Why Fronthaul Matters
A key foundation for Centralized and Cloud RAN
About the author

Dimitris Mavrakis

Area of expertise: Mobile broadband, LTE, Wi-Fi, small cells, SDN, network APIs, backhaul.

Dimitris Mavrakis is a Principal Analyst with Ovum. He is part of the Intelligent Networks team where he covers a range of topics including LTE, LTE-A, 5G, SDN, NFV, WiFi, IoT, network APIs and identifying how under-the-radar technologies may disrupt or improve the mobile value chain.

Dimitris is also actively involved in Ovum’s consulting business and has led several projects on behalf of Tier-1 operators and key vendors.

Dimitris has over 10 years experience in the telecommunications market. He has a strong background in mobile and fixed networks and an in-depth understanding of market dynamics in the telecoms business. In the past, Dimitris has worked as a project leader to perform network measurements and road tests. In his academic career, he has led a team of researchers to produce pioneering research and acclaimed publications.

Dimitris holds a PhD in Mobile Communications and an MSc in Satellite Communications from the University of Surrey.
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Executive summary

LTE networks are now starting to breathe new life into the business models of the operators, which are able to organically increase revenue while migrating many of their subscribers to smartphones and data packages. Ovum’s analysis illustrates healthy growth in operator financials in markets where LTE has been launched. On the other hand, initial LTE deployments have focused on rapidly deploying for coverage so that services may be offered to as many subscribers as possible.

LTE networks in advanced markets are now experiencing early signs of congestion, forcing operators to assess upgrade strategies, primarily driven by data access. Several technologies are available for this: macrocell densification, small cells, hetnets, and Centralized and Cloud RAN. Ovum’s research indicates that both small cells and Centralized/Cloud RAN rank the highest as upgrade strategies in advanced markets and are most likely to be used in the next two to three years for LTE and LTE-Advanced networks.

Ovum’s industry survey illustrates that there are challenges relating to the large-scale deployment of Centralized/Cloud RAN, mostly concerning practical issues such as power, placement, and backhaul/fronthaul. Despite these challenges, several operators in advanced markets (South Korea, Japan, and Western Europe) are already deploying small cells/small radio heads which may later evolve to Centralized/Cloud RAN networks that are tightly coordinated with the macro layer and even virtualized. These markets have dense fiber deployments that can easily be used for fronthaul, but several other markets (or areas in these regions) may not have the necessary optical deployments to support Centralized/Cloud RAN.

New fronthaul developments are facilitating the adoption of Centralized/Cloud RAN. In particular, developments in wireless delivery of CPRI are providing new types of deployments for local Centralized RAN, where a macro cellular site may become the aggregation point for several radio units deployed closer to the end user. Ovum expects that wireless fronthaul will play an important role in Centralized/Cloud RAN deployments, especially in markets where fiber is not widely available.

LTE market status

The telecoms market has become a hostile and increasingly competitive environment for all communication service providers (CSPs). Even Tier-1 CSPs that are now planning to evolve to a digital service provider are finding out that revenue growth is a considerable challenge, when competition for basic and advanced communication services within the existing value chain and new entrants – including Web giants – is heating up. LTE, LTE-Advanced, FTTx, and VDSL are providing some organic growth for the traditional access-based business models but CSPs need to plan ahead and implement new strategies to combat the threat of becoming simple dumb pipe providers.

At the same time, CSPs are experiencing healthy traffic growth in developed markets which are fueled by LTE and LTE-Advanced. This growth is expected to continue as subscribers migrate to higher-tier plans and smartphones with larger screens and overall data awareness increases. Several Tier-1 operators are now taking the next steps beyond LTE by aggregating carriers to offer higher download speeds. These carriers claim the availability of higher speeds are ensuring that the most valuable subscribers (enterprise and premium postpaid users) are subject to a very positive user experience, which in turn reduces churn and improves loyalty.

Some of these leading operators are also trialing new network architectures such as small cells, centralized RAN, or radio over fiber to better understand the deployment challenges and opportunities
and learn what is needed to evolve to the next step of mobile networks: densification, centralization, and virtualization. But before assessing these forward-looking topics, it is necessary to understand the current landscape of mobile network deployments and operator challenges.

