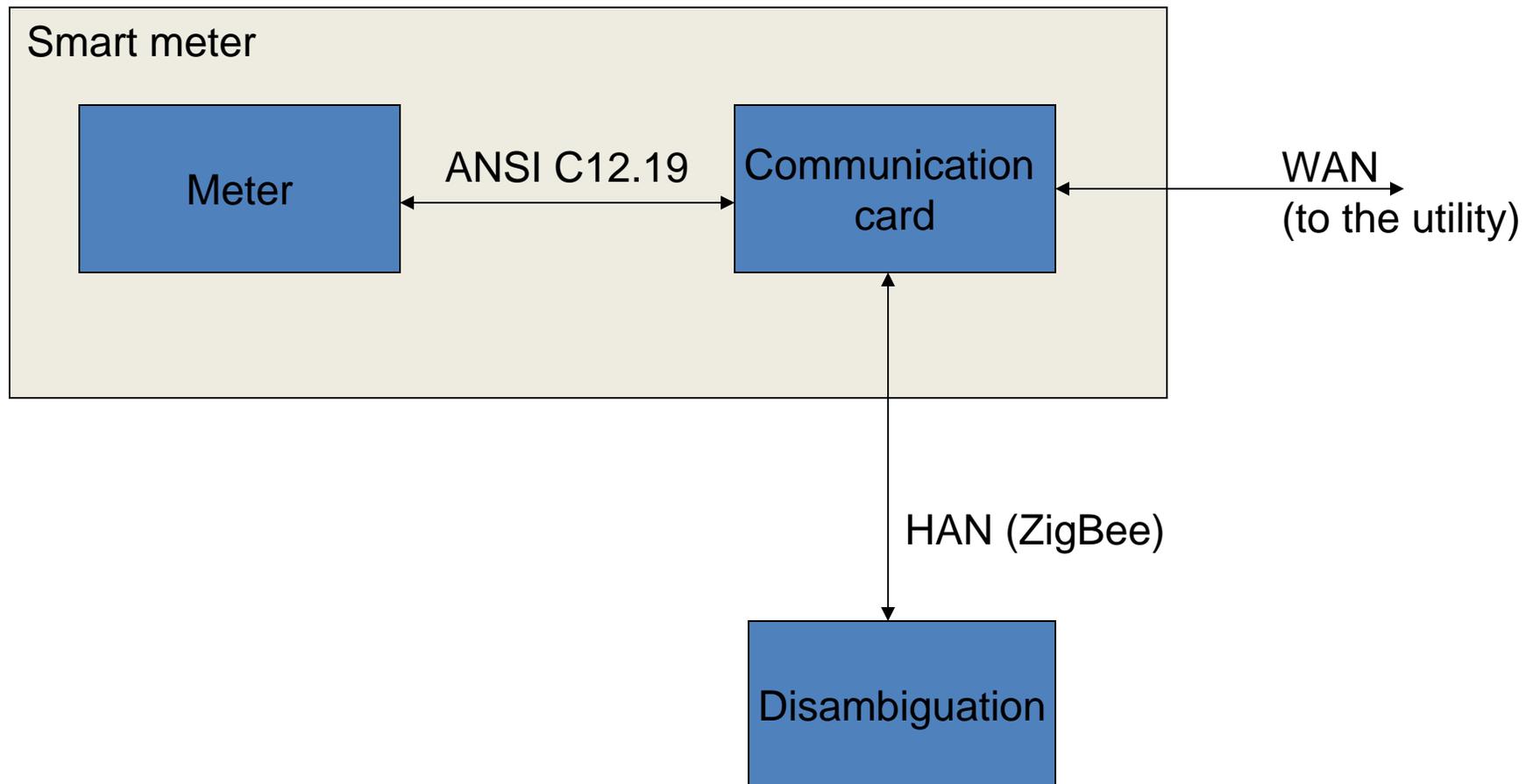# Gap analysis

Gireesh Shrimali
Visiting Scholar, Stanford University
Assistant Professor, Indian School of Business

Smart meter

Meter ←— ANSI C12.19 —→ Communication card ←— WAN (to the utility) —→

Communication card ↕ HAN (ZigBee)

Disambiguation

For most of the talk assume that disambiguation is external to smart meter

Algorithmic requirements: what is the need?

- Developer X: Hourly reads give 70-95% accuracy (is this possible?)

- Developer Y: 0.5-1Hz sampling gives 75-95+% accuracy
  - Sweet spot for sampling is 0.1-1Hz

- Developer Z: The best one can do is 85% accuracy (the rest 15% is always on – makes disambiguation ineffective)
  - With 0.5Hz active power data (e.g., TED) can get up to 70% accuracy
  - Reactive power adds 5%: total 75%
  - Harmonic power (up to 5th & 7th harmonics) adds 10%: total 85%

- Overall, would like (typical requirement): what is the ideal though?
  - Power: active, reactive, harmonic
  - Granularity: 10s of watts
  - Frequency: 1Hz

Hardware capabilities: what is (can be) out there?

	Worst case	Base case (typical)	Best case
Power	Active	Active Reactive	Active Reactive Harmonic
Granularity	1kW	10W	0.1W
Frequency	0.001-0.01Hz	0.1-1Hz	100Hz-1kHz

Is there a gap (between typical requirement and capability) ?

Data	Would like	Is it available?
Type	• Active power • Reactive power • Harmonic power	• Yes • Maybe (not sure) • No
Granularity	• ~10s of Watts	• Yes
Frequency	• ~1Hz	• Maybe (close)

The data type issue

- Power numbers available from the meter
  - Active: yes
  - Reactive: maybe
  - Harmonics: no

- Why?
  - Company A: essentially, it is all about business need. The business case for harmonics is not clear
  - Company C: why would you need increased complexity?

