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# Reliable Internet Connectivity for Relay of Live Broadcasts to Satellite from Remote Tropical Areas: Lessons from a GSM Link Aggregation Solution

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**Abstract:** ***Internet service provision is a business that continues to grow owing to the ever- increasing demand of Internet users on reliable Internet in both private and corporate spheres. Currently, many businesses are wholly dependent on the Internet for conducting their businesses. However, high bandwidth Internet service providers are common seen in the urban areas and cities where it is believed the majority of their clients are located. This trend has left many prospective businesses and activities in the remote areas that require high Internet connections without any reliable Internet facility to drive their operations. This paper is the result of a technical brainstorming that culminated to realizing a high Internet bandwidth and reliable connectivity that met and drove the live transmission of religious broadcasts to the Satellite port (for onward relay to global satellite subscribers) from remote tropical areas using mobile gsm link aggregation strategy as against the conventional VSAT connectivity. This paper features a cost-effective solution using an aggregator circuit and pooled mobile data connections: MTN, GLO, AIRTEL, and ETISALAT which were the common cellular services that are readily available in the locations in question. This arrangement was tested using an 8-hour high definition video broadcast of a live religious outreach to a geostationary Satellite port for global view.***

**Keywords:** Connectivity, Internet, Remote areas, Aggregation

## 1. Introduction

Advancement in Technology has revolutionized several processes and procedures that were known to work better in crude or rather manual and semiautomatic ways. Suffice it to say that no organization whether secular or religious would downplay the role of Technology in complementing to a large extent, the human participation and abilities when carrying out noble functions geared towards communication activities in general and communication service reliability in particular. This paper is the result of a challenge encountered during evangelistic outreaches in remote tropical areas where such activities were intended to be relayed to the Satellite for onward broadcast to viewers located throughout the globe. Our main problem stemmed from the fact that we could not relay any signals owing to the lack of a reliable Internet bandwidth for broadcasting. A mobile VSAT was not even an option as the budget for such could not be borne by the authorities. Considering the mobile broadband provided by major GSM providers, no individual connection was suitable for our project. The challenge was that we need a reliable connectivity that can drive any Internet requirements in those remote tropical areas the evangelistic mission would be conducted and the only cost-effective option was the mobile gsm. We considered pooling every available mobile broadband available in each area together. The link aggregation strategy was finally agreed upon against the conventional VSAT connectivity which grossly malfunctions on changing weather conditions and which could not be decommissioned and recommissioned easily as the programme moved from one location to another. This paper features a cost-effective solution using an aggregator circuit and pooled mobile data connections: MTN, GLO, AIRTEL, and ETISALAT, which were the commonest mobile services that were readily available in remote areas.

## 2. Link Aggregation Concepts

Link aggregation simply means the bundling or combining of multiple network connections to produce a single reliable connection with high throughput and reliability than any of the single connections used independently. Thus, link aggregation whether or not mobile is a promising option where reliability and throughput are in question. Link aggregation is expressed using such terms as: network bonding [1], link teaming, link bundling [2], etc. though may use different technologies in achieving the result. According to [2], "The IEEE 802.1AX-2008 Link Bundling provides a technique for aggregating multiple Ethernet links into a single logical channel that helps improve cost effectiveness a device by increasing cumulative bandwidth without requiring hardware upgrades". The IEEE 802.1AX-2008 Link Bundling capability includes dynamic provisioning, management, and monitoring of various aggregated links. Majority of works done under link aggregation had been in the domain of Ethernet bonding. Meethal & Joytish [3] had described a low cost connectivity solution for rural Telemedicine in India based on low speed communications links. In that implementation, various low speed connections including dial-up links, CDMA connections, etc. were aggregated to provide a relatively stable connection for rural telemedicine operations. However, it is important to note that telemedicine solutions may not require high bandwidth as the broadcasting of a live event in high definition video stream from remote tropical areas where the only mode of connectivity is the cellular/mobile gsm communication links. The apparatus described in [3] is similar to that discussed by [4] in which case aggregated links were used to drive mobile Telemedicine centres.