Networks in highly developed markets
Mobile networks in Northern America, Western Europe, and Asia Pacific are starting to experience significant traffic uptake due to the availability of higher capacity in the Radio Access Network (RAN). This uptake does not necessarily translate to a challenge for telecom operators in these markets: Several Tier-1 operators are now experiencing a healthy data package uptake that provides new revenue injection in an otherwise declining average revenue per user (ARPU) environment. The competitive landscape of established incumbents has also shifted in some markets with the launch of LTE. For example, the former companies that are now EE in the UK were challengers rather market leaders. Through aggressive LTE investment and network deployment, EE is now considered a leader in the UK with LTE services and enjoying some of the highest ARPU levels in Western Europe.

In terms of subscribers, operators in developed markets will aggressively attempt to migrate their users to newer networks and smartphones to increase data revenues: Figure 1 illustrates Ovum’s subscriber forecasts with respect to the network generation they are connected to. The migration of a subscriber to 4G requires a smartphone – given that very few 4G feature-phones exist in the market today and device manufacturers are not planning to aggressively launch non-smartphones. Therefore, 4G smartphones are expected to create an increasing amount of traffic that will dwarf previous 3G-network usage. This is already a trend in very advanced markets; in some areas, LTE networks are experiencing congestion, forcing operators to deploy carrier aggregation to maintain the user experience at a high level.

This significant migration to data-heavy usage will require operators to continuously upgrade their networks to maintain a healthy subscriber base. CSP service revenues are expected to remain fixed throughout the period 2014–19 and so is capex, as discussed in the next section.

Definitions
In this white paper, Ovum refers to several network technologies that are either deployed today or will be in the near future. These technologies are defined as follows:

- **Small cells**: Low-powered radio access nodes that have automatic configuration, environment sensing, and provisioning capabilities.
- **Small radio heads**: Smaller remote radio heads (RRH) that typically include micro and pico RRH. These are deployed in the context of a C-RAN or Cloud RAN and are split from baseband processing.
- **Hetnets**: Cellular networks that include both macro and small cells, that are coordinated and represent a consistent network to end user devices.
- **Centralized RAN (C-RAN)**: A radio access network where baseband processing capabilities are centralized.

- **Local C-RAN**: Where baseband processing capabilities are centralized to a distributed location, usually a macro site that has fiber backhaul.

- **Cloud RAN**: Where baseband processing capabilities are centralized and virtualized.

- **Mobile Edge Computing (MEC)**: Where new processing capabilities are introduced in the base station for new applications, with a new split of functions and a new interface between the baseband unit (BBU) and the remote radio unit (RRU).

Figure 2 illustrates an example of network evolution from today’s network to Cloud RAN and MEC.

It should be noted that certain operators may choose to skip certain steps or even migrate to MEC directly. However, Ovum expects that the structural differences between today’s macrocells and Cloud RAN are significant and require evolutionary steps, particularly in practical issues, including backhaul.

**Structural evolution to 4.5G and 5G**

As initial LTE networks in advanced markets are beginning to face congestion, operators are planning the next steps towards 4.5G and 5G. Carrier aggregation (CA) is the first step towards more capacity, better cell edge performance, and a better user experience but is dependent on spectrum assets, and device and ecosystem support. Although infrastructure today may support LTE Category 9 speeds (aggregation of three carriers and speeds of up to 450Mbps), device support is very limited and depends on “hero” handsets: predominantly Apple’s iPhone and Samsung Galaxy S series.

Carrier aggregation is being perceived as the most marketable and direct element of LTE-Advanced since it is much easier to communicate higher speeds to end users. According to Ovum data, nearly a third of LTE operators globally are now investing in carrier aggregation and nearly all of them are expected to follow suit 1–2 years after their initial LTE deployment.

According to an industry survey Ovum launched during 2Q15, small cells is the most popular technique to enhance RAN deployments, with Centralized RAN and Cloud RAN being the second most popular choice (see Figure 3).

