

Privacy in the Smart Grid

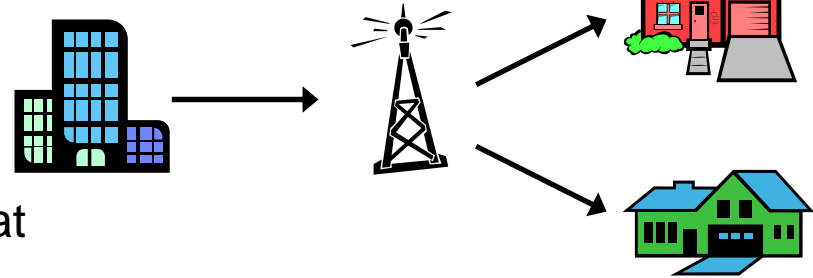
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Two Types of Demand Response

Utility → Residence

Direct Load Control (PCTs)

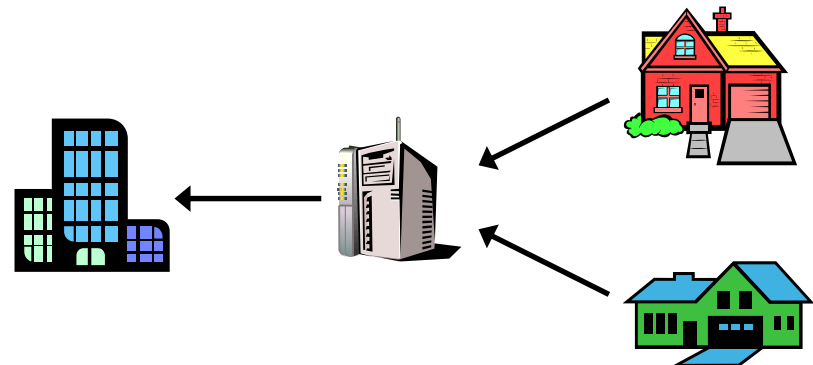
- Radio signal tells appliances to
 - cycle, or,
 - shut-off, or
 - change set-point on thermostat



Residence → Utility

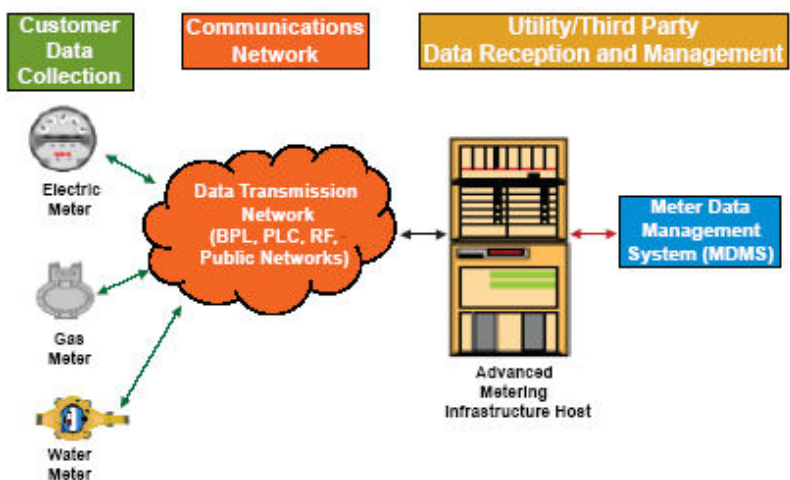
Advanced Metering Infrastructure (AMI)

- Automated meters
- Record data every 15-60 min
 - “Interval Data”
- No meter reader
 - Wireless, or,
 - Powerline