**The Link aggregator**

The link aggregator is a compact integrated system that comes in different forms and implementations but whose function is to provide the user with a high speed and low-cost internet link ideal for internet-intensive applications regardless of the location provided cellular networks exist in the area in question. In addition to drastically reducing broadband internet charges, it also solves the problem posed by absence of or poor broadband internet in places where such may be needed for broadcasting real-time events such as evangelical field outreaches and crusades. In this regard the link aggregator is useful for pooling all available mobile or cellular internet connections into a high speed tunnel that is sufficient to carry any multimedia (video and audio) transmission. For instance there are at least five cellular networks (***MTN, GLO, AIRTEL, ETISALA, VISAFONE***) amidst the other conventional broadband providers in Nigeria presently and each of these networks offers mobile internet (ranging from 2G to 4G) at a relatively affordable cost to end users often in form of dongles/finger-shaped universal synchronous bus modems (USB MODEM), data cards and some other compact platforms. With a link aggregator all the available networks (in any area where the church intends to broadcast its live events) could be exploited and fused to a more efficient single data stream to provide a high speed internet that is often more effective than the conventional broadband internet subscriptions used in corporate offices. The advantages of this technology include but not limited to high throughput and low latency as the failure of one of the component link(modem or DSL connection) does not affect the others neither does it affect that data that is already in transit through the tunnel.

## 2.1 Topologies

During the brainstorming process, we considered the following topologies:

**Teleporting option**

In this option we would have a compact model that enables would enable live video transmission over aggregated cellular data cards/modems and wifi. The apparatus features an integrated Video Optimization Module and adaptive video encoder algorithms that optimize the aggregated Internet protocol (IP) transport for live video relay in real time and avoids any need for a satellite or microwave link. The system that would be implemented would come as a composite system comprising one field unit and one receiver unit. The receiver unit is to be placed at a central location in Ijeshatedo in Lagos to receive live multimedia broadcast from remote locations across Nigeria. The received live broadcast can be recorded, viewed or encoded and re-broadcasted immediately to the web or Satellite video Server. One good advantage of this arangement is that it dynamically adapts to the available bandwidth in real-time seamlessly and provides the best possible video feed at any given time.

**Single compact live video broadcaster system**

This arrangement would be more compact and portable tthan the teleporting option and would enable live video transmission over aggregated 3G/4G wireless cellular cards as well as DSL, cable and T1 internet lines. The video camera system can be directly connected to this device to relay live multimedia from any location to a video server, website or CDN over the internet. This system can support up to eight 3G/4G data network cards to increase the available bandwidth for providing reliable high definition (HD) quality multimedia transmission. The device would have standard s-video, composite, SD-SDI, HD-SDI connectors and can accept an encoded video feed from an encoder through an Ethernet cable or WiFi. The video can also be relayed from a remote location to another location (central location at Ijesha Lagos) using a compatible Relay hardware in the target destination.

**Non-localized or Pressure-resistant compact system**

This variant is considered for „on the go" telecast such as multimedia broadcast of outdoor events that are not localized such as broadcasting live events that are dynamic (those that occur while moving from place to place during evangelistic outreaches). It would be ideal for broadcast of place to place evangelism (road walk/match), etc. This system can aggregate and intelligently orchestrate up to seven embedded 3G/4G cellular modems from different carriers (network providers) to provide increased bandwidth and thus increase performance and boost up-time of applications and services that run over the Internet.

**Link aggregator with an integrated video camera**

Another variant of the link aggregator is that which has a sophisticated video camera integrated within it. The essence of this integration is to enable the broadcasting of live events directly over the internet to a website or a satellite server/port (where satellite transmission is involved) under challenging environments. Thus the aggregator provides a good network tunnel and the requisite speed for conveying the multimedia during the live recording of the event in question by offering ports for aggregating up to six(6) 3G/4G/LTE(dongles). The system incorporates a built-in encoder, Ethernet, HD-SDI, HDMI input, and sophisticated software that would recombine the various data streams from the aggregated dongles.

