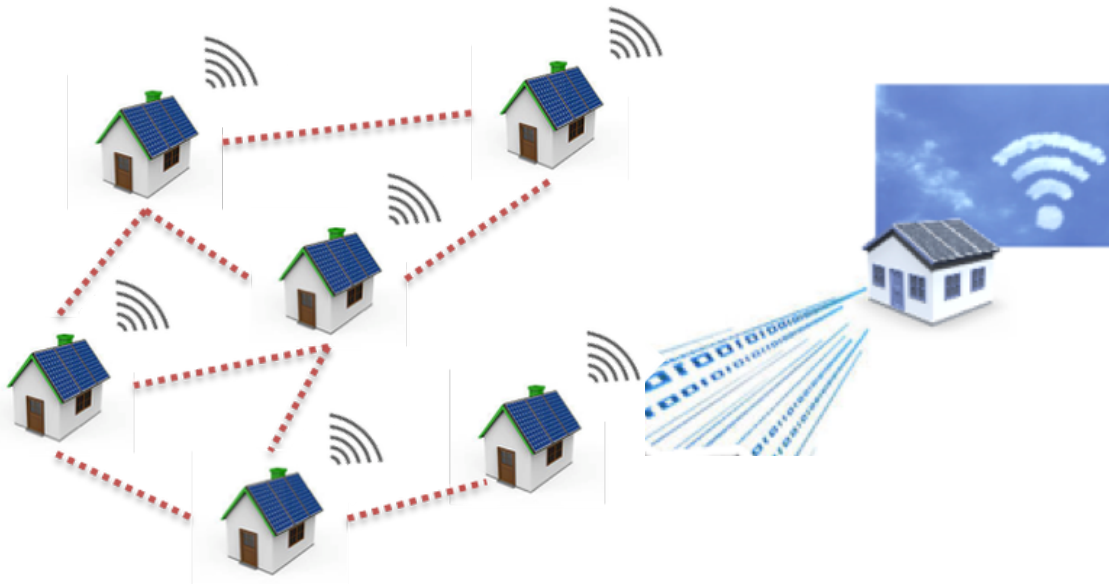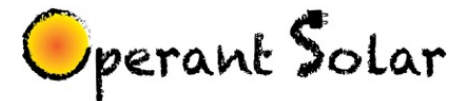# FleetLink: NDN-Powered Low-Cost, Low-Rate, Reliable, Secure Communication for Neighborhood Solar

A Practical Approach To Lowering The Cost Of Solar

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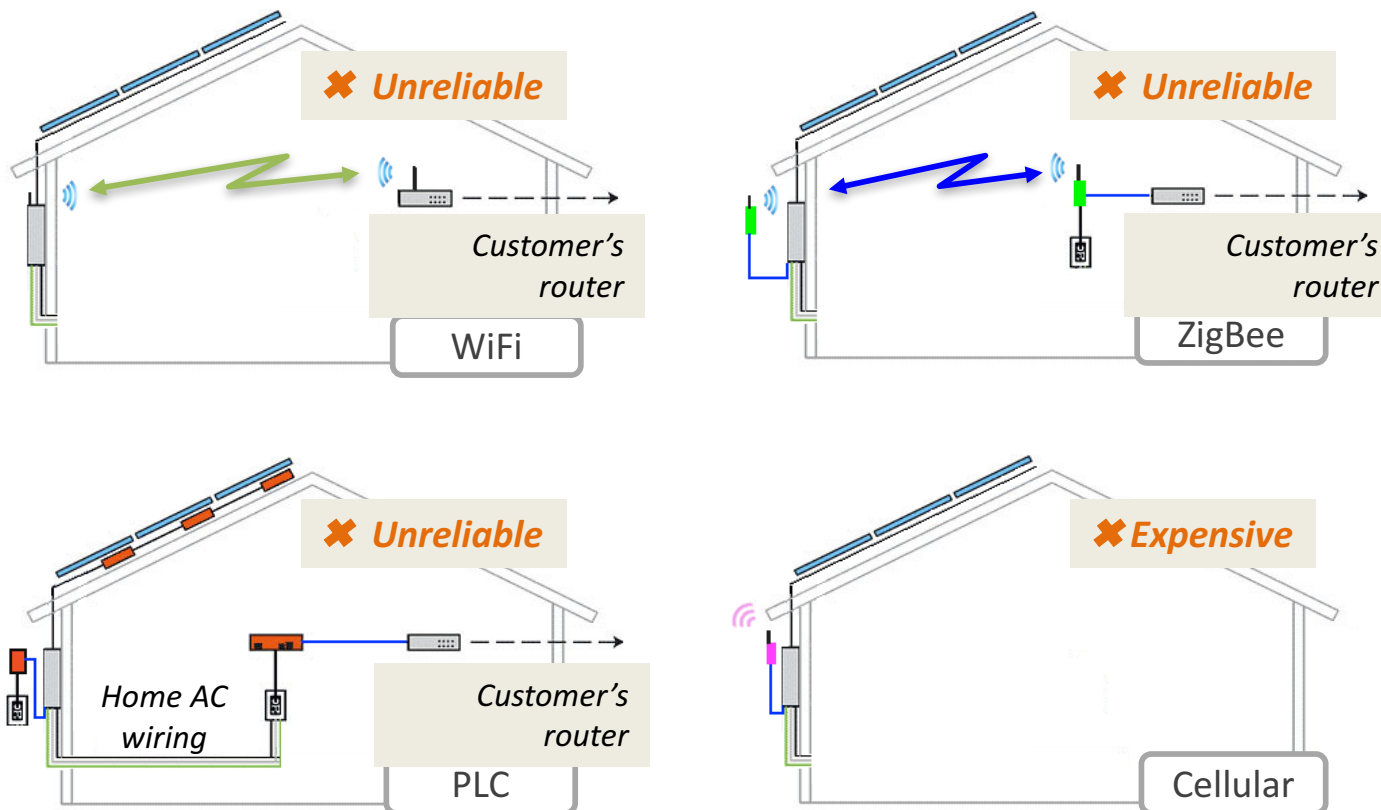
Residential Solar Installer Pain