Technical Overview

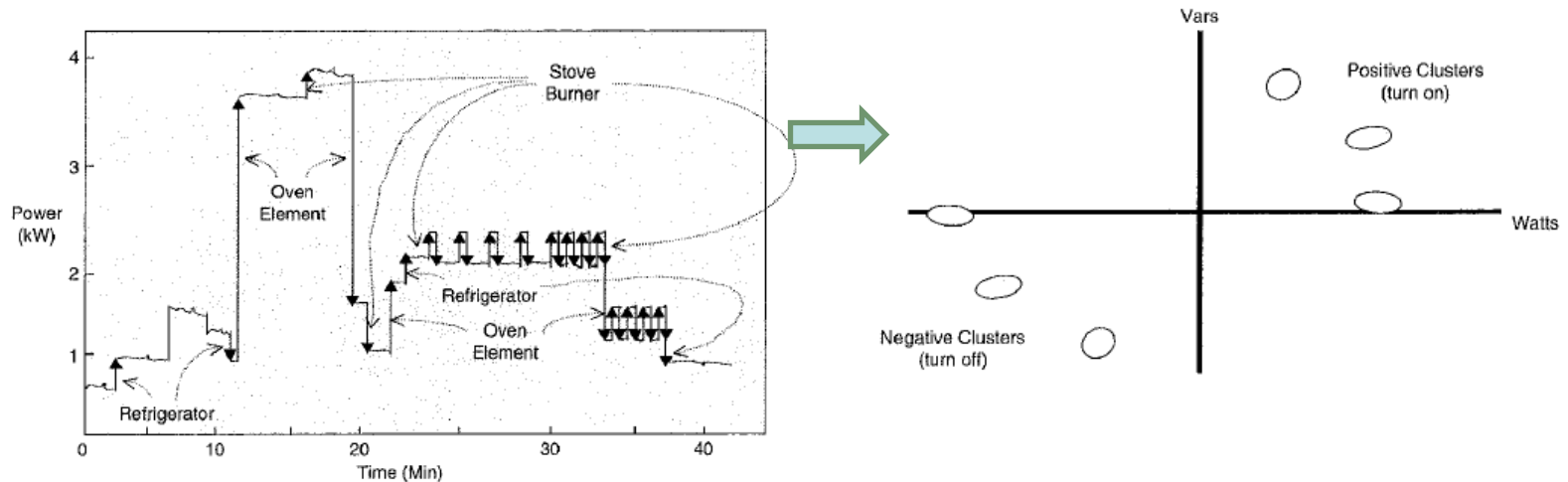
- Advanced Metering Infrastructure (AMI)



- Collects time-based data at daily, hourly or sub-hourly intervals

Technical Overview (contd.)

- Non-Intrusive Load Monitoring (NILM)



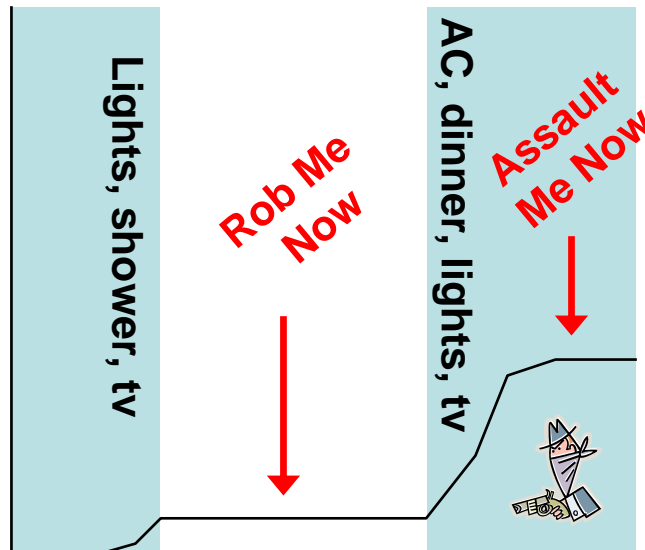
- NILM: fundamental tool for extrapolating activity

Technical Overview (contd.)

