

# Pragmatic approach for G3-PLC routing parameter optimization

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## Abstract

This document describes methodology and preliminary results of a pragmatic approach of parameters optimization for Routing algorithm for G3-PLC networks. The study is focused on an existing implementation and standard G3-PLC solution in order to assist routing configuration of actual networks according to specific network usages. Several routing quality indicators and their relevant routing parameter are introduced. Mainly, it is describing a study testing active route weighting factor (adp\_Krt) and hop count weighting factor (adp\_Kh). Results are therefore presented in a bi-dimensional space, proposing recommended and not-recommended ranges.

## Index Terms

G3-PLC, LOADng, Routing parameters optimization.

## I. INTRODUCTION

THIS document is describing a study targeting an optimization of routing parameters of actual G3-PLC networks. This work is motivated by the fact that on field performance of the data traffic is related to network topology, and user expectations (also known as *Use Cases*). As an example, users of a G3-PLC Meters network are presently utilities. Regarding applications, meters density, lines cabling topology and overall environment (Rural, Urban and Sub-Urban), we could expect that network topology should differ.

In a first section, we present an overall presentation of the study with scope, methodology and limitations. We also introduce key indicators of the relevancy of routing parameters sets, and we present a test setup enabling actual network reproduction.

In the second section validation results are shown and an example of routing parameters optimization is presented.

## II. OVERALL PRESENTATION

### A. Basic of G3-PLC Routing

In the papers, we focus on G3-PLC technology [1], especially the parameters of the routing algorithm [2]. The selected reference devices are G3-PLC meters based on a certified modem platform [3]. Those parameters are also known as adp\_K parameters, and accessible and configurable by the application layer (i.e. [4][5]). By consequence, the Metric used in the studied network will be Composite Metric (0x0F).

In G3-PLC, there is a dependency of the Channel Estimation performed by the modem (Link Quality Indicator, Modulation, Tone Map), and the computed route cost.

### B. Indicators

Quantitative values have to be chosen in order to rate the routing quality. These can be based on statistical computation from measurements. To cover maximum network behaviour use cases, we have studied several measure sources. For the presented study, we essentially used:

- Ping delays – evaluating the network speed.
- Links per device count – validation of active route weighting factor
- Average hop count – validation of hop count weighting factor

### C. Process and methodology

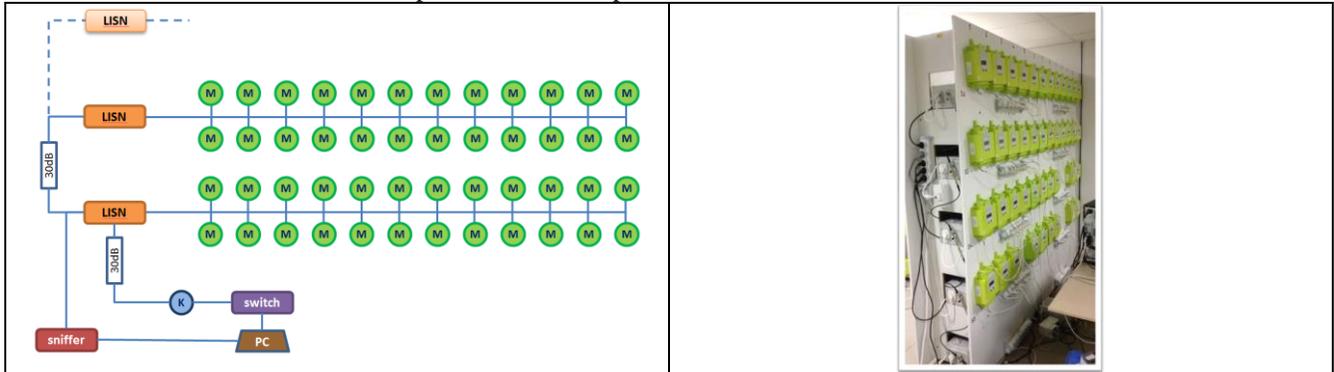
Considering the number of meters, it was necessary to set a of reliable test protocol to ensure reproducibility and independence from network beginning state. It is based on broadcast requests to access meters regardless of the existence and reliability of the route, and use of the *routing table entry time to live* (RT\_TTL) parameter to force route rebuild with wanted configuration.