Third Party Owned residential solar sites **requires internet connectivity** for

- – Monitoring production data
- – Receiving equipment alerts
- – Sending utility grid support commands (future)

Current monitoring solutions

Current Communication Solutions

…**unreliable**….

- **>7%** of homeowner internet-connected sites drop offline *each year* and must be reconnected by O&M
- **20% of links have failed** cumulatively, provisioning is complex, recovery is expensive, and production data is lost

….**insecure**….

- General purpose internet connections are in customer homes

…. and therefore **expensive**

- Including required O&M to repair, monitoring lifetime costs currently exceed **$0.07** of total $2.10/W install
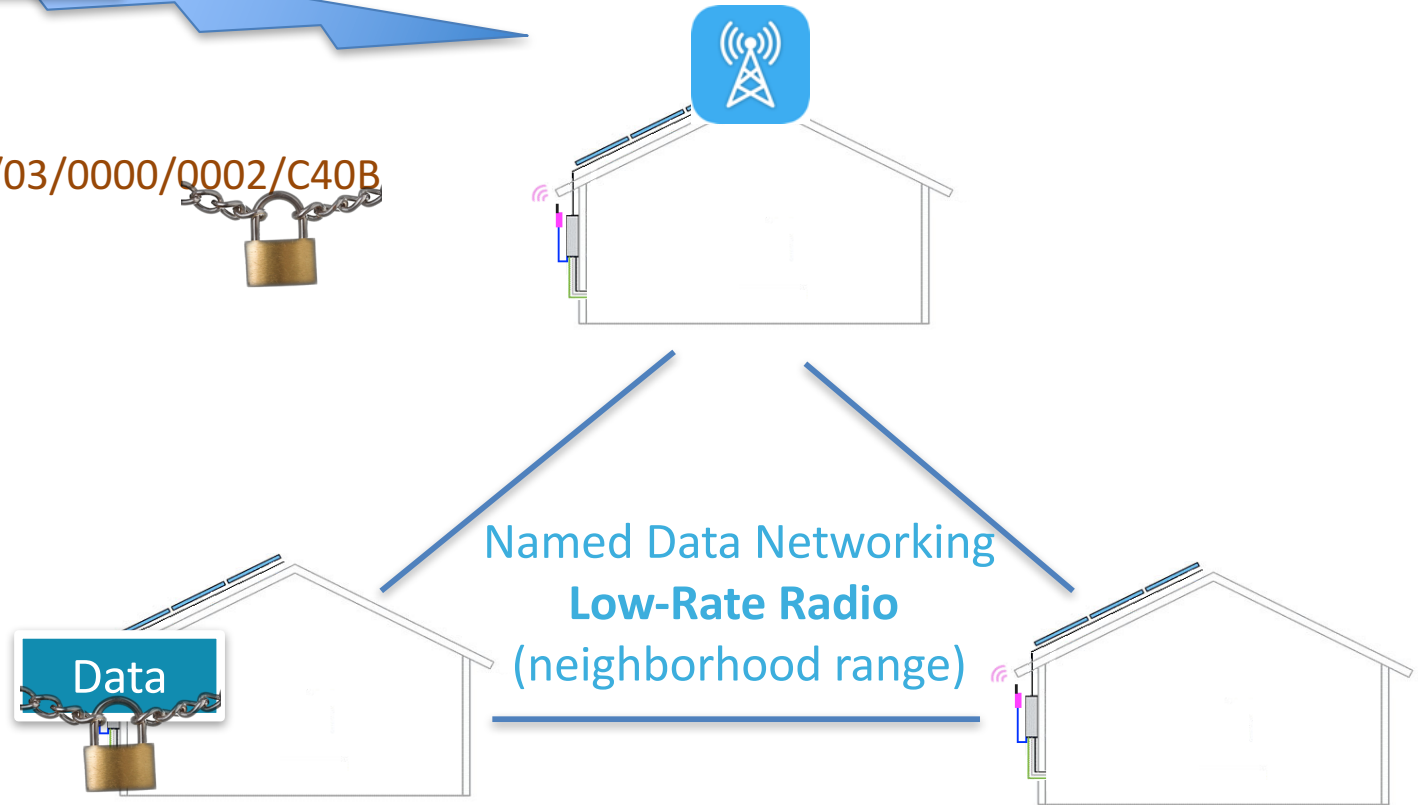
FleetLink: Technology View

