Building grid services over 35 Millions of Smart Meters using G3-PLC : Feedback from a DSO

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☑ Libre
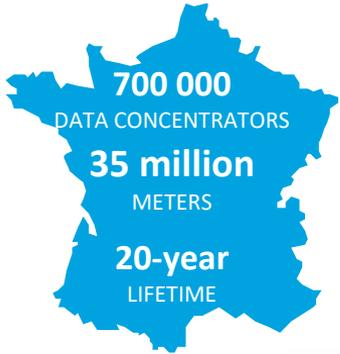☐ Interne
☐ Restreinte
☐ Confidentielle

3rd September 2019 – Asian Utility Week 2019 – Kuala Lampur

Linky Roll Out in a nutshell : Main targets

6 years

2015→ 2021

MASS ROLL OUT

700 000
DATA CONCENTRATORS
35 million
METERS
20-year
LIFETIME

5 billion

CAPEX BY 2021

10 000 JOBS
CREATED
(5 000 OPERATORS IN THE FIELD)

6 PARTNERS →

Sagemcom
- Single phase meters G1 / G3
- Three phase metersG3
- Data Concentrators G3

alfanar
- Three phase meters G1 / G3

Landis+Gyr
- Single phase meters G1 / G3
- Three phase meters G1 / G3
- Data Concentrators G1

CAHORS
- Data concentrators G1 / G3

Honeywell
- Single phase meters G3

Itron
- Single-phase meters G1 / G3
- Three phase meters G1 / G3

>3 billion

DATASETS COLLECTED / TRANSFERRED / STORED PER DAY

Linky Deployment: Key figures (September 2019)

20 000 000 METERS **INSTALLED**
30 000 METERS INSTALLED **PER DAY**

By the end of this 15 min talk,
1 000 Linky will be rolled out !

750 000 METERS PRODUCED **PER MONTH**

100 % PowerLine Communication

- G1-PLC : 15 %
- G3- PLC : 85 %
- GPRS : 0 %

99% SUCCESS RATE OF REMOTE OPERATION

98 % DAILY COLLECTION RATE (23h59)

What grid services built upon ?

From smart metering to smart grid

G3-PLC for grid services

Let's focus on 3 major grid-oriented service running on top of our 20+ millions G3-PLC meters rolled out (all patented):

1. Power outage detection

2. Phase detection

3. Grid cartography consolidation

→ **It is pure software based. No additional devices than meters and DC using G3-PLC are needed.**

→ **G3-PLC is by nature connected to the grid, so the protocol actually gather key informations from the grid state**
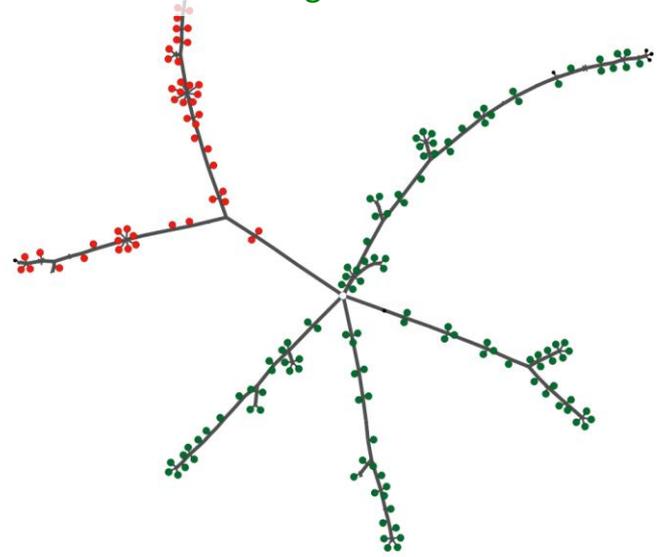
Power outage detection

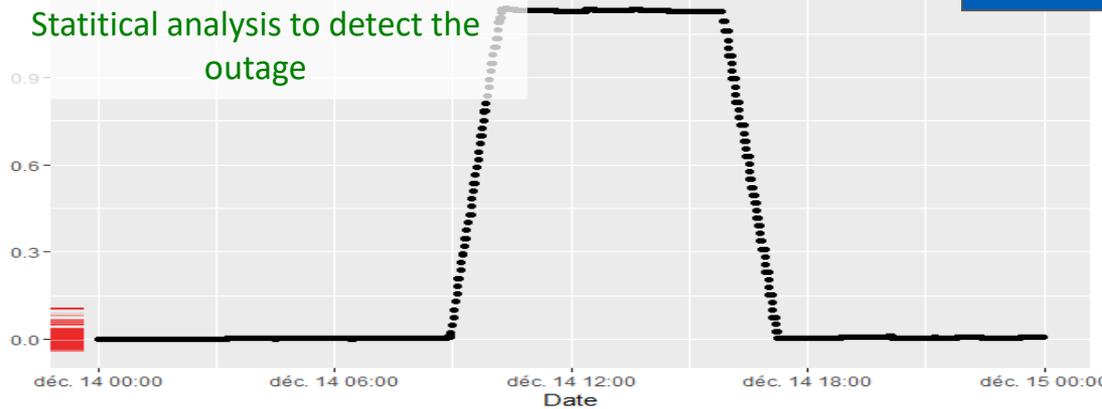Basic approach for power outage detection:

