ETH
Eidgenössische Technische Hochschule Zürich
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# Energy monitoring using wireless sensor networks
# Jiang et al. 2009

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# Motivation

- Costs
- Attribution to devices and users
  - Existing solutions insufficient
- Save energy!
  - Carbon and nuclear footprint


Image by Brendan Wood

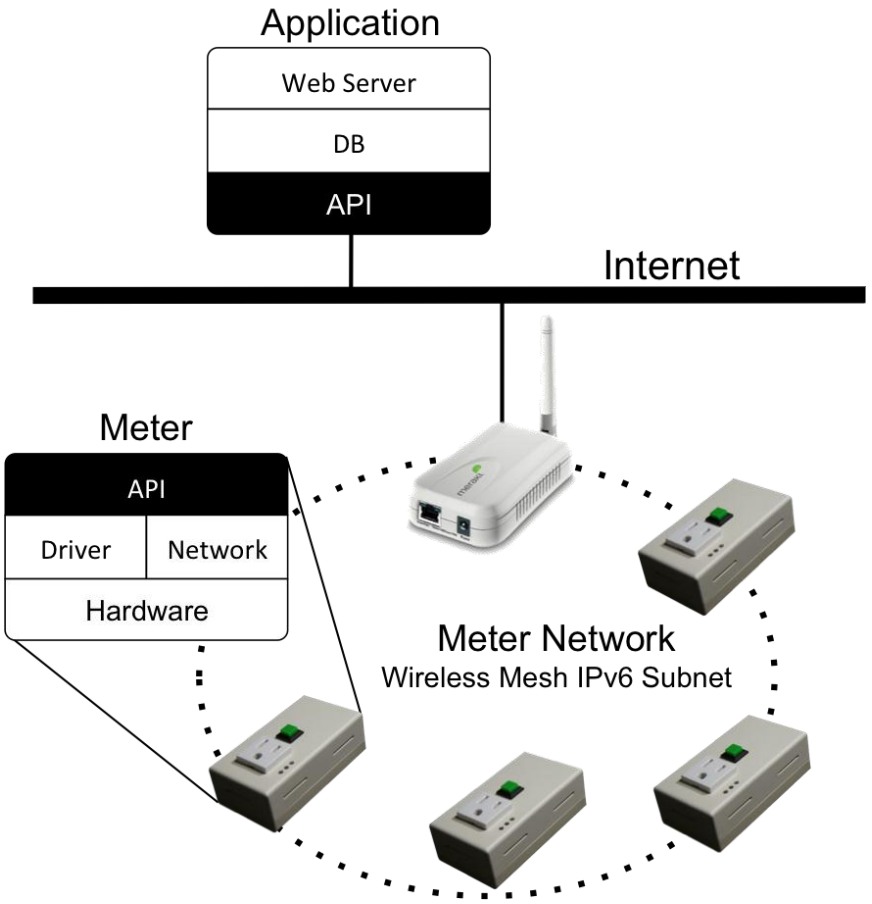
# WHO AND WHAT CAUSES MY ASTRONOMICAL ELECTRICITY BILL?

# Idea

- Use sensor network to monitor plugs
- Connect sensors wirelessly
- Store readings in database
- Visualize data
  - Web interface
- Enable new applications

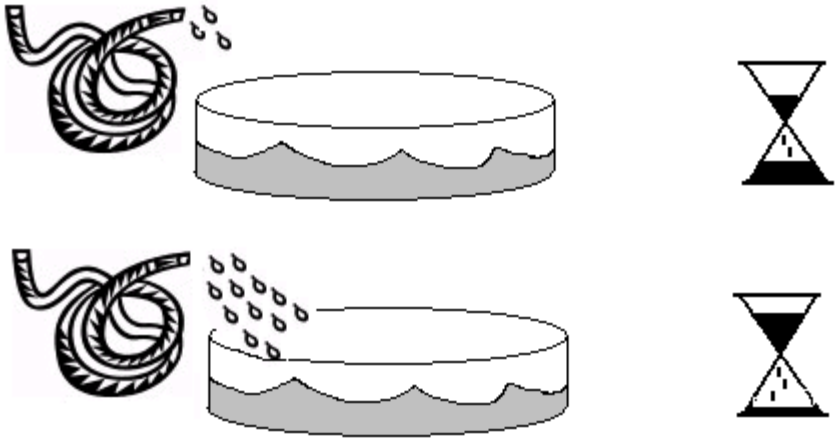
# System architecture

- Three tiers
  - Sensor node (ACme)
  - Network
  - Application



# Electricity units and concepts

- Voltage = Current x Resistance
- Power = Current x Voltage
- Energy = Power x Time
  - ~ 0.20 CHF / kWh