<p><u>Initialization</u></p> <ol style="list-style-type: none"> <li>1. Set RT_TTL = 10 min (Broadcast)</li> <li>2. Check Routing configuration (Unicast)</li> <li>3. Wait RT_TTL = 10 min for routes obsolescence</li> </ol>	<p><u>For each configuration:</u></p> <ol style="list-style-type: none"> <li>1. Set RT_TTL = 60 min (Broadcast)</li> <li>2. Check Routing configurations (Unicast, this is updating route entries)</li> <li>3. Ping tests to establish statistics</li> <li>4. Get paths to evaluate network topology</li> <li>5. Wait RT_TTL = 60 min for routes obsolescence</li> </ol>
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*D. Network topology use cases*

Our setup is constituted on (see figure below):

- o 1 data concentrator, Up to 144 meters, Up to 12 LISN



Although the network organization can easily be modified, we want to focus on a reference setup to ensure optimization study. It has been designed to allow meters to be accessed with various hop counts depending on routing configuration and attenuation setup.

Regardless of this assertion; we used, in a preliminary step, simplified organization to validate the function of the hop count and active route weighting factors.

III. EXPERIMENTAL RESULTS

*A.  $K_{rt}$  active route weighting factor validation*

Devices with best link costs – mainly with best link quality indicators (LQI) – may be involved in most of the possible route, creating a clogging situation. Active route weighting factor ( $K_{rt}$ ) allows supporting network uniformity with more dispatched routes. In the Figure 1, we present the result of a test, experiencing the effect of increasing  $adp_{Krt}$  that is adding uniformity to the network topology.  $M_x$  denotes meters number X.

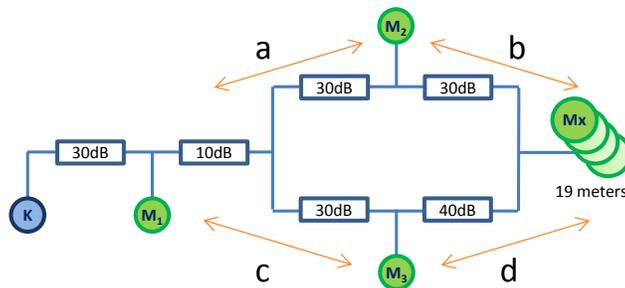


Figure 1 : Physical configuration

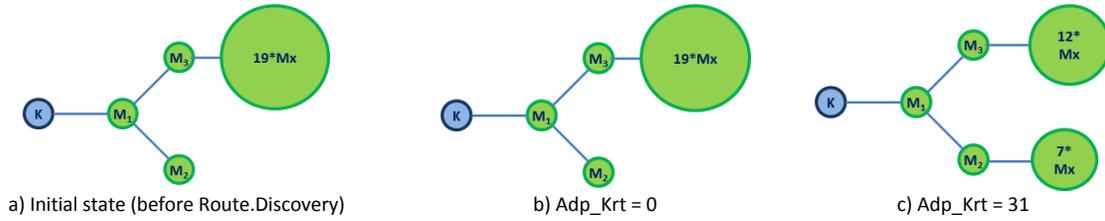


Figure 2 : Balancing network topology

The Figure 2 does not present a perfect split of nodes among  $M_2$  and  $M_3$  routes. This is explained by the Link Cost contribution. In this test,  $adp\_Kq$  is equal to 4. Therefore, there is a contribution of the best LQI to not move from  $M_3$  route to the  $M_2$  one. This contribution could be estimated from the difference of link attenuation  $b$  and  $d$  (respectively 40 and 30 dB). Those attenuations could be expressed into cost, according to  $adp\_Kq$  parameter, respectively 2.8 and 2.1, leading to a cost difference of  $2.8 - 2.1 = 0.7$ . So, while the Active Route contribution is below this value, meters will join the best neighbour. In this example,  $(0.7) / (adpKrt/255) = 5.75$  entries are to be filled before it compensate the difference of Link Quality contribution to the Link Cost.