Ping sequence during an outage
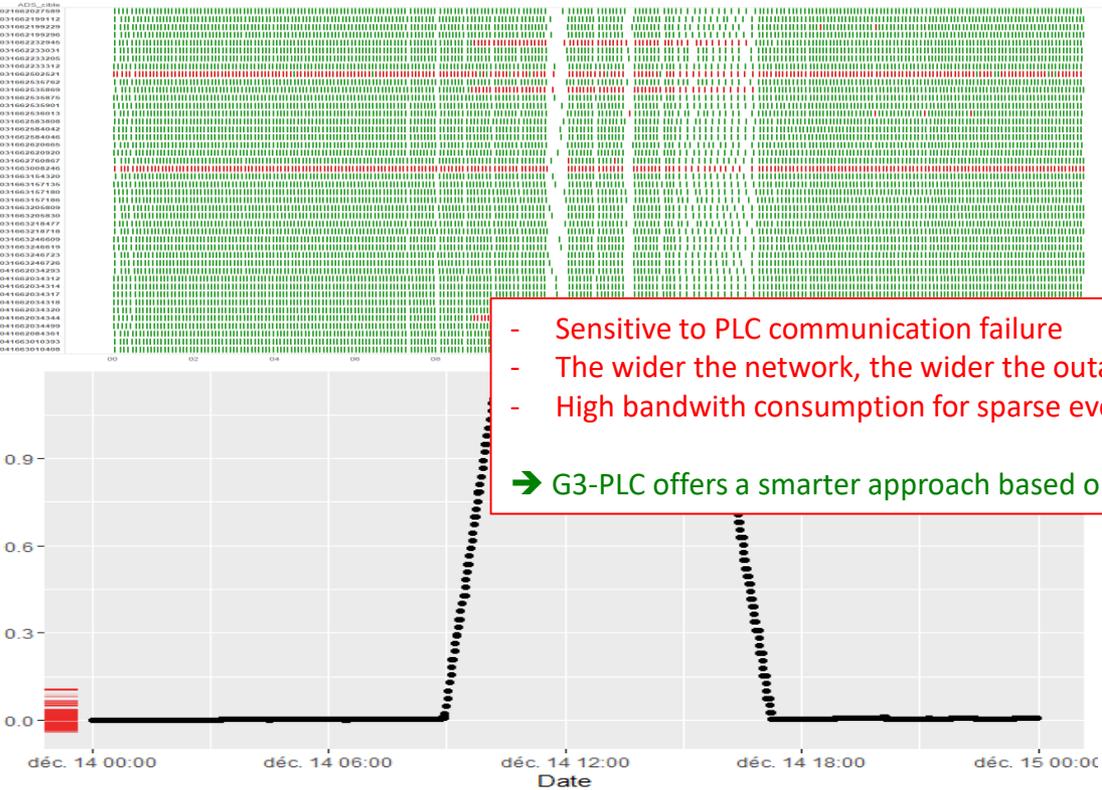
Statitical analysis to detect the outage
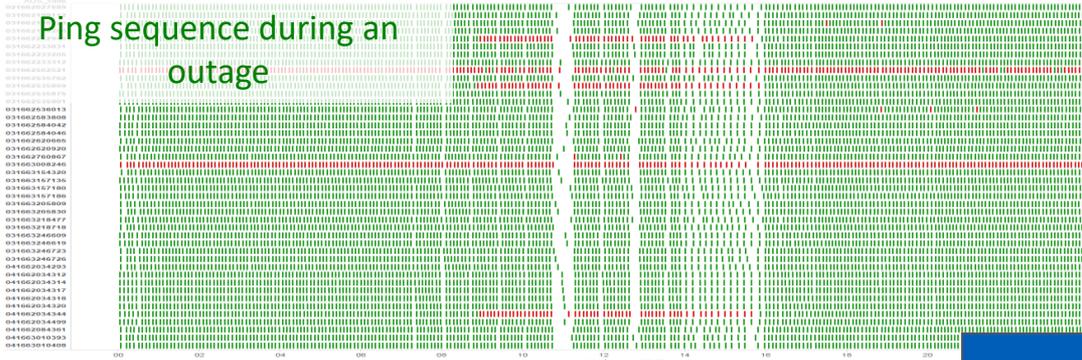
Representation of the outage on the LV grid

Power outage detection

Basic approach for power outage detection:

- Sensitive to PLC communication failure
- The wider the network, the wider the outage, the lower the service…
- High bandwith consumption for sparse events !

→ G3-PLC offers a smarter approach based on neighbor tables

Power outage detection

➔ G3-PLC offers a smarter approach based on neighbor tables

The collection of the minimum number of neighbor tables is sought to monitor the power state of the grid.