## 2.2 Video Camera Selection

Video cameras are very important in capturing live video events hence appropriate cameras must be selected to suit the kind of video needed for broadcasts. For instance, where HD video broadcast is needed then the video camera selected must be one that support high definition imaging, whereas there wouldn't be need to incur high costs in procuring HD cameras when a standard definition(SD) video is all that is needed. We have considered two specifications of camera systems that would serve the video capturing function.

**Compact integrated camera system**

A suitable compact integrated pan-tilt remote camera system can output 4K(4 x 1080p) video via HDMI, USB and IP transmission. It should be suitable for movie production and TV station use. In selecting a product, consideration must be given to their usability in a variety of environments as well as the possible resolution they can offer under worst environment conditions as well as in situations where higher image quality is necessary, such as lecture recordings and

conferences, meetings, wedding and funeral hall content production. Other considerations are:

- Number of lens system: at least a four-drive lens system; three zoom lenses and one focus lens that are driven independently and simultaneously.
- Zoom level: 20x is excellent
- Frequency: 59.9hz or above
- Frame rate which must be up to 60fps
- Bit rate: must be up to 50mbps
- Audio quality of about 48 kHz (AAC)
- Power over Ethernet plus(POE+) support.

**HD Integrated video camera system**

The ideal device under this arrangement would offer a full high definition with integrated Pan-Tilt-Zoom (PTZ) and would provide a production quality video output through 3G-SDI, HDMI or IP Transmission. An example is the Panasonic‟s AW-HE130series compact cameras equipped with three 1/2.86 MOS sensors for high sensitivity, a superior signal to noise ratio and high resolution. The AW-HE130 series supports PoE+(advanced power over Ethernet), so the camera only needs one LAN cable for its power supply, control and video output.

## 3. Implementation

In this paper, we have excluded the intricacies of procurement since every piece of infrastructure included here can be ordered from the respective vendors perhaps by a procurement team once the bill of quantities is approved for procurement. The implementation process starts with the site preparation. The site in question in this document is not restricted to any given location as the project is a mobile one hence could be deployed in any tropical location. The only exception is the central location at Ijeshatedo in Lagos which is a permanent site that may also receive live multimedia broadcasts from remote areas anywhere across Nigeria provided such area has mobile network presence of at least 3 of the GSM networks. The site preparation at the central location involves a large auditorium with a capacity of 6000 viewers, in which case a wiring/cabling plan as well as the precise locations for the various devices(fixed video cameras, controllers/mixers/switchers, mobile large screen display, etc) must be clearly defined. We shall use diagrams to represent the schematic implementation of each of the system discussed beginning with the link aggregators.

### 3.1 Materials

Below is a summary list of hardware included in this project:

1) Compact link aggregator
2) Teleporters(receivers and field units)
3) Special-purpose/non-localized link aggregator system
4) HD Integrated remote-controlled video cameras including live switchers/mixers and controllers
5) Large screen LED unit
6) Cabling and connectors

### 3.2 The Link aggregator circuitry

The link aggregator does not require a complex circuitry since it is intended to support mobility to the fullest. The implication of this is that it does not disturb the existing workflow system of broadcasting as it can just be plugged in to serve as the internet source for broadcasting multimedia over the internet whether live or recorded(on demand). The implementation diagram for the compact device employing the link aggregator is shown in Figure 1.


**Figure 1:** Block diagram of a link aggregator

Figure 2 shows the block implementation of a teleporting system. Note that teleporting is ideal for situations where remote broadcasts may be sent to a central location for recording only, synchronous live re-broadcasting or delayed re-broadcasting. For instance, the church‟s evangelical activities from any part of the world can be teleported to the location at Ijeshatedo Lagos for recording, live re-broadcasting, etc.