Named Data Networking over cellular
(One for the neighborhood)

Interests

/FleetLink/LA/WestSide/
18SUJ22850705/MAC/01/03/0000/0002/C40B

Named Data Networking
Low-Rate Radio
(neighborhood range)

Data

4

LoRa Wireless Radio Technology

800 meters

New LoRa radios provide exceptional range at low cost

	LoRa	Current
Transmit Power	+30 dBm	+30 dBm
800 meter Free Space Loss	-90 dB	
Fade Margin @ 99% reliability	-20 dB	
Bit Rate	1 kbps	250 kbps
Receiver Sensitivity	-132 dBm	-98 dBm
Remaining Margin	52 dB	18 dB

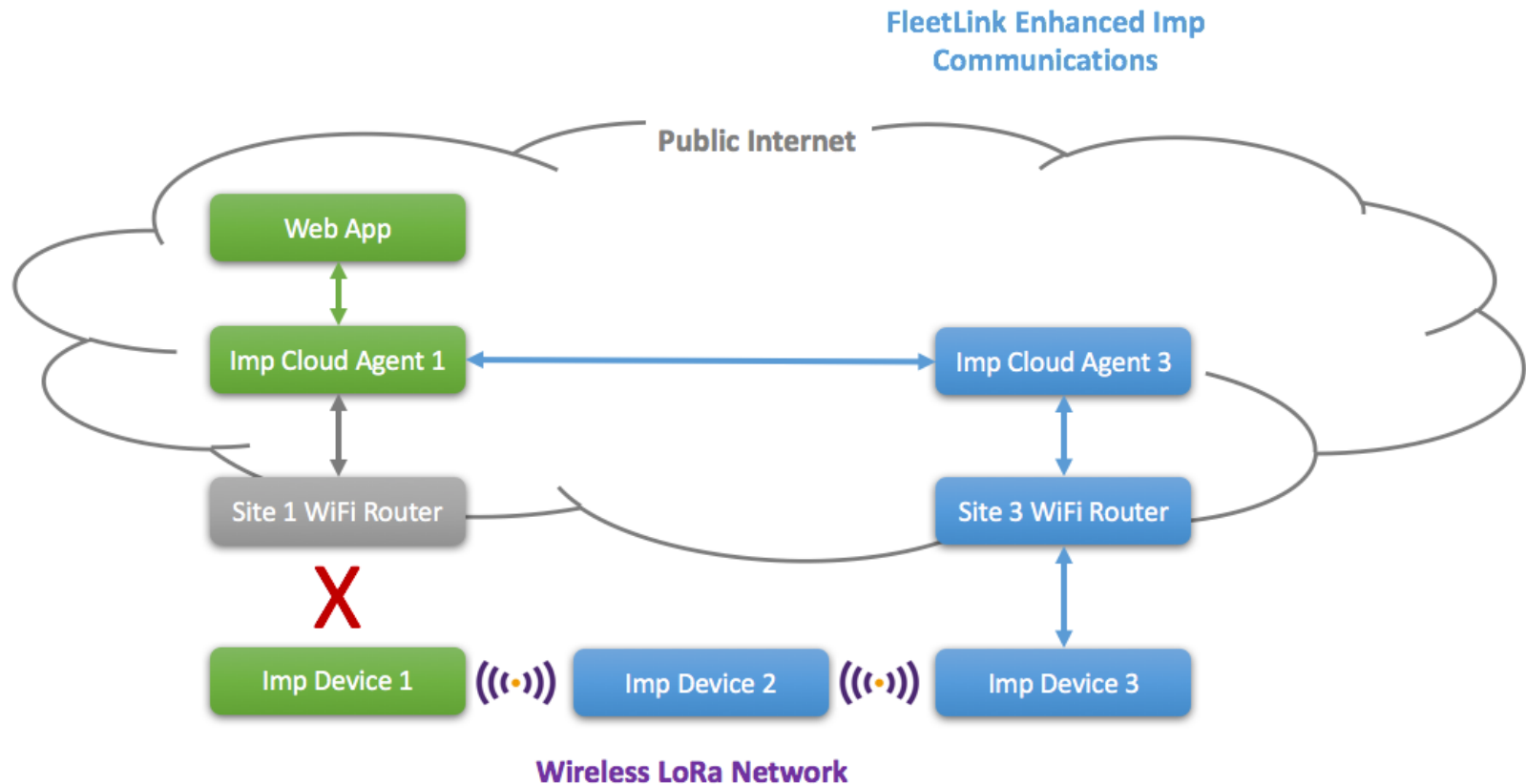Required margin for obstructions: House = -7 dB, Tree = -5 dB
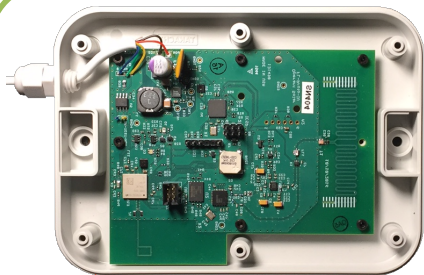
FleetLink circuitry can be either inverter-integrated or a standalone external module

Named Data Networking

- Secure data directly
- Leverage geo-routing to retrieve/send commands
- No requirement for connections to retrieve measurement data and deliver commands