- i7 dedicated server
  - 1.3A x 230V = 300 W
  - 24h x 300W = 7200 Wh
  - 7.2 kWh x 0.20 CHF/kWh = 1.44 CHF

Images by Gail Raker

# ACme Node

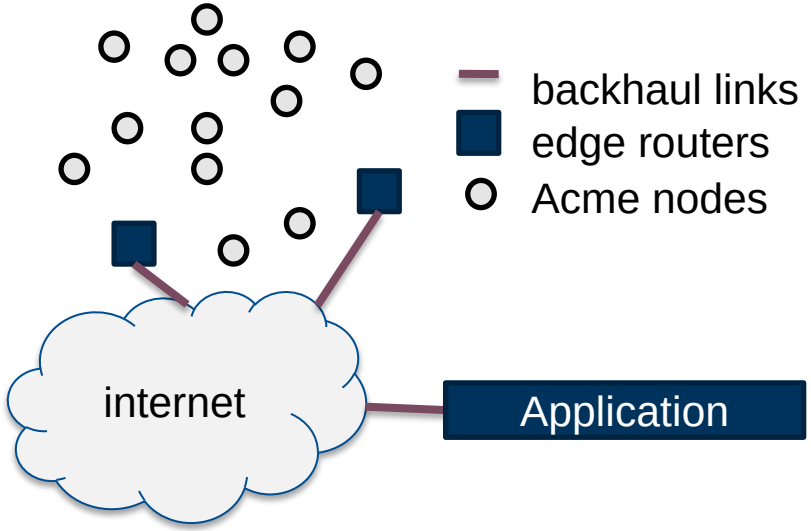
- Plug-through
- Measuring and calculation of **power** and **energy**
- UDP communication
  - Read measurements
  - Switch load on/off
  - Data periodically sent to application

# Challenges

- Powering
- Device size

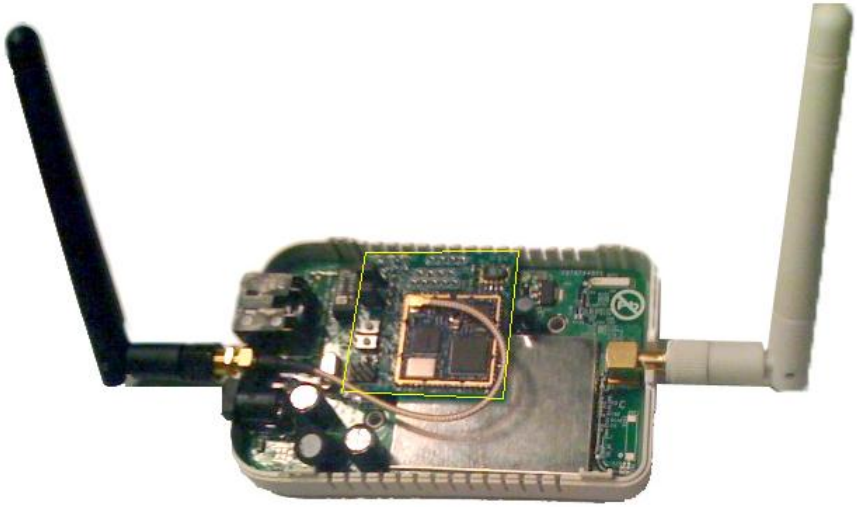
# Networking

- Berkeley Low Power IP Stack
- Multi-hop
- Edge routers bridge networks
- Auto-Configuration