Ovum expects that there will be an increasing trend to integrate small cells into Centralized/Cloud RAN deployments in order to expand macro-based RAN improvements to the small cell layer. This could initially take the form of small radio units (i.e. microRRH/picoRRH) rather than integrated small cells, which will help expand LTE technologies such as eICIC, coordinated multipoint, and carrier aggregation. It could be said that the lack of correlation between the macro- and small-cell layers [and the inability to introduce the above advanced technologies in the small-cell layer] has been so far a barrier of entry for small cells in the mass market.
Although other LTE-Advanced options are not as marketable as carrier aggregation, they provide a glimpse into the future of networks but require a somewhat structural disruption of existing cellular topologies. Adding new spectrum to a mobile network can only provide short-term improvements, especially when users are equipped with high-end smartphones and subscribe to data packages of up to 10GB per month. In order to maintain a positive user experience for their subscribers, operators now have to plan their strategy for the future of network, which overlaps with the transition to 5G with its dense, distributed networks where the radio access is much closer to the end users and adapts to change.

**Centralized RAN**

Centralized RAN (C-RAN) refers to the aggregation of baseband unit resources to a more centralized location, either at a macro site (e.g. local C-RAN or C-RAN site) or at a data center (e.g. BBU hosteling), so that decisions can be made for a larger part of the network rather than for each base station separately. Figure 4 illustrates a brief overview of the C-RAN concept.

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**Figure 3:** In the next 2–3 years, how do you expect MNOs to maintain or enhance radio access networks?

![Figure 3](image-url)

*Note: n=89  
Source: Ovum C-RAN and fronthaul deployment survey, 2015*

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**Figure 4:** Legacy to Centralized RAN evolution

![Figure 4](image-url)

*Source: Ovum*
A legacy base station consists of baseband and radio units that are typically connected via fiber (CPRI). A C-RAN architecture consolidates baseband capabilities to a more centralized location (a local macro site for the example in Figure 4) while the CPRI link needs to become longer in terms of distance.

Apart from the added flexibility of centralizing processing and decisions, operators can reduce opex through lower real-estate requirements at the C-RAN cell site. Of course, there are practical challenges to deploying C-RAN: How to power them; how to calculate the ideal location of a C-RAN site; and, finally, connecting them to the baseband unit. In 95% of cases, this link consists of a standard called Common Public Radio Interface (CPRI) which has been adopted by all vendors. This link is also referred to as fronthaul and is discussed in later sections.

Cloud RAN
Following Centralized-RAN, the next step is to implement Cloud RAN. In a way, Cloud RAN is a more extreme implementation, where most of baseband processing is virtualized, and located in data centers that will – most likely – be distributed across an operator footprint rather than centralized as in IT deployments. Nevertheless, virtualizing and centralizing baseband processing for hundreds – or even thousands – of sites allows operators to adapt to changing user requirements and traffic patterns in a much more fluid way and deploy processing capabilities where they are necessary. This is contrary to common network dimensioning and design principles that depend on overprovisioning and traffic forecasts to plan ahead of traffic requirements.

Cloud RAN may impose heavier requirements on the network compared to Centralized RAN but the transition is easier if Centralized RAN has already been implemented. Most likely, the backhaul links to Centralized RAN aggregation points (as illustrated in Figure 4 above) will be >1Gbps to cater for multiple cell sites. Moreover, the fronthaul links will already be in place for C-RAN which may also be used for Cloud-RAN. The challenge will be to migrate existing cell sites (either C-RAN sites, small cells, or micro/macro sites) to Cloud RAN without network or service interruption and to a common management platform.

There are also two distinct steps for Cloud RAN: coordination and virtualization. In the first step, the radio access layer is coordinated in a consistent way to increase user experience and minimize the impact of traffic on the network. This does not necessarily require virtualization, which is the next and final step towards a fully virtualized Cloud RAN.

MEC as an alternative to Centralized RAN
Mobile Edge Computing (MEC) is an ETSI initiative, where processing and storage capabilities are placed at the base station in order to create new application and service opportunities. This new initiative is called “fog computing” where computing, storage, and network capabilities are deployed nearer to the end user.

MEC contrasts with the centralization principles discussed above for C-RAN and Cloud RAN. Nevertheless, MEC deployments may be built upon existing C-RAN or Cloud RAN infrastructure and take advantage of the backhaul/fronthaul links that have been converted from legacy to these new centralized architectures.

MEC is a long-term initiative and may be deployed during or after 5G if it gains support in the 5G standardization process. Although it is in contrast to existing centralization efforts, Ovum expects that MEC could follow after Cloud RAN is deployed in large scale in advanced markets. Some operators may also skip Cloud RAN and migrate from C-RAN to MEC directly, but MEC is also likely to require the structural enhancements that C-RAN and Cloud RAN will introduce into the mobile network.