In the following example, 3 neighbor tables (out of 28) suffice to cover a 28-node network:

DC neighborhood

Mx Neighborhood

My Neighborhood
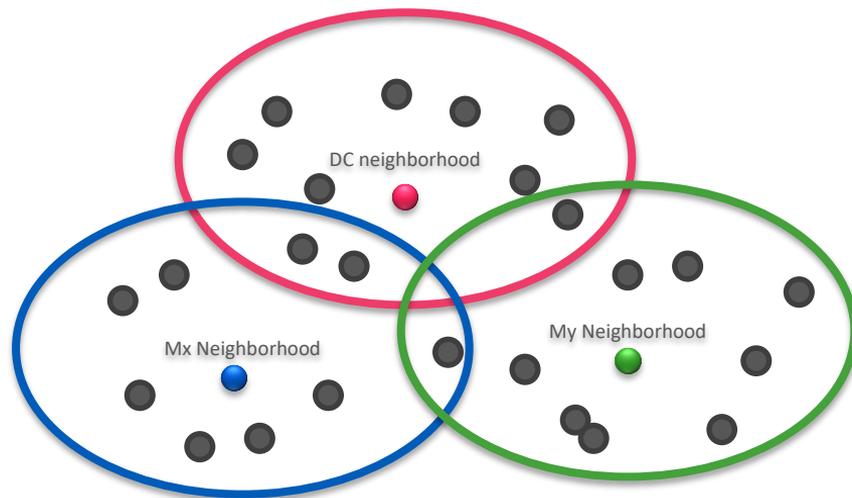
Power outage detection

> ➔ G3-PLC offers a smarter approach based on neighbor tables

The collection of the minimum number of neighbor tables is sought to monitor the power state of the grid.

In the following example, 3 neighbor tables (out of 28) suffice to cover a 28-node network:

Short_Address	Neighbor_Valid_Time
0001	255
0002	255
0101	255
…	…

Short_Address	Neighbor_Valid_Time
0090	255
0101	255
0130	255
…	…

Neighbor_valid_time is refreshed for each neighbor using flooding
(Only useful neighbor table entries are shown)

Power outage detection

➔ G3-PLC offers a smarter approach based on neighbor tables

The collection of the minimum number of neighbor tables is sought to monitor the power state of the grid.

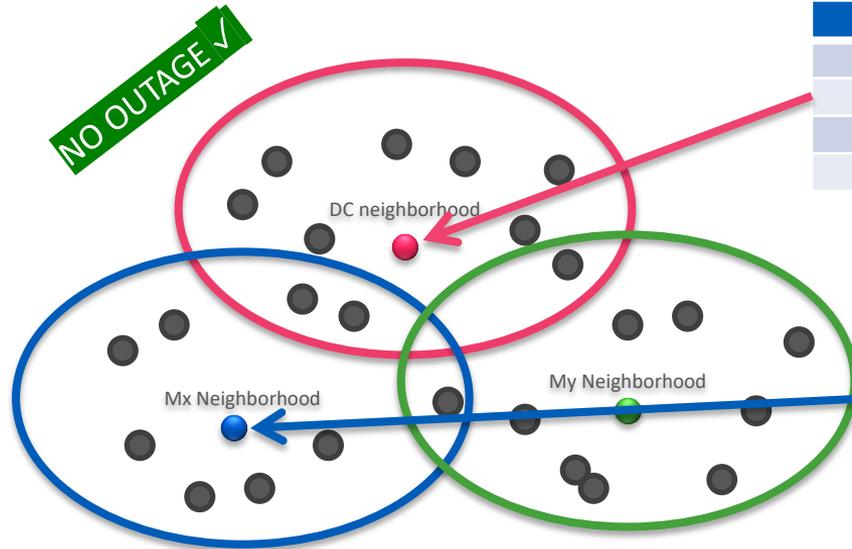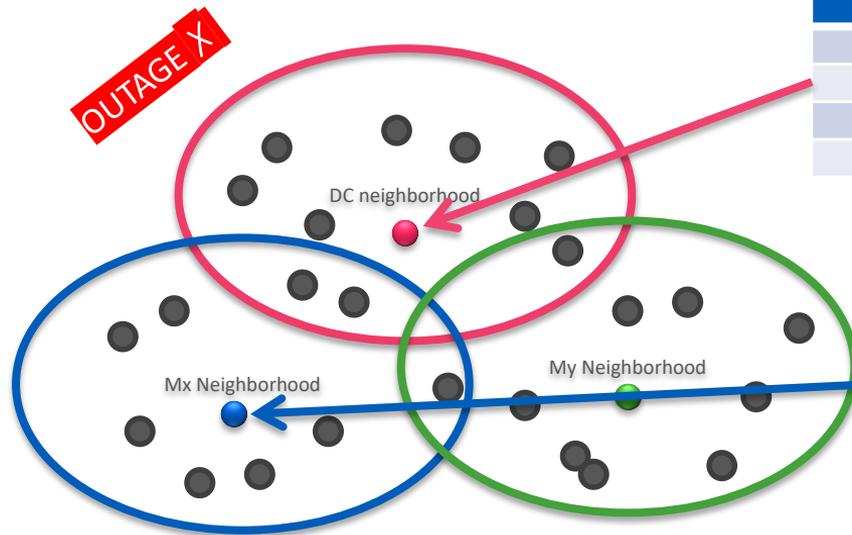In the following example, 3 neighbor tables (out of 28) suffice to cover a 28-node network:

Short_Address	Neighbor_Valid_Time
0001	255
0002	255
0101	200
...	...

