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Distributed Gain Architecture

The high-capacity, lower power future

White paper

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HIGH CAPACITY, LOWER POWER

As Moore's law continues, capacity in homes and businesses from cable broadband networks will grow. More innovation is needed to expand and stretch network assets with as little additional investment and disruption as possible. Cable's minimalist success-based capital model can continue to provide enough capacity for the next twenty years and so remain the alpha broadband player.

EXECUTIVE SUMMARY

Jan explains how Distributed Gain Architecture (DGA) enables networks to bypass standard economics when upgrading to 10G Extended Spectrum DOCSIS (ESD) 4.0. His team's DGA solution radically shakes-up cable, delivering more than the 10G network capacity with a solution which importantly is available now.

DGA introduces flex-split upstream/downstream data transmission enabling cable to be a flexible 10G software defined network (SDN) – which is second-to-none. This gives bandwidth optionality to react as needed to the applications that develop over the next twenty years. DGA does all this without increasing Total Cost of Ownership (TCO).

BENEFITS SUMMARY

During this period of rapid innovation, a debate over technology standards is essential. The industry proposals currently being promoted rely on upgrading past technologies by continuing to upgrade the signal power outputs of network actives to compensate for the increased cable losses of the higher transmission frequencies. High power results in a less reliable network, higher electrical power consumption and results in civil engineering to add additional electrical power provision. The DGA concept was borne out of making time to analyze the problem in another way.

DGA, through small differences in cost and benefits, creates wildly different economics when scaled up, taking into account capital expenditure (CapEx) and TCO.

There is a clear winner for the technological future of the cable industry. DGA is the differentiated system that can deliver both 1.8 GHz ESD and FDX DOCSIS 4.0 today. Going forward it will be the only way to deliver 3 GHz ESD DOCSIS 4.0.

DGA features:

1. GREATER DATA CAPACITY

DGA delivers over 40% more capacity when compared with the high-power alternatives currently being offered, due to:

A Full 8k QAM modulation across the whole spectrum

- Instead of decreasing the modulation scheme on high frequencies, DGA's lower intermodulation distortion enables the use of 8k QAM over the entire transmission spectrum.

B Diplexer free means guard band elimination and flex-split

- No diplexer means there are no guard bands. Guard band removal regains valuable spectrum.

  Eliminating a 'high-split' 204/258 MHz guard band, recovers 54 MHz of spectrum

  Eliminating an 'ultra-high-split' 684/864 MHz guard band, recovers 180 MHz of spectrum.

- No diplexer means a completely flexible upstream/downstream split.

  This unleashes complete network flexibility, allowing all upstream and downstream transmission frequencies to be used at any moment while upstream and downstream traffic can be adapted in real time.

  The network is flexible and can work with all protocols: Frequency Division Duplex (FDD), Full Duplex DOCSIS 4.0 (FDX) or Extended Spectrum DOCSIS 4.0 (ESD).

2. LOWER POWER

DGA reduces electrical power consumption by over 50% when compared with high power Hybrid Fiber Coax (HFC) systems.

3. GREATER RELIABILITY

DGA uses low power amplifiers employing monolithic microwave integrated circuits (MMIC) which, due to them being far less complex using a single semiconductor chip, are considerably more reliable. Legacy amplifiers and the new generation high power amplifiers are much more complex and less reliable using hybrid printed circuit board assemblies with 50 components or more.

THE CHALLENGE AHEAD

With the current Compound Annual Growth Rate (CAGR) in broadband demand, the industry will require 10 Gbps downstream towards 2030. To be able to offer 10 Gbps ideally the network should be able to support at least 13 Gbps. The demand for 10G may increase sooner; the industry is currently focused on rolling out DOCSIS 3.1 with 1.2 GHz but needs to consider that there is the capability for a DOCSIS 4.0 roll out now. To meet this demand, operators have a choice between ESD or FDX DOCSIS 4.0. The beauty of DGA is it works in both scenarios, supporting both ESD and FDX. This is particularly convenient given that the two options are very likely to merge in the longer term.

Whichever option is chosen, one thing is clear: operators sell broadband data subscriptions in a competitive market. Therefore, profitability depends on the cost-per-megabit.