### 3.3 Integrated remote-controlled camera network

The remote-controlled camera system can be implemented in several forms. The compact fixed IP cameras may be used alone or in combination with studio cameras and mounted variants all linked to a remote controller and a compact all-in one mixer(with integrated live video switcher). In each case, the system is effective in recording live events at very high resolution in conferences and church services. Some remote controllers like the Panasonic AW-RP120G was found to handle reliably 100 remote video cameras connected through a switching hub. The diagram in Figure 4 shows this concept using a schematic diagram.

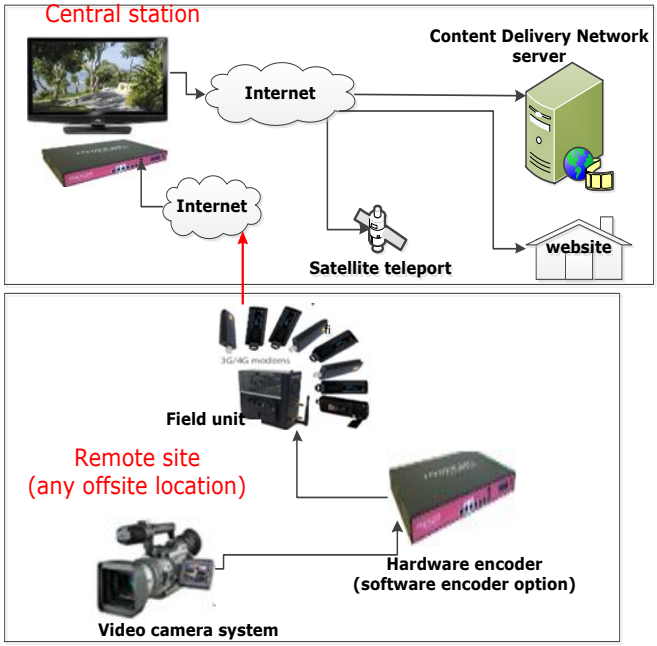


**Figure 2:** Implementation of the Teleporting system

Figure 3 shows how the link aggregator could be used for broadcasting non-localized events such as that those occur on the move.


**Figure 3:** Block diagram of an „on the go" implementation of a non-localized event

## 4. Conclusion

Transmission of live multimedia from events spanning long hours from rural tropical areas could be tasking and very costly especially where such areas are not covered by high bandwidth broadband Internet service providers. The VSAT option whether KU or C-band has long become old-fashioned in many applications as they are affected by climatic conditions. Moreover, a VSAT option is costly and stationary in most implementations. A mobile VSAT option is beyond the reach of many not-for-a-profit institutions such as religious institutions. This paper is a demonstration of a successful project undertaken to solve the problem of land-to-Satellite and land to land live broadcasts from remote tropical areas in Nigeria. The link bonding of 3 GSM mobile broadband Internet links was tested and deployed successfully for the transmission of live events over long hours without a link failure. With this result, we conclude that the barrier posed by costly internet in rural tropical areas could be eliminated when planning a deployment of an internet solution that is aimed to drive any meaningful business or non-business activities.