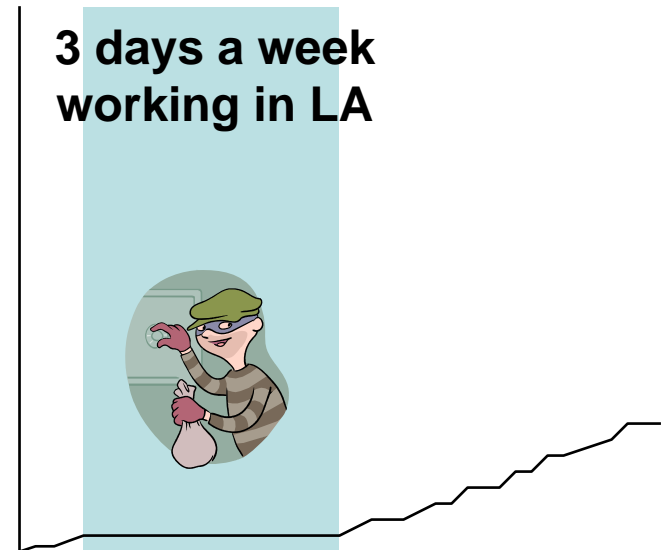
- Sensor networks in homes
 - appliances communicating with thermostat and other appliances, applications
 - Supporting remote monitoring and control of home environment

Interval Data

- 3000 (750) data points per month – vs. 1
- Virtual biography of household activity in near real-time



Daily Patterns



Weekly Patterns

Confidentiality in Current Law & Regulation: CPUC 394.4

CPUC 394.4 (a)

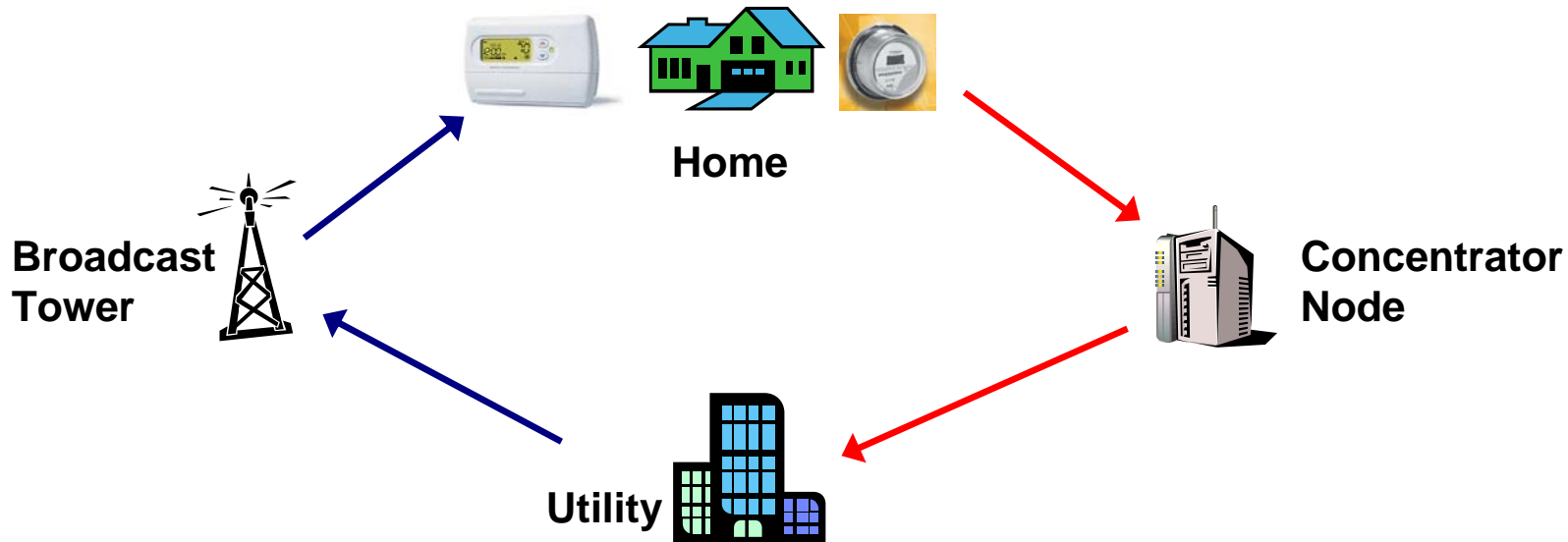
- Confidentiality: Customer information shall be confidential unless the customer consents in writing. This shall encompass confidentiality of customer specific billing, credit, or [usage information](#).