FleetLink Enhanced Imp Communications

NDN Geo-Forwarding Strategy Highlights

`/FleetLink/11SLT67227061/MAC/01/03/0000/0002/C40B`

`11SLT67227061 = {x:6722, y:7061} (x 10 meters)`

LoRa
11SLT 6681 7072

Interests

LoRa
11SLT 6722 7061

LoRa
11SLT 6700 7056
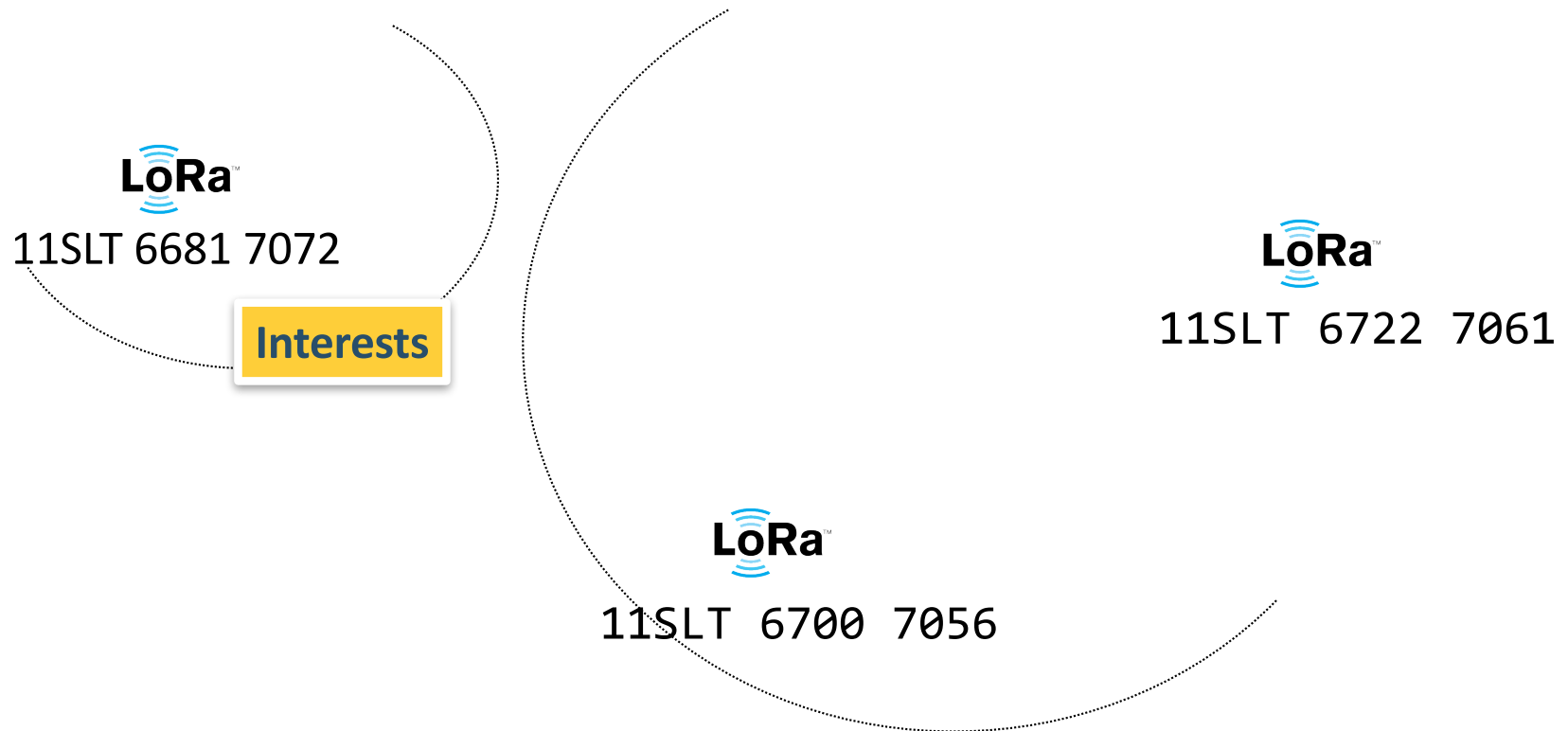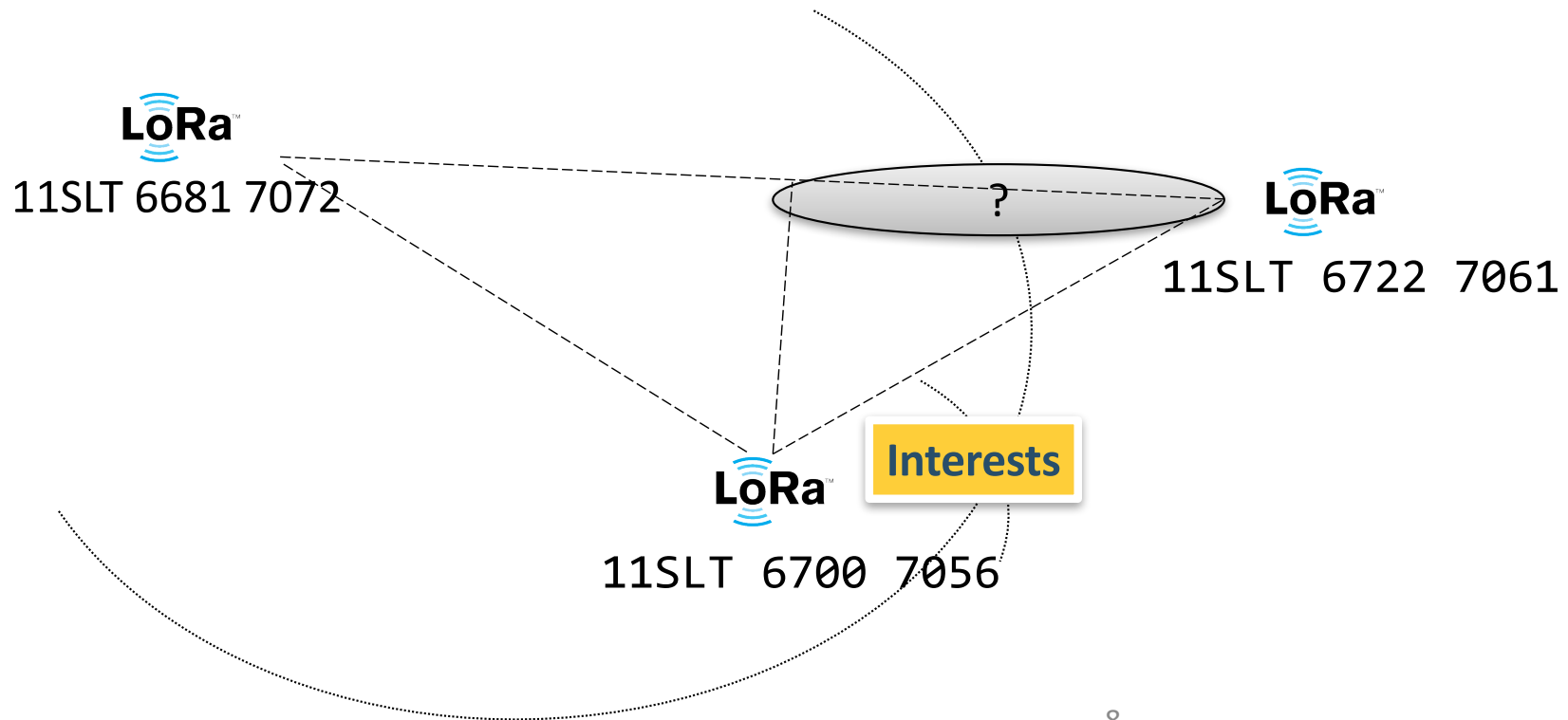
NDN Geo-Forwarding Strategy Highlights