Two facets of the technology will ultimately drive system adoption in the market. They are:

- Minimum cost-per-megabit
- Frictionless transition of existing access networks.

HYPOTHESIS

The industry is very familiar with the purchase costs of access network sub-systems but often ignores that 70-80% (Energy 2020: SCTE•ISBE Energy Management Program) of the electrical power consumed by an MSO is in the access network. The high-power amplifier options currently being discussed in the industry will double electrical consumption, meaning a massive increase in operating costs and an embarrassing sustainability story. The hypothesis of this paper is therefore: low-power DGA networks are the high-capacity future.

MODELLING ASSUMPTIONS

To test the hypothesis, calculate the Total Cost of Ownership (TCO) for each of the candidate architecture scenarios - high-power, mid-power or low-power. Then map them against the data capacity each solution can deliver. This allows a comparison between the three cost-per-megabit outcomes, revealing the most efficient solution.

COST CALCULATIONS

Technetix took the following cost components into consideration to calculate TCO:

1. **CapEx**
   - RF actives
   - RF passives
   - Power supplies

2. **OpEx**
   - 24/7 power consumption
   - Truck roll costs including:
     - Installation
     - Network design time
     - Upgrade costs
     - Replacing and introducing new power supplies
     - Maintenance and repair

Cost assumptions:

- Electricity cost of 1 kWh is $0.10
- A fully loaded field engineer cost is $60 per hour.

Please contact us to find out more about preparing a model based on your network.

ARCHITECTURAL DETAILS

To test the hypothesis Technetix modelled realistic examples of future ESD network architectures, plugging-in actual power consumption rates and real-world quality performance figures.

The comparison is based on a N+2 network with 480 homes passed. The three specific cases used are:

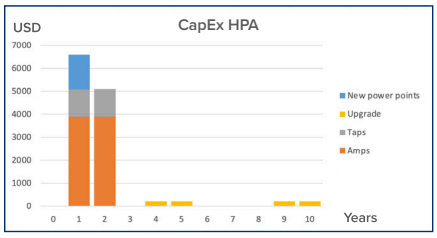
1. **HPA:** High-power amplifiers with 48 dB gain
2. **MPA:** Mid-power amplifiers with 44 dB gain and mid-span booster amplifiers
3. **DGA:** Low-power amplifiers with 20 dB gain

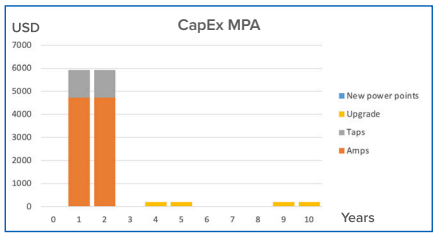
It is critical to note that within these architectures we have assumed the HPA and MPA networks use diplex filters to create the upstream and downstream paths. In contrast, the DGA option avoids diplex filters in favor of Technetix' MC coupler, which creates a bi-directional amplifier. A diagram of each network is provided in the appendix.

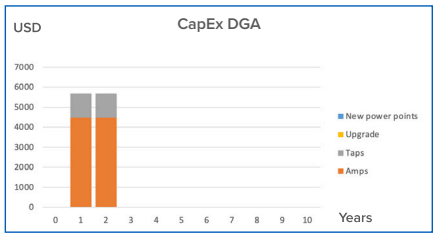
COST PERFORMANCE

An overview of the three architectures (HPA, MPA and DGA) is broken down into a comparison of operational expenditure (OpEx) and CapEx profiles and then combined into respective TCO below.

