, CoolDH, ETH Campus
- Lower temperatures
  - More waste heat available
  - Lower losses
  - Cheaper piping
- Mix of heat/cold supply
- Inclusion of "prosumers"
- Sometimes complete lack of "plant"

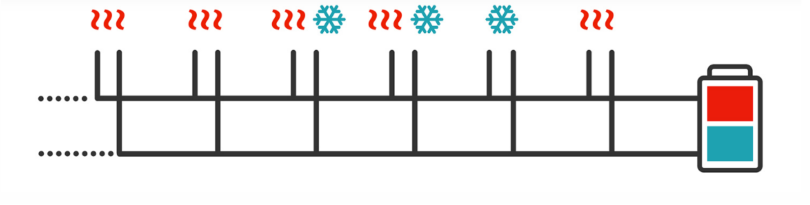


Figure: Source: ectogrid.com

4th gen. Challenges

- Matching demand and supply optimally (Solved?)
- Scalability Issues
  - Autotuning new connections
  - Providing enough circulation

Summary Traditional vs. 4G

Traditional DH:

- Based on big plants
- Distributed control
- Load control challenging
- Scaling up fairly simple

4G DH:

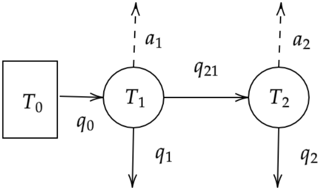
- Sometimes no plants
- Global optimization
- Load control name of the game
- Scaling up might be tricky

Department Challenges

- Positive system extension and application
- (Sparse) network model identification
- Identifying and supporting weak network points
- Autotuning (with network connection)

Department Challenges - Positive Systems

A model of a (small) DH-network:



$$\dot{T} = \left(\begin{bmatrix} -a_1 & 0 \\ 0 & -a_2 \end{bmatrix} + \begin{bmatrix} -q_1 - q_{21} & 0 \\ q_{21} & -q_2 \end{bmatrix} \right) T + \begin{bmatrix} q_0 \\ 0 \end{bmatrix} T_0 \qquad (1)$$

Positive Systems

Why would this be useful?

- Linear programming for optimal flows
- Performance guarantees
- Temperature guarantees
- Stability guarantees

Challenges when applying positive theory to DH:

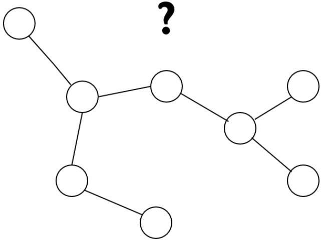
- Flows subject to Kirchoff's current law
- Other nonlinearities (delays, bilinearity)
- Requires good system model
- Global control strategy

Network Identification

District heating network models are

- Hard to get
- Dependent on expert knowledge
- Often ignored in papers

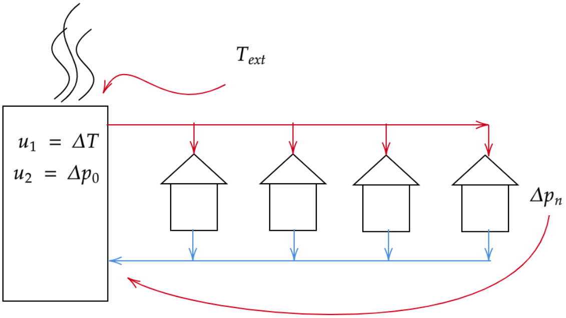
Data driven network identification would go a long way here.



Weakest Network Point

During high loads, the pressure drops so that the last customer cannot satisfy their needs.

Idea: Can other customers collectively help out? Instead of customer N dropping 5°C, everyone drops 0.5°C



Regulator Loop Autotuning

Growing 4G DH networks need to tune new customers that connect to the grid.

- Does this affect the other controllers in the network?
- Can this be done automatically with better performance?

Summary Department Challenges

- Positive system extension and application
- (Sparse) network model identification
- Identifying and supporting weak network points
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Thank you!