`/FleetLink/11SLT67227061/MAC/01/03/0000/0002/C40B`

11SLT67227061 = {x:6722, y:7061} (x 10 meters)

$$D_{self \rightarrow dest} = \sqrt{(6722 - 6700)^2 + (7061 - 7056)^2}$$

$$D_{source \rightarrow dest} = \sqrt{(6722 - 6681)^2 + (7061 - 7072)^2}$$

$$D_{source \rightarrow self} = \sqrt{(6681 - 6700)^2 + (7072 - 7056)^2}$$

LoRa
11SLT 6681 7072

?

LoRa
11SLT 6722 7061

Interests

LoRa
11SLT 6700 7056

NDN Geo-Forwarding Strategy Highlights

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`11SLT67227061 = {x:6722, y:7061} (x 10 meters)`

LoRa™
11SLT66817072

LoRa™
11SLT67227061

Interests

LoRa™
11SLT67007056

NDN Codebase Support

- NDN-Squirrel for Electrical IMP
  - Port of the NDN Common Client Library
  - Full support for basic NDN primitives
  - Transports to send/receive between agent/device, serial port, or the local Micro Forwarder
  - HMAC and RSA signatures
  - AES and RSA encryption

- Micro Forwarder
  - Light-weight NDN forwarder
  - pure Squirrel implementation
  - PIT, FIB + application-configurable faces and routes
  - Forwarding strategies for geo routing (coming soon)

- Compiled size of NDN-Squirrel + Micro Forwarder (w/o geo forwarding): 160 KB

The Larger Opportunity

Residential solar is just one example of a class of **industrial IoT applications** with these general attributes:

- Require a reliable and secure internet connection
- Are distributed geographically, minimum one site per square mile
- Have a long service lifetime
- Are largely unattended, so that communications repairs are expensive
- Require moderate data throughput (~100 kB per day)
- Permit moderate latency (up to 30 seconds)
- Are valued <$50k, not so expensive that cellular charges are immaterial

Some potential examples include:

- Agricultural sensing and control
- Building automation

Operant IoT Opportunity – Market View

FleetLink is superior to the future LTE NB-IoT Cat M-2. In 2020:

- Data charges for IoT will be $2/year
- An estimated 20 billion IoT units will be deployed
- This projected $40B is LESS than today's cellular IoT revenue ($47B)
- That's only 4% of current global cellular connectivity revenue ($1T)
- Limits carriers ability to monetize and deploy LTE IoT technologies
- [Reference](#)

FleetLink is superior to other LPWAN solutions

- Peer network means end customers own and control everything
- Lowers customer risk; they are not dependent on Operant's success
- < $1/year data charge
- Extremely lightweight and secure software limits support requirements