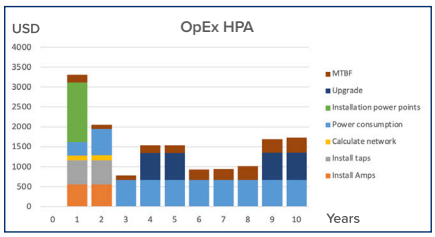
Comparative CapEx per 480 homes

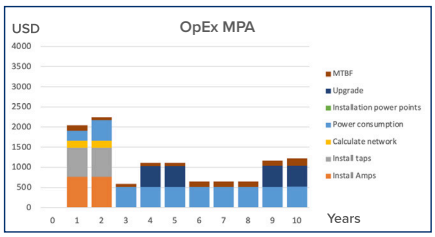


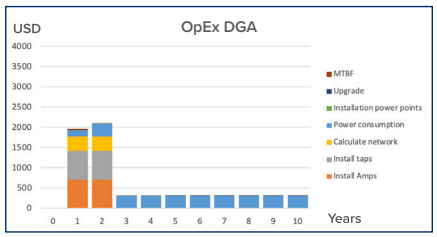




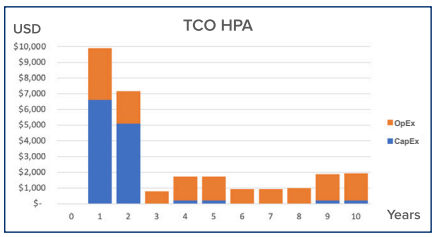
Comparative OpEx per 480 homes

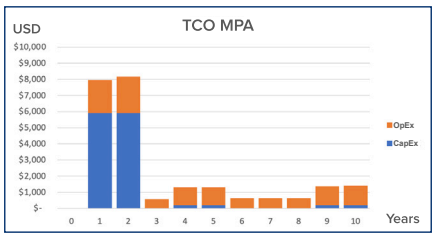


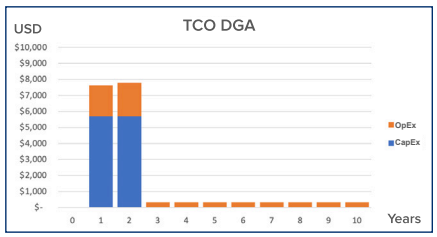




Comparative TCO per 480 homes







When comparing the three scenarios little difference in CapEx is noted. However, the disparities in OpEx are worth some attention, a quick glance at the line of comparative TCO graphs confirms that a low-power DGA is far less costly, with the high-power HPA being the most expensive option.

If we divide the TCO by the 480 homes passed, the cost per home passed (HP) the differences are revealed as follows:

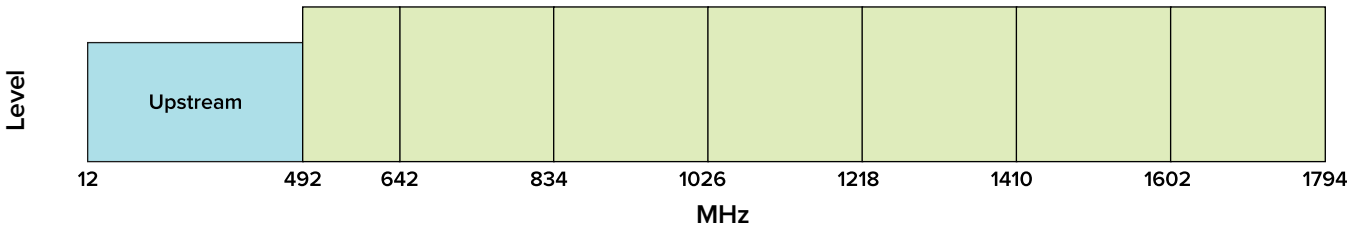
Network	TCO per HP (10 years)
HPA	$58
MPA	$50 (11% less than HPA)
DGA	$37 (37% less than HPA)

Technetix' MC coupler, enables a bi-directional amplifier which in turn facilitates a low-power network, radically changing the cost profile of network operations.