- Gaps given new players
- Constitutional Privacy issues
- US -- business records v. Kylo
- CA -- Burrows and Chapman

Privacy implications

- New data flows
 - Transmission in real-time
 - Wardriving?
 - Wiretapping?
- New players
 - Outside scope of CPUC regs
 - 3rd parties -- tivo for the home
 - 3rd party access
 - Law enforcement
 - Private parties
- New risks
 - Networks
 - “Smart” meters, with limited physical security
 - Sensor networks making inside visible/controllable remotely

Make Security Plans Well Thought Out I



Node-by-node analysis is critical, e.g., concentrator

- What data is stored here? (How valuable is to thieves?)
 - How many days worth of data?
 - How many different consumers? (30 >> 1)
 - Is it encrypted?
 - How can it be accessed? (Is it connected to the internet?)
 - Can it be tapped or sniffed? (Is this the most efficient spot?)
 - Can it physically be stolen?

Make Security Plans Well Thought Out II: Web Access



- Multiple utilities plan to make interval data available by internet or phone
- How safe is web access?
 - Pretexting (eg, HP)
 - Phishing for passwords
- 53% of users use same user name and password at all or most sites they visit

The future of the SmartMeter™ program

The main function of the PG&E **SmartMeter** program is to improve overall customer service. But the **SmartMeter** program also gives our customers increased control over their energy usage and bills.

In the future, our customers will have the ability to monitor their own energy usage via the Internet. All PG&E customers will be able to log in at www.pge.com and see their hourly electricity usage and daily gas usage. You'll see when and how you're using the most energy so you can better manage your energy bill.

http://www.pge.com/customer_service/ami/

Access to information you need to make decisions about how and when you use electricity

The government's current plan calls for customers to have access to their previous day's consumption data by 8 a.m. the following day through the Internet and/or telephone. By making your consumption data available to you, it is anticipated that you will make personal choices to change your electricity usage patterns. By shifting your usage to "Off Peak" periods you will be able to take advantage of lower electricity costs. **Although not in effect yet**, the Time of Use rates will reflect lower rates in the Mid and Off-Peak periods as compared to the On-Peak periods. [Click here](#), to view the planned Time of Use rate table.

http://www.torontohydro.com/electricsystem/residential/smart_meter/index.cfm



What can be revealed?

“humidity measurements can disclose private information such as human presence.” Han et. al. 2007

“Hourly power averages such as the ones produced by California's AMI system may also be used to determine presence and sleep cycles, although to a coarser degree. Major appliances a large steady state power consumption (e.g. heat lamps) can also be identified.” Wicker et. al. 2008

Algorithms are fully automated, so analysis may be done on a extremely large scales.

References

Lerner, J. I., Mulligan, D. K., "Taking the 'Long View' on the Fourth Amendment: Stored Records and the Sanctity of the Home," Stanford Technology Law Review (STLR), Vol. 3, 2008.

<http://ssrn.com/abstract=1099121>

P.A. Subrahmanyam, D. K. Mulligan, D. Wagner, U. Shankar, E. Jones, J. Lerner. "Network Security Architecture for Demand Response/Sensor Networks". Technical report, On behalf of California Energy Commission, Public Interest Energy Research Group, January, 2005.

[http://www.ucop.edu/ciee/dretd/documents/DR%20Security%20Final%20Report%20\(DRAFT\).pdf](http://www.ucop.edu/ciee/dretd/documents/DR%20Security%20Final%20Report%20(DRAFT).pdf)