Short_Address	Neighbor_Valid_Time
0090	255
0101	200
0130	255
...	...

OUTAGE X

DC neighborhood

Mx Neighborhood

My Neighborhood

If Neighbor_valid_time is not updated after several floodings and the information is cross-checked through other tables, something is going wrong

Results in laboratory

Time to gather the list of meters switched off Vs number of meters swithed off
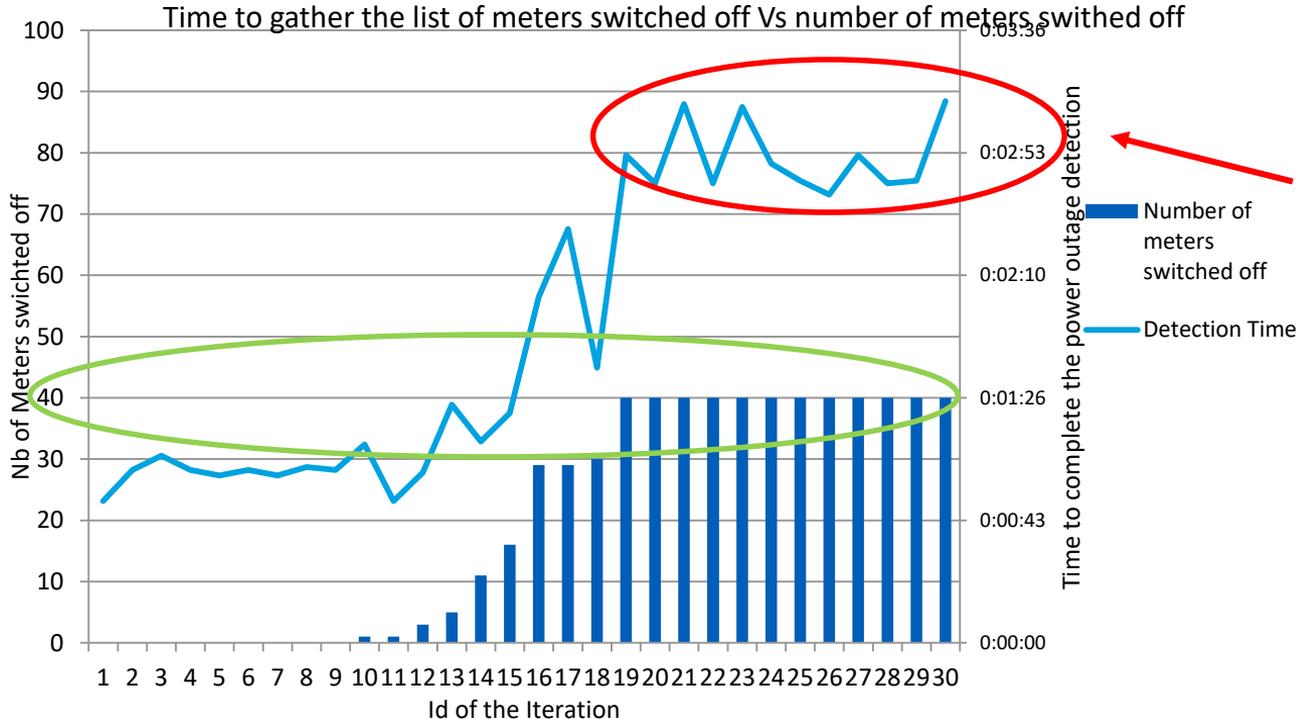
Less than 3 minutes to detect the outage of 40 meters over 100

Resilient to PLC communication failure (we use markov chain to learn communication patterns)

Scalable regarding the network size, and outage size

Limit the bandwith needed : Can be triggered using only DC neighbour monitoring

Phase Detection

Phase connection information of customers is useful to:

- Balance load in the three-phase public distribution network
- Detect phase-neutral inversion
- Get fine-grained information about outages, overvoltages, etc. ➔ enables LV grid monitoring

Phase connection information is a need for some AMI programs and part of its business plans

Continuous update of phase connection information during grid maintenance and operations is of **great benefit from an operational perspective**

Phase Detection

How does G3-PLC perform phase detection ?