- Need to have a compelling business case for the inclusion of (reactive and) harmonic powers
  - Reactive power should be easy to do
  - Harmonic power would need cost-benefit analysis

- The data granularity (i.e., units) does not seem to be an issue

The sampling issue (1)

- Most smart meters provide information at the 1-minute granularity

- However, most SMs are compliant with the ZigBee Smart Energy Profile
  - Can provide information once every 7.5s

- Most SMs should be compliant with the CPUC InHome Display Initiative
  - Information once every 6s

- What if we need higher (kHz/MHz) sampling?

- At the end of the day, it is a balancing act among competing interests

1Hz	10Hz	100Hz	1kHz	1MHz
Likely	Somewhat likely	Somewhat unlikely	Unlikely	Highly unlikely

- The meter has registers to store information (active/reactive power, etc.)
  - Company A: registers get updated every second
  - Company B: registers can get updated every 0.6Wh (frequency would depend on how much energy is being used)
  - General view: can always be compliant with any HAN standards

- *The meter may/may not be the issue? (need cost numbers)*
  - At least from a 1Hz sampling perspective
  - May not get further down: e.g., internal sampling itself ~1kHz

- *Can the meter do disambiguation? How does the cost change?*

1Hz	10Hz	100Hz	1kHz	1MHz
$0	$??	$??	$??	$??

- The communication card reads meter registers over ANSI C12.19 and transmits over the HAN
    - Company C: can easily do updates once per second or faster.
    - General view: The actual rate depends on what else is going on WAN/HAN

- *The communication card does not seem to be the issue? (need cost numbers)*
    - At least from a 1Hz sampling perspective
    - Company C: can go up to ~1kHz

- *Can the communication card do disambiguation? How does the cost change?*

1Hz	10Hz	100Hz	1kHz	1MHz
$0	$??	$??	$??	$??

- **The ZigBee protocol**:
  - Multiple devices competing for the same bandwidth: thermostat, smart appliances, etc.
  - Rated at 100kbs but practically 10kbs
    - Radio frequency issues: Interference from other devices
    - Mesh network topology (multi-hop) limits the throughput

- *Is ZigBee the real culprit? (need cost numbers)*
  - Can it even get to the 1Hz sampling rate?
  - Can this limit be improved? If yes, How?
  - Is WiFi (or Internet or powerline) a better solution?

1Hz	10Hz	100Hz	1kHz	1MHz
$0	$??	$??	$??	$??

What would it cost to pass data? (current/future generation)

	1Hz	10Hz	100Hz	1kHz	1MHz
Meter	$0	??	??	??	??
Comm Card	$0	??	??	??	??
ZigBee	$0	??	??	??	??
Internet	??	??	??	??	??

At least need to understand this qualitatively: 5-point scale
Highly/somewhat possible – Possible – Highly/somewhat impossible

In summary

Component	Current spec	Ways to reduce limitations	Cost of reducing limitations	Barrier to reducing limitations (aside from cost)
Meter hardware	Frequency=1Hz Reactive=perhaps Harmonics=no Q: Could it do disambiguation?	-Technical: Upgrade hardware and/or firmware -Policy: Utility initiate & PUC approve	$??/meter (to increase to kHz/MHz) -Note: specify for current as well as existing meters -Q: Is it even possible to assess?	-Utility motivation to propose new meter standards -Regulatory process & interest -Fear of government and consumer repercussions w/ perception of error
ANSI standard C12.19	Freq=1kHz-1MHz	NA	NA	NA
Networking card	Frequency=0.001-1Hz; Q: Could it do disambiguation?	-Technical: Upgrade hardware and/or firmware -Policy: Utility initiate & PUC approve	$??/meter (to increase to kHz/MHz) -Note: specify for current as well as existing meters	-Smart meter company willingness -Others similar to meter hardware
ZigBee (HAN)	Frequency=1/~6s	-Technical: Switch to powerline, WiFi, or Internet? -Policy: Utility initiate & PUC approve	$??/meter (switch cost) -Note: specify for each substitute -Q: Is it even possible to assess?	-Existing meters use ZigBee Q: What problems arise with this discrepancy?
Communication networks (WAN)	Frequency=1/15min	-Technical: Bandwidth limitations of WAN -Policy: Utility initiate & PUC approve	$??/meter (to increase to kHz/MHz) -Q: Is it even possible to assess?	-Similar to meter hardware

Moving forward

- Need a stronger business case for disambiguation
  - What are the benefits with increasing accuracy?
  - How each of the requirements relate to accuracy?

- Need closer interaction with
  - Policy makers: CPUC and others
    - The InHome Display Initiative discussions are underway at CPUC
    - Others?
  - Standard bodies: ZigBee, ANSI C12.19
    - Figure out the actual limits of devices in variety of settings
    - Figure out the capabilities of devices to perform disambiguation internal/external to the device

- (5-10 min) What sets the once per 6s/7.5s (~1Hz) limit? Why?

- (5-10 min) Could we fill the cost table (assuming disambiguation is done outside the meter)?
  - Data type:
    - Quantitative (i.e., $) would be ideal
    - Qualitative (i.e., likely-unlikely) would be a good start
  - Process: parse the table four times

- (5-10 min) Could disambiguation be done inside one of the devices? If so,
  - What would be the corresponding costs?
  - What would be the corresponding data requirements?

- (5 min) Does the rest of summary table make sense?
  - Is ZigBee the right interface?