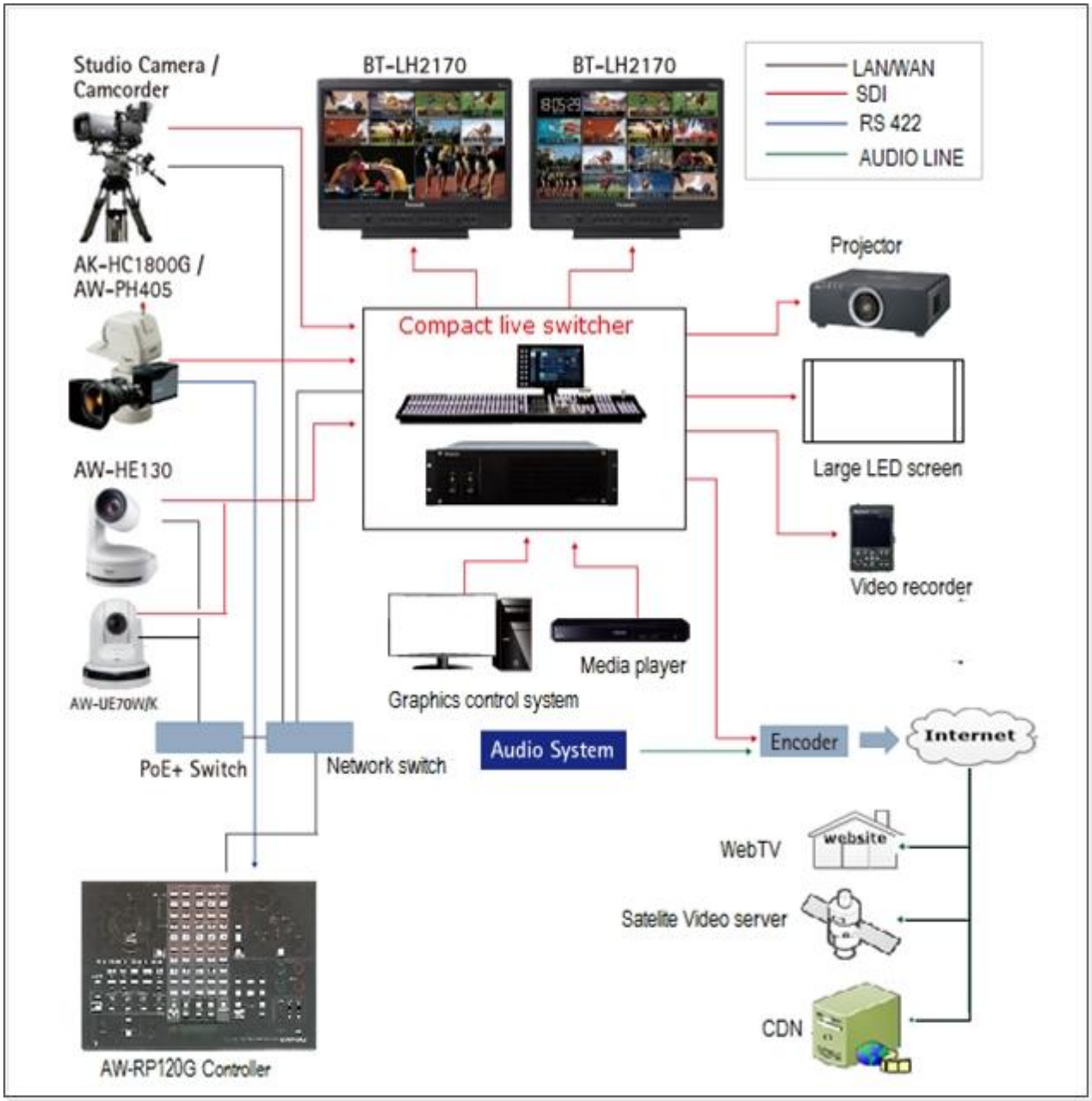


**Figure 4:** Schematic of an Integrated Remote-controlled HD camera system in operation at the central location

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## Author Profile

**Wilson Nwankwo** received his PhD in Information Technology (with specialization on Informatics and Intelligent software systems) in 2015 from the Federal University of Technology Owerri Nigeria, He received a MSc in Computer Science and B.Sc. in Business computing. His other qualifications are: MBA in Information Technology, and LLB degree in Law which he concluded recently. Dr. Nwankwo is a seasoned Project and Risk manager, a certified Quality auditor, Chartered Information Engineer. He also holds other professional certifications spanning across different disciplines. He has over 12 year‟s industrial experience in Information and Communications Technology. He currently serves as a Consultant and Senior Lecturer. His main research interest is in the convergence of Healthcare, Information Technology and Law.