G3-PLC provides relative phase detection between neighbors

➢Use of CSMA/CA (unlike some PLC standards using TDMA-like 50/60 Hz-bound medium access)

➢Use of a « **Phase Detection Counter** » which value is included in the PHY header of each G3-PLC frame
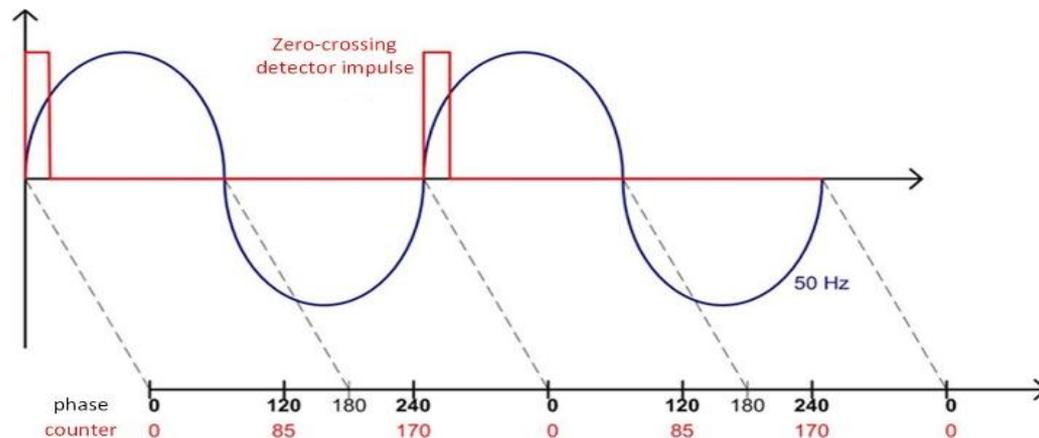
The PDC field of the received frame **updates the « PhaseDifferential » attribute** related to the transmitter node **in the neighbor table**.

Phase Detection

The algorithm was run on 2725 meters :

➢Phases correctly computed for 2725 meters: **32,9%** for Phase 1, **32%** for Phase 2 and **34,1%** for Phase 3

➢25 meters (0,9%) with phase-neutral inversion

Network size	Meters with a phase correctly computed						Total found
	P1	P2	P3	Inversion P1	Inversion P2	Inversion P3	
<=20	3	13	5	3	3	5	32
]20,60]	13	10	16	0	0	0	39
]60,150]	251	227	256	2	2	3	741
>150	628	624	654	3	2	2	1 913
Total	**895**	**874**	**931**	**8**	**7**	**10**	**2 725**

Mostly Balanced Network   **Inverted connections !**

Grid Cartography Consolidation

➢Beauty of PLC : telecom links ≈ electrical links

➢Use of the telecom topology created by G3-PLC routing to (re)establish the electrical topology

Meter A

DC

Routing

Meter A

DC

All PLC Links in a real network

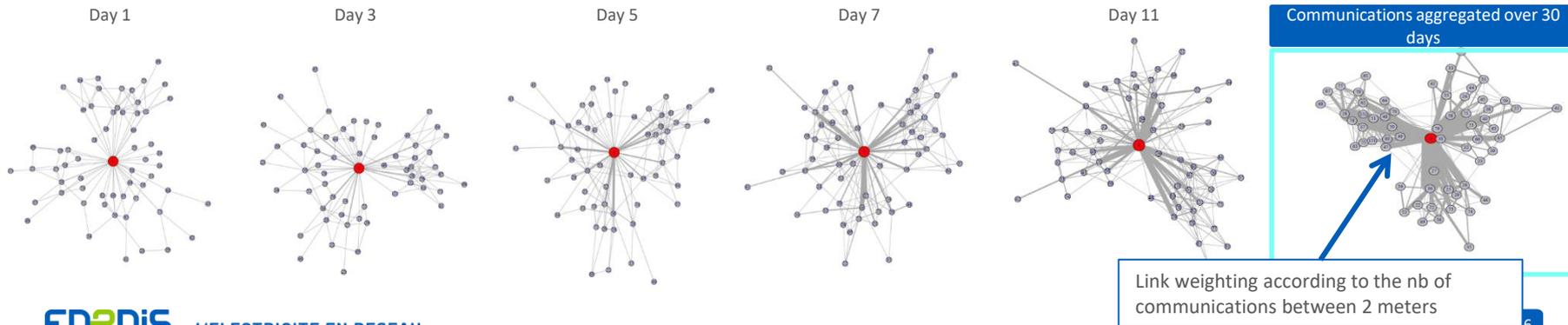Paths optimized by G3-PLC using the LOADng protocol
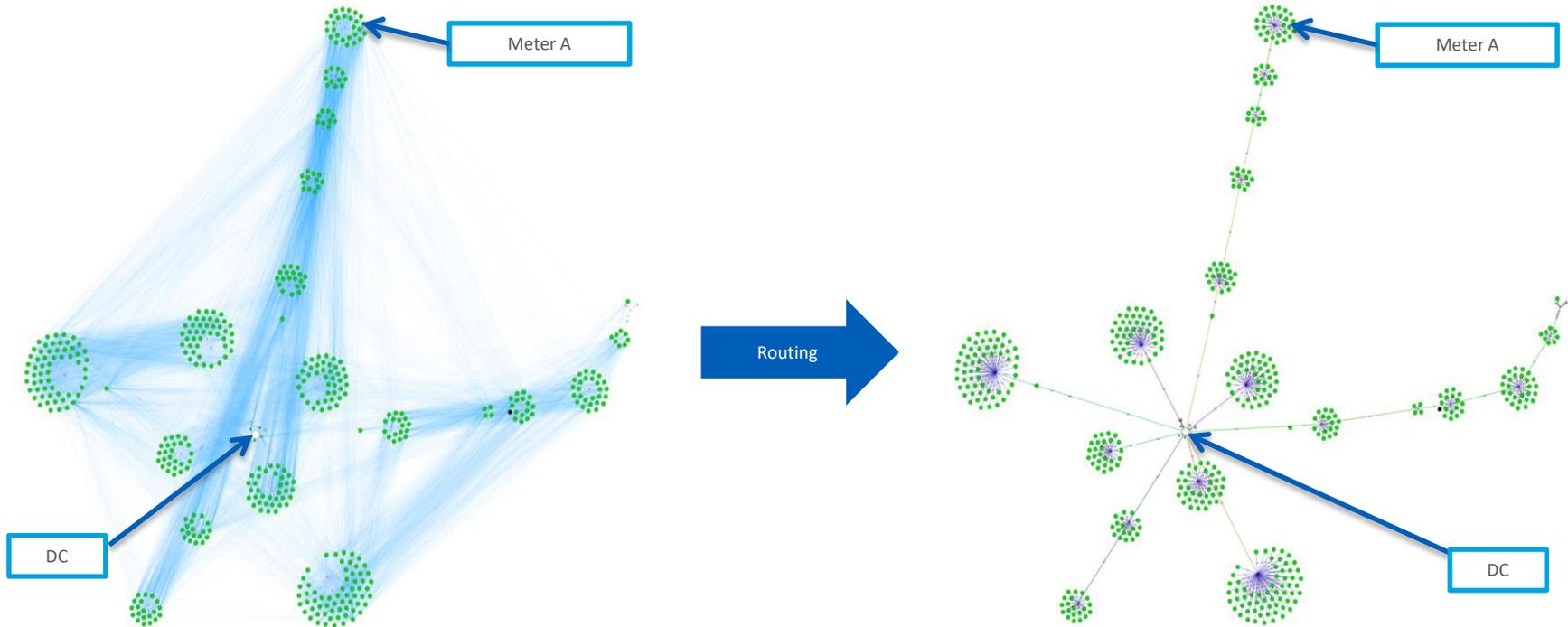
Grid Cartography Consolidation