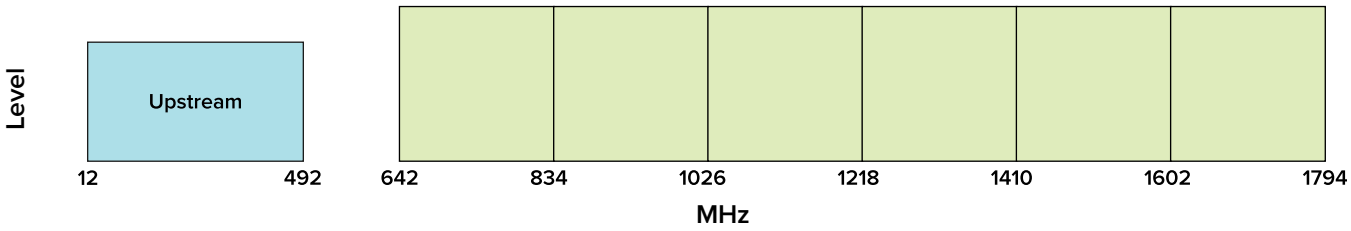
REVENUE PERFORMANCE

If the low-power DGA delivers a proportionately greater loss of signal quality, it may yet prove to be uneconomic. To test this condition, the signal strength and qualities in each of the designs were modelled to calculate what could be delivered to the CPE[1].

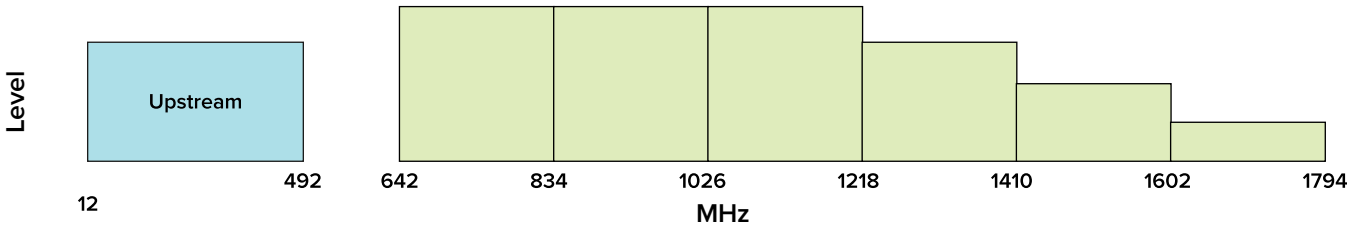
Signal levels DGA



Signal levels MPA



Signal levels HPA



Using a proportion of annual average daily traffic occurring in an hour (k-factor) of 1.3 to model for simultaneous data traffic, the following speeds can be delivered to CPE devices:

- HPA: levels must be reduced to prevent overdriving the amplifiers
- MPA: 4k QAM is deliverable up to 1.8 GHz
- DGA: up to 8k QAM can be delivered - with no diplex filter and therefore no guard band

While it may seem counter-intuitive, DGA low-power networks will deliver a higher quality signal than either of the HPA or MPA alternatives.

1. Technetix can apply this revenue/performance calculation to your network. Please contact our CTO team for more details.

CONCLUSION

The hypothesis is proven. Given their superiority on both cost and quality criteria, DGA low-powered networks are the future of high-capacity architectures.

The table below demonstrates the conclusion clearly:

Network	TCO / HP	Data to CPE
HPA	$58	7.8 Gbps
MPA	$50	9 Gbps
DGA	$37	11 Gbps

MORE FOR LESS: The DGA solution delivers 41% more data capacity at 37% less cost. It is easy to be sceptical about these results – equally it is difficult to ignore them.

If you would like further information on the content of this White Paper and to find out how to prepare your network for DOCSIS 4.0, please do not hesitate to get in touch.