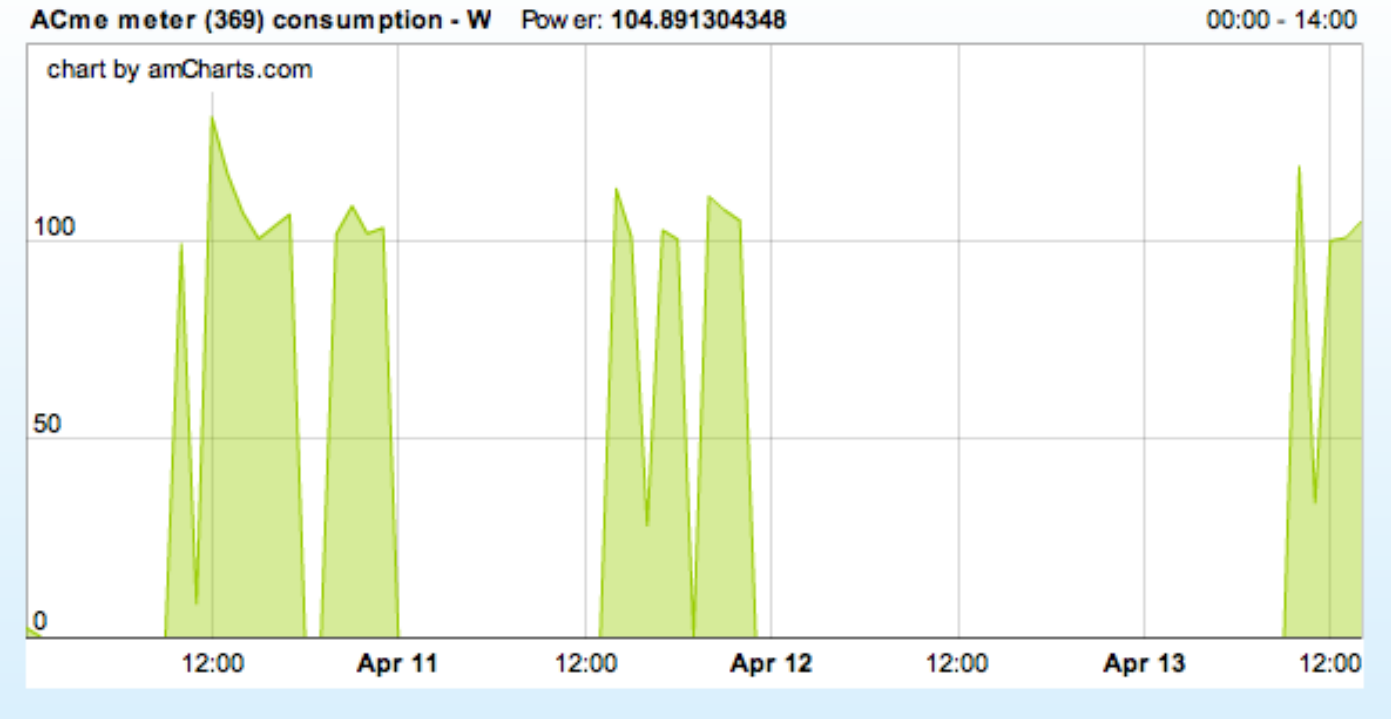

# Challenges

- Difficult settings
- Solution: high node density



# Application

- Daemon process receiving data
- Database storage
- Web front-end



# Advantages

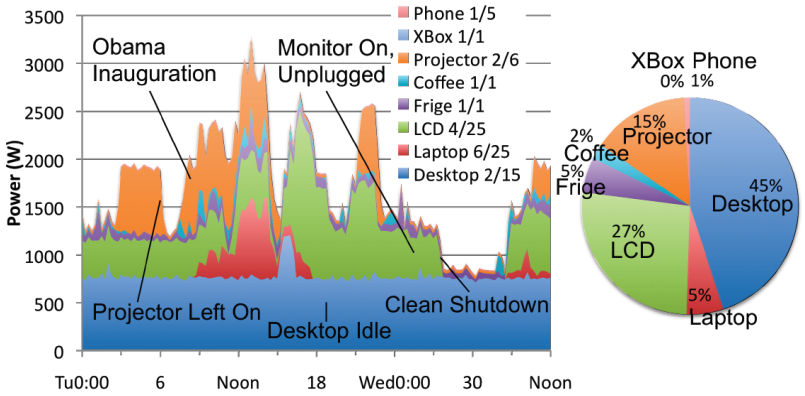
- Easy real-time monitoring of devices
- Ad-hoc adding of new nodes
- Switch off devices remotely
- Relatively simple & cheap hardware