➢ Use of G3-PLC « path discovery »

➢ Procedure run on grids with more than 70% of meters rolled out, stable communication links over 30 days
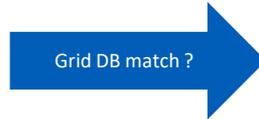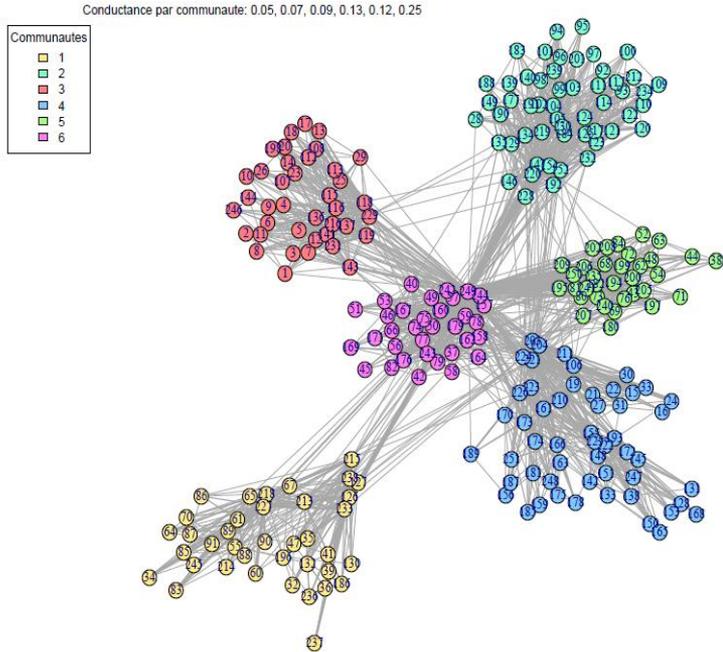
Metric_type	Path	RouteCost	Status	TimeStamp	IdC	mac_longue	mac_courte	topo	horodate	ID_PRM
15	NA	42	0	2016-09-27T11:53:50	021570010034	NA	8	c(0, 29, 8, 29, 23, 127, 0)	2016-09-27 11:53:50	14276266278027
15	NA	53	0	2016-09-27T11:52:48	021570015450	NA	67	c(0, 116, 145, 67, 145, 136, 17, 50, 0)	2016-09-27 11:52:48	14275253252663
15	NA	11	0	2016-09-27T11:51:45	021570013111	NA	71	c(0, 71, 0)	2016-09-27 11:51:45	14240231545813
15	NA	34	0	2016-09-27T11:50:43	021570017765	NA	184	c(0, 137, 177, 184, 177, 137, 0)	2016-09-27 11:50:43	14253835019035
15	NA	32	0	2016-09-27T11:49:42	021570017801	NA	19	c(0, 137, 19, 17, 50, 0)	2016-09-27 11:49:42	14243125901829
15	NA	41	0	2016-09-27T11:48:39	021570015393	NA	196	c(0, 12, 196, 12, 44, 129, 0)	2016-09-27 11:48:39	14258465988660
15	NA	12	0	2016-09-27T11:47:37	021570018096	NA	84	c(0, 84, 0)	2016-09-27 11:47:37	14268451516826
15	NA	21	0	2016-09-27T11:46:36	021570010031	NA	10	c(0, 41, 10, 85, 0)	2016-09-27 11:46:36	14280607812012
15	NA	11	0	2016-09-27T11:45:34	021570018101	NA	61	c(0, 61, 0)	2016-09-27 11:45:34	14286396524017