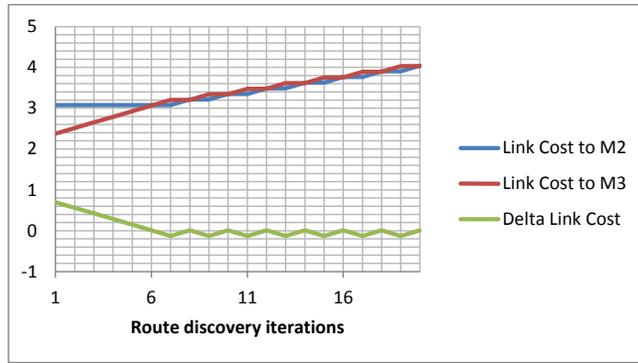


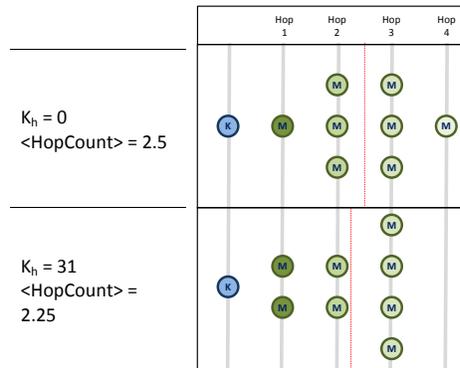
Figure 3 : Link Cost from M2 or M3 per Discovery iteration

B.  $K_h$  hop count weighting factor validation

In this experiment we validated the penalty of hopping consecutive to the increase of hop count weighting factor ( $K_h$ ). We define the average hop count by formula (2):

$$\langle HopCount \rangle = \frac{\sum_{HopCounts} (HopCount \cdot HopCountOccurence)}{\sum_{HopCounts} (HopCountOccurence)} \quad (2)$$

Hop count occurrence is the number of devices reachable with a given hop count.



C. Reference network, first results

We present here the results in a map to help the decision of parametrization. Here, the map is based on a 4-by-4 map for the parameters set. Further work with high density will be presented.

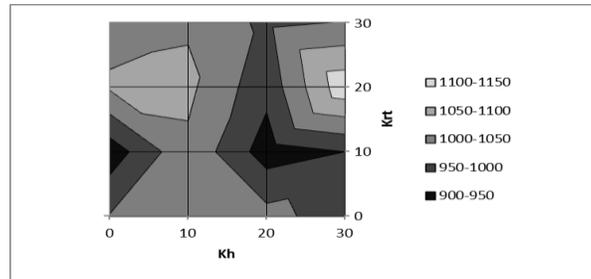


Figure 4 : Average ping delay (ms)

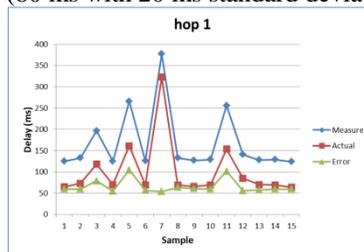
In the figure above, we see a lower performance area to avoid (the lightest) that corresponds to the couple  $\{Krt = 20; Kh = 10\}$ .

#### IV. CONCLUSION

In this paper, we demonstrate that the combination of a customized test setup and the choice of proper measures permit routing parameters mapping. This can be used for network optimization according to user expectations. As the methodology is based on standard interfaces, it is possible to optimize directly in field, in order to find the best set of parameters.

#### APPENDIX A - CALIBRATION

Experimental network is managed through a data concentrator; measurement is then dependent on its operating system. It is particularly the case of ping delays, which are tributary of sockets management and of a Ipv6 to PLC virtual interface. We had then to estimate the error of measured delays with actual ones. This had been done by sniffing PLC packets to get actual delays. The error is relatively constant (80 ms with 20 ms standard deviation).



It is very important to avoid unwelcome communication during ping tests, one must be mainly careful about tone-map or route requests.

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