Historical and Future perspective of using PLC based communication technology for Smart Meter deployments in Africa.

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THE COMMUNICATION LAYER IS A CORE COMPONENT OF ANY SMART GRID OR SMART METERING PLAN
• Until now, smart-meters projects were mainly based on PLC in Europe with cellular for certain areas.
• In the US, Utilities have widely adopted RF Mesh solutions.
• PLC is used widely in China.

• These differences can be explained by:
  – A very strict regulation of RF spectrum in Europe which limit the access to frequencies used for RF Mesh (especially those lower than 1 GHz).
  – The European Architectural characteristics (high buildings, meters in basement, steel content in buildings, etc) which are less favorable for wireless technology.
  – The American electric grid characteristics (number of meters per transformer is significantly lower than in Europe) which tend to make PLC too extensive (with a technology that does not go through transformers).
  – Goals for AMI: US is focusing on security & stability (lend itself to Self Healing RF mesh networks) while Europe is focusing more on Greenhouse emission reduction, consumer engagement, renewable targets etc)
# Technology Comparison

*TABLE Source: Bearingpoint.com

<table>
<thead>
<tr>
<th></th>
<th>Low data-rate PLC</th>
<th>RF Mesh</th>
<th>Cellular</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Costs</strong></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Equipment</td>
<td>Strongly depends on the number of meters by transformer</td>
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<tr>
<td>Installation</td>
<td>Installation in owned transformers or substation, plug &amp; play</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Operation &amp; Maintenance</td>
<td>Few maintenance needed</td>
<td></td>
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</tr>
<tr>
<td>Coverage</td>
<td>Total by definition</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Meter access capabilities (basement, high-building, ...)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Coverage</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Signal propagation</td>
<td>Not affected by topography</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Performance</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Range</td>
<td>&lt; few kms</td>
<td>&lt; 50+ meters</td>
<td></td>
</tr>
<tr>
<td>Data-rate/Bandwidth</td>
<td>&lt; 10+ Kbit/s</td>
<td>&lt; 100+ Kbit/s</td>
<td></td>
</tr>
<tr>
<td>Latency</td>
<td>&lt; 1 sec</td>
<td></td>
<td>Difficult to forecast, depends on the number of knots</td>
</tr>
<tr>
<td><strong>Service quality</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Interferences risks</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Interoperability</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Standardization</td>
<td>Open standards solutions IEEE P1901.2</td>
<td></td>
<td></td>
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<td></td>
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<td></td>
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<tr>
<td><strong>Network property</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Interferences risks</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td><strong>Standardization</strong></td>
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<td></td>
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<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td><strong>Public acceptance</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Public pollution, privacy, cyber security perception</td>
<td></td>
<td></td>
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</tbody>
</table>

- **Private**
  - Average
    - (Very sensitive to electrical components of the grid)
  - **High**
    - (Operate on frequencies shared with other equipments (walkie-talkies, baby-phones, ...)

- **Public**
  - Low
    - (Operate on licensed spectrum)
  - High operating costs for a large scale use
  - Very good performance
  - Dependence to a telecom operator and service quality control risks
  - Public acceptance risks
  - 2G and GPRS networks future uncertainty

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- **PLC**

- **RF Mesh**

- **Cellular**

* Few public debates
* Strong debates in smart-meters rollout in the US
* installation and operations costs can be high since it needs to find equipment’s locations and to acquire new telecom skills
* Good performance in good topography and for easy to access meters
* Mainly proprietary solutions
* Strong public acceptance risk
GLOBAL AMI SNAPSHOT

EUROPE: +70M
Italy: +34M; Spain: +12M; Sweden: +5M;
(Source: European commission)

CHINA: +410M
(Source: NAVIGANT)

USA: +70M
(Source: USEIA)

• UK: AMI Includes a HAN device (CIU)
• AFRICA: +20M STS prepayment meters (non smart) with a CIU.
African Utilities tend to follow European Standards (IEC), Frequency Regulation not as well established but tend to follow EU. (CENELEC A) eg: NRS049 specification in South Africa

Electrical Topology, (Meters to Transformer ratio similar to Europe)

PLC dominant technology for HAN/NAN/WAN communication.

**WHAT IS AFRICA ADOPTING?**

- **AMI Deployments:**
  - South Africa: City Power (+100k GPRS meters); Eskom (+30k PLC); Others +30k (GPRS and PLC meters).
  - Botswana (+120k PLC).

- **IMPACT of STS prepaid:**
  - +20M basic (non-AMI) prepaid meters deployed in Africa.
  - Installed CIU (Point to point) from Meter
  - PLC and Wired connection are dominant technology for CIU -> physical installation in the HAN limits RF technology and PLC has been quite successful.