The biggest challenge facing MEC in the current state of the market is its very high costs and questionable new service/revenue opportunities. Moreover, several operators are looking to invest in C-RAN and Cloud RAN in the near future, which may require significant investment to maintain a healthy network and traffic
growth. In a way, MEC is counter to the centralization principle of Centralized/Cloud RAN and Ovum expects it will only come into play when localized applications are perceived as revenue opportunities.

According to Ovum’s research and survey findings, Centralized and Cloud RAN will be critical for cellular networks in the next few years. The benefits of these two principles include:
• A cellular network may adapt better to changing traffic patterns and user requirements
• Coordination between macro and Centralized/Cloud RAN layer can introduce advanced techniques in both layers (e.g. carrier aggregation)
• Evolution to 5G architecture
• Software features and centralized control, leading to better management and configuration capabilities.

C-RAN deployment challenges
As Centralized RAN is the first step towards a Cloud RAN and new network architecture, it is prudent to assess the challenges required today. Ovum’s survey found that the biggest issues about hetnets and C-RAN deployments are arguably fronthaul and dark fiber requirement (see Figure 5).

The CPRI interface requires very high capacity and very low latency between baseband and radio units and in many cases can only be satisfied by dark fiber (see Table 1).

<table>
<thead>
<tr>
<th>LTE UE category</th>
<th>LTE rate</th>
<th>CPRI rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>75Mbps</td>
<td>1.2288Gbps</td>
</tr>
<tr>
<td>4</td>
<td>150Mbps</td>
<td>2.457Gbps</td>
</tr>
<tr>
<td>6</td>
<td>300Mbps</td>
<td>4.9152Gbps</td>
</tr>
<tr>
<td>11</td>
<td>600Mbps</td>
<td>9.83Gbps</td>
</tr>
</tbody>
</table>

Source: 3GPP

Even if an operator does not require hundreds of Mbps of LTE capacity to be carried in a fronthaul link (tens of Gbps are needed in a fronthaul link to carry multiple sectors), they are likely to deploy for the future rather than just one or two years ahead. Fronthaul – and the connections between baseband and radio units – are perceived as being of strategic importance and likely to be planned in detail.

Fronthaul developments
Our discussion has so far illustrated that fronthaul and CPRI are currently perceived as major challenges in the deployment of hetnets and C-RAN. According to Ovum’s survey, respondents expect that fronthaul will consist of a mix between fiber and wireless elements (see Figure 6).
Optical fronthaul

Early C-RAN deployments have been in regions with a very high penetration of fiber, most notably China, Japan, South Korea, and other Asian countries. Deployments are a mix of passive optical equipment (see Table 2).

Wireless fronthaul

Wireless fronthaul is also a recent development. It has been pioneered by backhaul vendors and a few specialists. CPRI is very demanding in terms of capacity requirements and thus is difficult to transfer over wireless links that are typically constrained in terms of spectrum (or distance if mm-wave is considered). Therefore there has been little activity in the wireless fronthaul area, but a few vendors are now proving that it is possible. Their technologies are proprietary but Ovum expects that they are enabled by CPRI optimization and spectral efficiency. As illustrated in Ovum’s survey and Figure 6, most operator respondents expect that fronthaul will be provisioned by a mix of fiber and wireless – where fiber cannot reach. Several regions (e.g. Southeast Asia, Africa, and even some European countries) will not have fiber

Although optical fronthaul is the standard for transporting CPRI, not all regions have dense fiber deployments that can enable Cloud RAN. Recent developments in wireless technologies are now making wireless CPRI transfer possible, thus providing the ability to deploy C-RAN sites to many more locations.

### Figure 6: What is the best way to deploy fronthaul for Cloud RAN?

![Figure 6: What is the best way to deploy fronthaul for Cloud RAN?](image)

- A mix between fiber fronthaul and wireless where suitable: 56%
- Deploy new fiber: 22%
- Fiber only where available; Cloud RAN sites limited by availability of fiber: 22%