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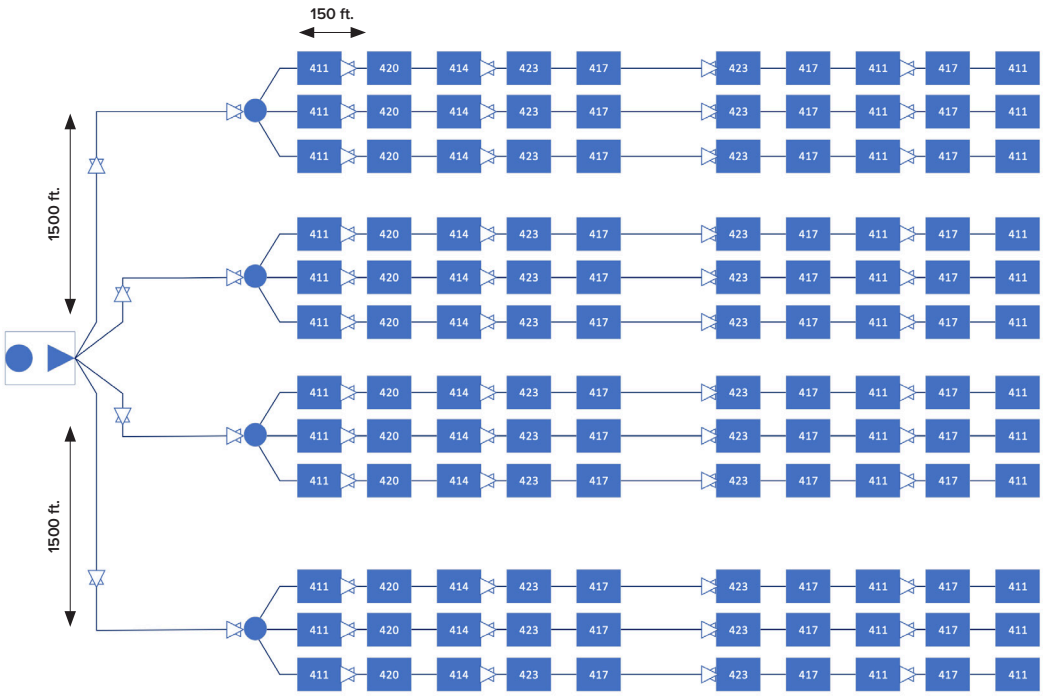
APPENDIX:

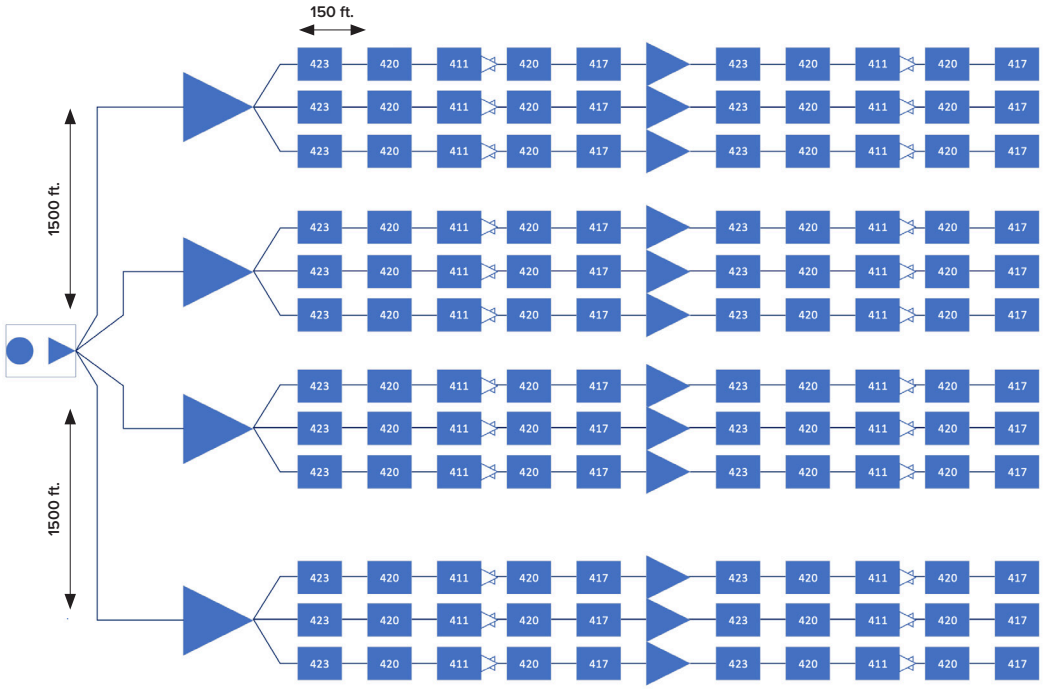
1. DGA network

Low power / 20 dB direction neutral amplifiers



2. MPA network

Medium power / 44 dB amplifiers



3. HPA network

High power / 48 dB amplifiers