- **IMPACT of Chinese meter manufacturers**
PLC TECHNOLOGY EVOLUTION

1st generation: Mono-carrier
- FSK, S-FSK, BPSK

Last generation: Multi-carriers
- OFDM
- PRIME OFDM 97 carriers
- G3-PLC & PRIME development
- G3-PLC: 150-500 kHz spectrum

Theoretical data rates available:

<table>
<thead>
<tr>
<th>Technology generation</th>
<th>1st</th>
<th>3rd: OFDM (48 subcarriers sample)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Modulation scheme</td>
<td>FSK</td>
<td>DBPSK</td>
</tr>
<tr>
<td></td>
<td>S-FSK</td>
<td>DQPSK</td>
</tr>
<tr>
<td></td>
<td>BPSK</td>
<td>D8PSK, D16PSK</td>
</tr>
<tr>
<td>Raw data rates (Kbps)</td>
<td>2.4</td>
<td>19.2, 38.4, 57.6, 76.8</td>
</tr>
</tbody>
</table>

With OFDM, data rates depend on the number of subcarriers used (Up to 128 kbps with PRIME technology with 97 subcarriers)
FREQUENCY BANDS

Low Frequency, Narrowband PLC Bands Plus Very Low Frequencies

• PLC Frequency bands in Europe
  - Defined by the CENELEC:
  - CENELEC-A (3 kHz – 95 kHz) are exclusively for energy providers.
  - CENELEC-B, C, D bands are open for end-user applications.
  - Bands A, B and D protocol layer is defined by standards or proprietarily defined.
  - Band C is regulated – CSMA access.

• PLC Frequency bands in USA
  - Single wide band – from 150 to 450 kHz
  - FCC band 10kHz – 490kHz
  - Access protocol defined by standard
  - HomePlug Broadband: 2-30MHz

• PLC Frequency bands in China
  - 3-90KHz preferred by EPRI
  - 3-500KHz single band not regulated

• PLC Frequency bands in Japan
  - ARIB band 10kHz – 450kHz
## PLC STANDARDS

<table>
<thead>
<tr>
<th>Standard</th>
<th>Technology</th>
<th>Band Occupied</th>
<th>Data Rate range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Iberdrola PRIME</td>
<td>OFDM</td>
<td>42-90 kHz</td>
<td>21-128 kbps</td>
</tr>
<tr>
<td>ERDF G3</td>
<td>OFDM</td>
<td>35-90 kHz</td>
<td>2.4-34 kbps</td>
</tr>
<tr>
<td>P1901 / G.9960</td>
<td>OFDM</td>
<td>2-30 MHz</td>
<td>&gt;100 Mbps</td>
</tr>
<tr>
<td>Homeplug Green PHY</td>
<td>OFDM</td>
<td>2-30MHz, 120-400 KHz</td>
<td>250Kbps – 3.8Mbps</td>
</tr>
<tr>
<td>IEC 61334</td>
<td>SFSK</td>
<td>60-76 KHz</td>
<td>1.2-2.4kbps</td>
</tr>
</tbody>
</table>

- PRIME designed for low voltage lines with low noise → targets higher data rates
- G3 designed for medium voltage lines → lower data rates, 802.15.4 MAC
- Homeplug Green PHY specification in progress nearing completion
- SFSK implementations available in Celenec A or B bands
- Also HomePlug C&C and LonWorks

[www.african-utility-week.com](http://www.african-utility-week.com)
PILOT FINDINGS (PLC)

- ERDF: French Utility
  - Target 35M Meter, 600k Concentrators, 95% daily data collection rate
  - Route Topology & Number of hops.
  - Collection Rate.
  - Bootstrapping Time
  - Domestic Load Interference + (PV inverter)
  - Other applications (street lighting)

(Source: Theirry-Lyss, ERDF feedback)
PILOT FINDINGS (PLC)

- ORES: Belgium Utility
  - Meter Reading (Billing & Load Profile)
  - Broadcast Test (Time of day dependent)
  - Meter installation density (per kiosk)
  - Detection Time.
  - Domestic Load Interference + (PV inverter)
  - Other applications (street lighting)
PILOT FINDINGS (PLC)

- Encourage AFRICAN UTILITIES to share their experiences in AMI PLC deployments.
- City Power have shared their experience with GPRS technology deployed (RF Zigbee for the HAN to CIU.)
- ESKOM (South Africa)
- BPC (Botswana)
- Nigerian Utilities
- Other Utilities in Africa
Options changing faster then a lady changes her shoe collection.
KEY TAKEAWAYS FOR AFRICA

• Africa will continue to follow EU standards,
• STS Prepayment will be a dominant requirement and influencer even in the AMI “world” as deployments start to increase.
• The characteristics of electrical network and physical characteristics of environment (shacks, rural vs urban) will favour PLC over RF mesh solutions in Africa.
• With the PLC Technology evolution, in Africa, G3 technology appears to be the front runner at this stage.
• The Critical Use Cases such as Load Management, Fraud detection and the impact of some poorly maintained networks has NOT been trialed or fully tested as yet.
• New emerging communication technologies may have some advantages for certain applications (eg: water meter reading)
• Choose a path, however have a multi-bearer strategy.
• PLC will also continue to be a dominant AMI communication technology used in Africa for HAN/NAN/WAN.
THANK YOU

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