Note: n=89
Source: Ovum C-RAN and fronthaul deployment survey, 2015

### Table 2: Optical fronthaul deployment examples

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<thead>
<tr>
<th>Technology description</th>
<th>Pros</th>
<th>Cons</th>
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</thead>
<tbody>
<tr>
<td>Dedicated fiber</td>
<td>Passive solution: CPRI signal is transported natively without encapsulation</td>
<td>No additional cost for transmission equipment; no need for power supply at radio site</td>
</tr>
<tr>
<td>Passive CWDM</td>
<td>Uses colored SFPs (tuned to specific wavelength frequencies) at BBU and RRH locations combined with CWDM filters that channelize the fiber</td>
<td>Uses no active components; well suited for outdoor deployment; does not introduce latency and provides a highly reliable low-cost solution for CPRI transport</td>
</tr>
<tr>
<td>Active WDM</td>
<td>Uses active OTN/WDM gear to transport CPRI encapsulated in OTN frames</td>
<td>Provides CPRI transport over a standardized format; offers a high degree of OAM capabilities</td>
</tr>
<tr>
<td>Passive optical networking (PON)</td>
<td>Passive solution to support CPRI front-haul transmission</td>
<td>PON is typically deployed in dense urban neighborhoods and by its nature has access to existing fiber in places where C-RAN is likely to be deployed.</td>
</tr>
</tbody>
</table>

Source: Ovum
deployments capable of supporting C-RAN and so Ovum expects that wireless fronthaul may be successful in these markets to start with.

Ovum also expects that fronthaul will largely be driven by fiber where available; in other urban areas, wireless fronthaul will be used to connect small radio heads (micro or pico radio units) that are satellite to existing macro cells and fiber backhaul. It will be these macro cells that are likely to become the initial aggregation point for baseband processing, before computational power moves further inside the core network.

**Ethernet fronthaul**

Ethernet fronthaul is the most recent development and takes advantage of Ethernet’s wide-scale deployment. Ethernet is widely deployed in backhaul, it is well-understood by operators, and it aims to support the low-latency fronthaul requirements of next-generation mobile networks. There are currently two flavors of Ethernet fronthaul:

- CPRI over Ethernet encapsulates existing fronthaul signals in Ethernet frames and uses the very same baseband/radio units with Ethernet equipment. It is an evolution / continuity of the current CPRI protocol.
- New baseband/radio unit interfaces that are transferred through Ethernet. This is currently being developed by a few vendors and startups but may require significant changes in existing networks to implement. This is a revolution / discontinuity with the current CPRI while MEC is based on this principle.

In either case, Ovum expects that Ethernet will, over time, be as popular in fronthaul as in the backhaul market, assuming that C-RAN deployments mature.

**Fronthaul forecasts**

Ovum has attempted to forecast the fronthaul market, using base data from its optical component forecast database. This database includes transponder shipments for optical components and segments CPRI which is used for optical fronthaul today. Ovum assumes that 2% of these links will be complemented by wireless fronthaul during 2015, which will increase to about 15% during 2019. Under these assumptions, fixed and wireless fronthaul link shipments are presented in the chart below.

![Figure 7: Global fiber and wireless fronthaul shipment forecasts, 2015–19](image)

Source: Ovum

Ovum assumes that wireless fronthaul will be used to complement fiber rather than replace it. Even though the percentages used for these forecasts are moderate, wireless fronthaul is still expected to make a significant impact, especially as networks prepare for 5G.
Conclusion and takeaways

Ovum’s research indicates that small cells/small radio heads and C-RAN/Cloud RAN will be key technologies to upgrade existing LTE networks in the next 2–3 years, but some challenges remain. Regarding fronthaul, Ovum expects wireless and Ethernet technologies to be part of large-scale deployments in the near future. In particular, wireless fronthaul may provide deployment opportunities in areas without fiber and operators that take advantage of this may be at a significant advantage compared with other operators that will not deploy where fiber is not available. Local C-RAN will be the first step for the architectural change to hetnets and Ovum expects wireless fronthaul to alleviate a major barrier for its deployment.
EBlink: Making wireless fronthaul a reality

The term ‘fronthaul’ is gaining industry recognition as the interface between the cellular base station’s processing elements (namely the baseband unit – BBU) and the attached radio units (RRU). EBl ink takes fronthaul to the next level by allowing the RRUs to be located practically anywhere, and linking them to the baseband processing via a wireless link. EBl ink is revolutionizing the mobile network market with a new industry standard: wireless fronthaul.