# Drawbacks

- Node pretty big
- One plug per node
- Can’t monitor all loads
- Edge router needed
- High node density needed in difficult settings

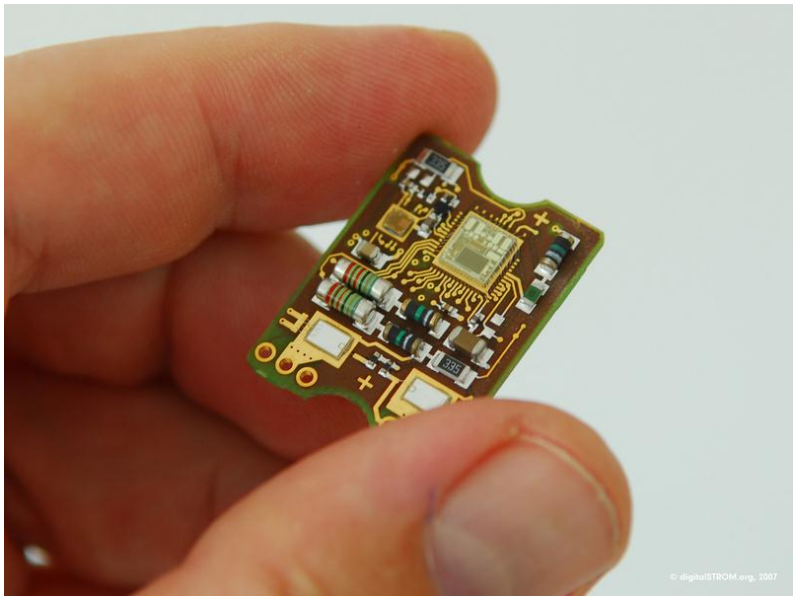
# Evaluation and results

- Deployment in computer science building
  - 49 devices
  - 4 floors
  - 1 edge router
- Auto-configuration successful
- 99% packet delivery
  - UDP!
  - well, most of the time …



# Similar systems

Plogg



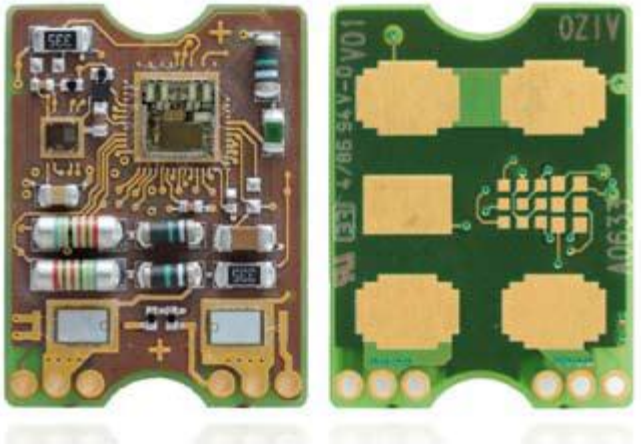

Digitalstrom

# Plogg

- Commercially available
  - Different formats available (e.g. Swiss plug) ☺
  - ~100 GBP per device ☹
- Not too user-friendly
  - Data logs in CSV format
  - SDK for developers
- ZigBee protocol stack
  - Physical and MAC layer identical to ACme

# Digitalstrom

- Developed at ETH!
- Tiny chip
  - Power measurements
  - Coordination of devices (Smart Home)
- Communication via power network
- Extension of existing devices
- Server module
  - access via internet
  - data storage



# Summary & Conclusion

- Ad-hoc sensor network of energy meters
- Networking under difficult conditions
- Visualization of measurements
- Enables many new applications

# THANK YOU!