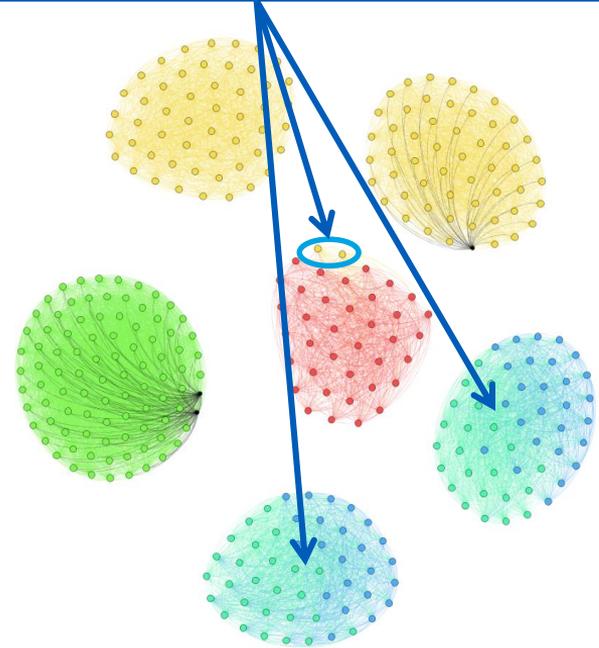➢ Graphical representation of the paths over a G3-PLC network

Day 1   Day 3   Day 5   Day 7   Day 11   Communications aggregated over 30 days

Link weighting according to the nb of communications between 2 meters

ENEDIS L'ELECTRICITE EN RESEAU

Grid Cartography Consolidation

Community detection algorithm

Conductance par communaute: 0.05, 0.07, 0.09, 0.13, 0.12, 0.25

Communautes
1
2
3
4
5
6

Grid DB match ?

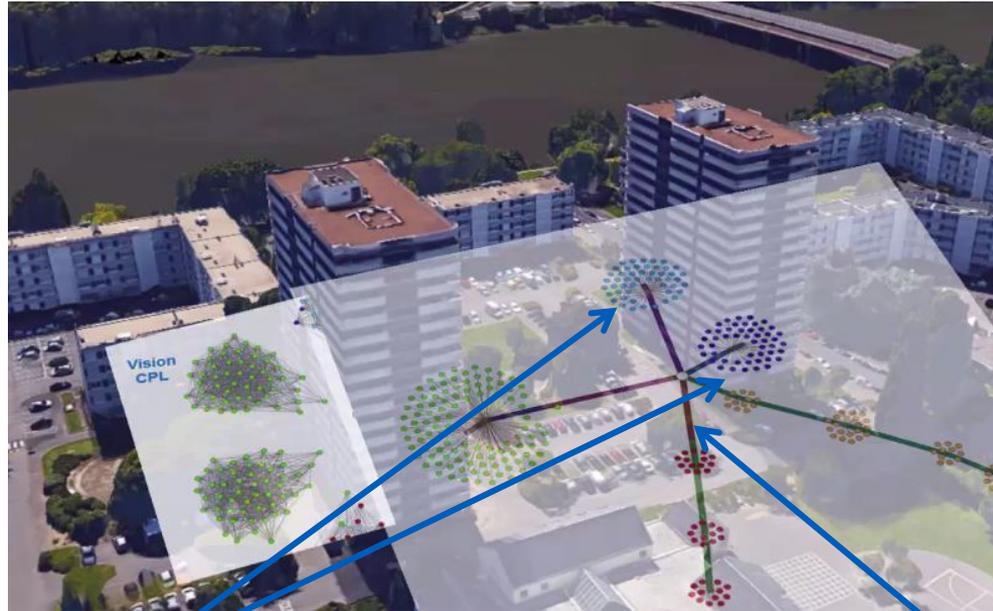Telecom (PLC) and grid database do not match, who's right ?