EBl ink’s patented technology eliminates the last few hundred meters of fiber that are so costly for mobile operators, and so long and difficult to deploy. Its wireless fronthaul solution FrontLink™ reflects the evolution towards increasingly centralized telecom architectures (C-RAN / V-RAN) and small cells, and gives carriers an immediate solution to the growing demands of mobile multimedia applications. It allows for faster and easier deployment of 3G and 4G mobile networks, and will be essential to future networks.

Cost-effective evolution towards Centralized RAN architecture
FrontLink™ makes it easier for mobile operators to meet network capacity and coverage needs, while providing a risk-free evolution toward denser cellular networks and C-RAN / V-RAN architecture. C-RAN / V-RAN architectures not only deliver better radio efficiency, but also generate substantial capex and opex savings for mobile operators. Leading mobile operators have been using distributed network architectures for several years already, installing remote radio heads connected by fiber to centralized data centers hosting baseband pooling.

Unfortunately, fiber rarely reaches every potential cellular site, preventing cost-effective implementation of C-RAN architecture. FrontLink™ addresses the last few hundred meters where fiber is not available, removing one of the key obstacles to C-RAN adoption in many markets.

Studies done by industry analysts, as well as by infrastructure vendors, show the TCO advantage of wireless fronthaul vs. fiber fronthaul for the “very last mile connection,” where fiber is often not available at a reasonable cost. Studies also show the TCO advantage of wireless fronthaul vs. wireless backhaul, thanks to the higher radio efficiency between the macro layer and the small-cell layer achieved with wireless fronthaul (savings of up to 40% in most scenarios).

Wireless fronthaul as a key enabler for network densification
One of the key benefits of the FrontLink™ solution is its suitability for both traditional macro network architecture (remote macro sector extension, small cells hooked to existing macro sites that act as a local C-RAN) and full-scale C-RAN/V-RAN architecture. EBl ink’s technology offers mobile operators a risk-free migration from today’s network topology to architectures of the future.

With the FrontLink™ solution, mobile operators can densify their network and add capacity in urban environments, protecting their investment in the existing macro network while at the same time preparing for migration towards C-RAN/V-RAN architecture.
Industry leading spectral efficiency

The FrontLink™ solution provides revolutionary spectral efficiency: up to 7.5Gbps CPRI on a wireless link in less than 70MHz bandwidth. With unequaled performance, the FrontLink™ solution offers new possibilities to mobile operators in their network deployment. It is capable of connecting, via a wireless link, up to three remote sectors (three RRUs).

The FrontLink™ solution is about 20 times more efficient than other wireless fronthaul products, in millimeter bands that typically are capable of carrying only 2.5Gbps CPRI on 500MHz bandwidth.

EBlink’s technology allows for the rapid development of wireless fronthaul solutions that can carry over 30Gbps of CPRI data.
ABOUT OVUM

Ovum is a leading global technology research and advisory firm. Through its 180 analysts worldwide it offers expert analysis and strategic insight across the IT, telecoms, and media industries. Founded in 1985, Ovum has one of the most experienced analyst teams in the industry and is a respected source of guidance for technology business leaders, CIOs, vendors, service providers, and regulators looking for comprehensive, accurate and insightful market data, research and consulting. With 23 offices across six continents, Ovum offers a truly global perspective on technology and media markets and provides thousands of clients with insight including workflow tools, forecasts, surveys, market assessments, technology audits and opinion. In 2012, Ovum was jointly named Global Analyst Firm of the Year by the IIAR.

For more details on Ovum and how we can help your company identify future trends and opportunities, please contact us at enquiries@ovum.com or visit www.ovum.com. To hear more from our analyst team join our Analyst Community group on LinkedIn www.ovum.com/linkedin and follow us on Twitter www.twitter.com/OvumTelecoms.

ABOUT THE SPONSOR – EBLINK

Founded in 2005, EBlink is revolutionizing the mobile network market with a new industry standard: wireless fronthaul. Based on the founders’ vision of the evolution of mobile telecoms networks, EBlink’s technology provides operators with an immediate solution to the growing demand for mobile multimedia applications.

EBlink is headquartered just outside Paris, France. In 2013, a subsidiary was created in California’s Silicon Valley. EBlink’s leaders have 20 years of experience in the deployment, operation, and optimization of mobile networks.

A rising start-up in the mobile telecoms industry, EBlink continues to build partnerships with leading industrials in order to foster technological synergies and accelerate the distribution of its solutions worldwide.