The previous step leads to several telecom communities represented above

Communities are colored according to the electrical cartography in the database (1 color = 1 LV feeder)

Grid Cartography Consolidation

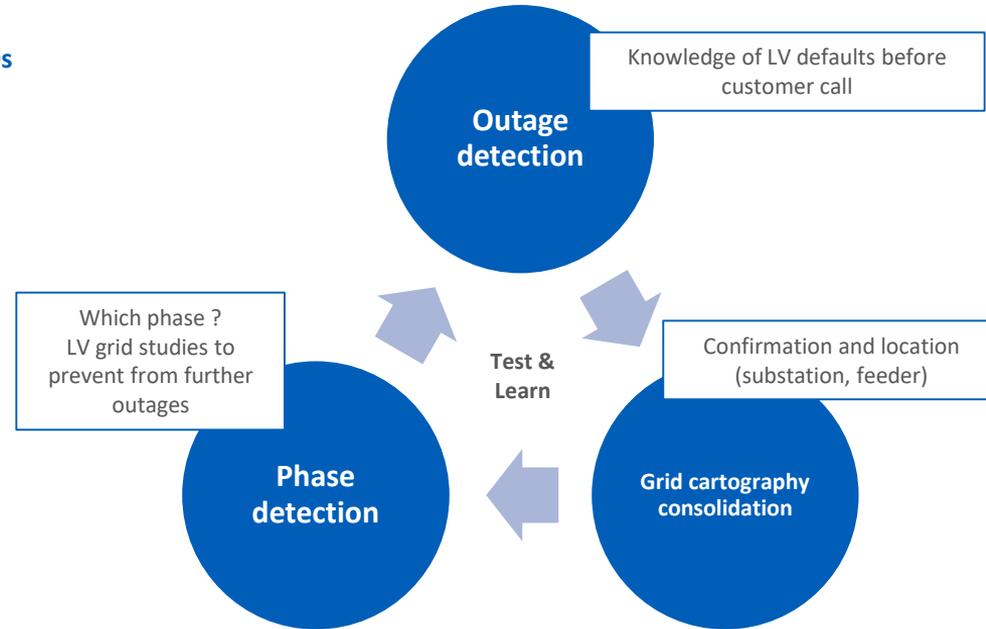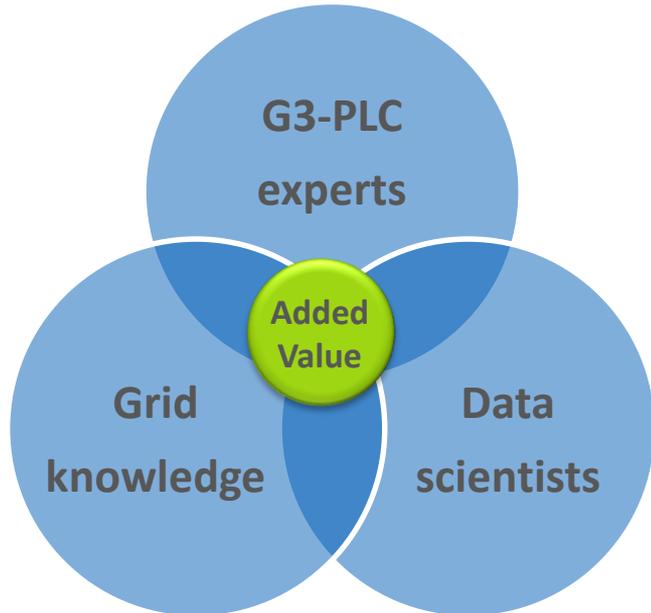Telecom (PLC) and grid database do not match, who's right ? ➔ **G3-PLC was right**

1 connection to the grid BUT PLC enables to look beyond the current knowledge of grid cartography (floors 1-8 + floors 9-16)

2 meters were uncorrectly referrenced

Conclusion

Added benefit of G3-PLC technology: **the virtuous cycle of G3-PLC for DSOs**

➢Power outage detection

➢Phase detection

➢Grid cartography consolidation

G3-PLC experts

Grid knowledge

Added Value

Data scientists

Knowledge of LV defaults before customer call

Outage detection

Which phase ?
LV grid studies to prevent from further outages

Test & Learn

Confirmation and location (substation, feeder)

Phase detection

Grid cartography consolidation

Data is the next golden raw material for DSOs:

Gather PLC experts, data scientists and grid experts and make them work together !

One more thing(s)... we build <u>LOT</u> more for a smarter grid

	Technical Solution	Outage time	Grid Observability	Supply quality	CAPEX economy	Safety
Exploitation	**Overvoltage Alarms**	✔		✔		✔
	Remote interrogation of a meter group (**Grouped Meter Ping**)		✔			✔
	Power **Outage** detection	✔	✔			*Presented !*
	Analysis of the **loss of power supply on the DC**	✔	✔			
	Loss of phases alarms on triphased meters	✔	✔			
MV Driving	**Remote transmissions of fault detectors** connected to the DC	✔	✔			✔
	Remote control of the DC		✔			
	Reverse voltage detection alarm on the DC	✔				✔

ENEDIS L'ELECTRICITE EN RESEAU

... really

	Technical Solution	Outage time	Grid Observability	Supply quality	CAPEX economy	Safety
Trouble Shooting	Meter Ping		✓			
	Remote Diagnostic	✓	✓			
Cartography and studies	Analysis of **PLC connection** between meters and their DC		✓			✓
	Consolidation of the **cartography**		✓			✓ *Presented !*
	Phase Detection using PLC	✓	✓	✓	✓	*Presented !*
Supply quality	Recording and remote transmission of supply quality data		✓	✓	✓	

Want to know more ? Come visit G3-PLC Alliance booth

Thank You & see you in Paris for EUW!