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Business Model for On-Demand Real-Time Video Surveillance Security System

[1]Nwokolo C.P., [2]Prof. Inyiama H.C.
[1]*Department of Computer Engineering, Federal Polytechnic, Oko Anambra State, Nigeria*
[2]*Department of Computer Engineering, Nnamdi Azikiwe University, Awka, Anambra State, Nigeria*

----------ABSTRACT----------

Continued increase in crime rate over the years has aroused growing concern for security of life, property and infrastructure all over the world. This paper presents a method of identifying clients that request for real-time surveillance security service activated by Short Message Service (SMS) or phone call in event of invasion or suspected robbery attack. The business model for on-demand Real-time Security System discussed in this paper is activated by Global System for Mobile communications (GSM) interfaced with a microcontroller to automatically resume video recording using video surveillance cameras, and instantly transmit the data wirelessly to a remote location for storage via Internet Protocol (IP) technology. A surveillance control station has been designed to receive SMS or phone call from a subscriber and utilize location data stored in the database to trigger relevant components for surveillance action over the area. The paper also discusses use of servo motor to rotate surveillance cameras such that a camera could serve more than one subscriber to minimize equipment procurement costs.

Keywords: surveillance video, security, GSM, client subscription, microcontroller

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I. Introduction

Criminal activities have tremendously increased especially at places of high national interest all over the world. There is also increased threat from armed robbers and hoodlums who invade locations of both public and private interest even in broad daylight and at night. Security consciousness has consequently risen among all the nations especially since after the tragic incidence of September 11, 2001 attacks on the world trade centre in the New York City during which 2996 deaths were recorded, with about 6000 injured. In such places as Nigeria, Boko haram terrorism and kidnapping have been the talk of the decade. These incidents of crime often occur without anybody being able to trace who did it and how. This state of insecurity has led to individuals and corporate bodies apportioning huge sums of money in procurement of security apparatus. Consequently, there arose the need to identify who demands security service at any point in time for instant surveillance action.

1.1 Significance of the model

Emergency phone lines are often publicly displayed so that security agencies could be contacted and summoned to crime scenes in case of criminal occurrences. Many a time, it is not often easy for such agencies to arrive at the crime scenes in due time because of delays due to road traffic or similar reasons. The automated video surveillance system discussed in this paper serves as instant eye- on- the -scene for the security agencies by automatically taking secure video capture of the crime scene and instantly transmitting it to a remote location as it is being recorded so that they could be retrieved and used for forensic investigations. Video evidence of criminals caught in the act is often a quicker means of catching the suspects rather than gathering biometric data of suspects who might not actually be the suspects.

II. Surveillance Service Technique

Request for service are sent by clients to the control station either by phone call or by SMS. Client's database is stored in the storage memory of the microcontroller, typically the EEPROM (Electrically Erasable Programmable Read Only Memory).. However, due to limited on-chip memory space, client's subscription updates are done in the computer interfaced to the control system such that the database in the microcontroller is updated from the PC through a USB (Universal Serial Bus) application . This application is utilized in validating command to clients. The details of the techniques of handling client's request can be found in the publication on Client Identification Model for GPS-based On-demand Real-Time Video Surveillance Security System

(Nwokolo et al, 2015). The Application typically done using Visual Basic is used to link up the client subscription database (table1) with the client service charge (table 2) to determine the mode of the surveillance service to render.

Table 1: Client Subscription Database

Client_Name	Phone_No	Subscrptn _No	Geog_Zone	Area_ Code	Lat.	Long.	Cam_ No
Madona_Hospitl	07056419866	00001	AFR_NG_EN_CS1	001	6273112	7316695	DVR1_CAM1
Nwokolo_Brt	08033562355	00002	AFR_NG_EN_CS1	001	6291963	7310030	DVR1_CAM2
Shoprite_Enugu	08145667191	00003	AFR_NG_EN_CS1	001	6275486	7297492	DVR1_CAM3
Army_Bar82Div	08023421780	00004	AFR_NG_EN_CS1	001	6276981	7306470	DVR1_CAM4

2.1 Clients Location Data (or Client's Global Address)

Every location on earth has a global address which are represented as numbers. This makes it easy to communicate about location irrespective of language. A client's global address corresponds to two numbers called coordinates. The first number is the latitude while the second number refers to the latitude which altogether qualify the location of the client. Using coordinates is different from using a street address. Instead of having a specific street address, latitude and longitude works with a numbered grid system, like what one sees when one looks at graph paper. It has horizontal lines and vertical lines that intersect. A location can be mapped or found on a grid system simply by giving two numbers which are the location's horizontal and vertical coordinates. By this, every client location data is known and recorded in the database and reference is made to it whenever there is valid request for service.

III. Surveillance System Control flowchart

A software control flowchart for the on-demand video surveillance service delivery is shown in fig. 1.0

From the flowchart in fig.1.0, the microcontroller checks for incoming **SMS** or **Call** from any client. In event of call or SMS via the SIMM module at the control station, the system checks for client's validity. If call or SMS is from valid client, the client location to be monitored is automatically detected from the location data already stored in the database. This is automatically followed by video recording of the client location with instant remote storage.

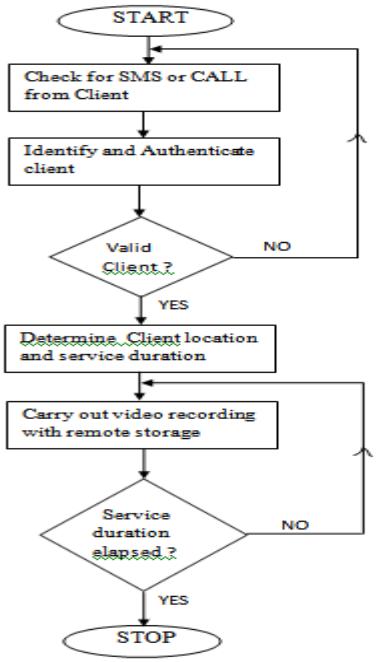

Fig. 1.0 Flowchart of control software for on-demand video surveillance service delivery system.

IV. Resource Sharing using Servomotor

A motor is basically a machine that converts electrical energy into mechanical energy. Servomotors are one of the most useful devices in any control and automation project. Unlike mere DC motors they do not simply go round and round at a specified speed but simply go "where they are told" by giving room for one to specify what angle the rotor should go to with respect to the stator. *It will go there at maximum speed and it's full torque and stay there when it gets there*. This makes servos very useful for position oriented control systems. This particular feature was utilized and matched with the client location data all stored in the database to initiate surveillance action over the desired area. A servo motor essentially consists of a motor coupled to a sensor for position feedback. It is a rotary actuator that allows for precise control of angular position, velocity and acceleration. By closed loop servomechanism, servomotors automatically use error-sensing negative feedback or error-correction signals to control mechanical position, speed, or other parameters. A car's cruise control for example uses closed loop feedback which classifies it as servomechanism.

4.1 Position Control

A common type of servo such as was used in this work serves for position control, using an electric motor as the primary means of creating mechanical force. Other types of servos use hydraulics, pneumatics, or magnetic principles. Servos operate on the principle of negative feedback, where the control input is compared to the actual position of the mechanical system as measured by a sort of transducer at the output. Any difference between the actual value and the expected value which is the error signal (actual value – expected value = error signal) is amplified and used to drive the system in the direction necessary to minimize or eliminate the error (fig.2.0).

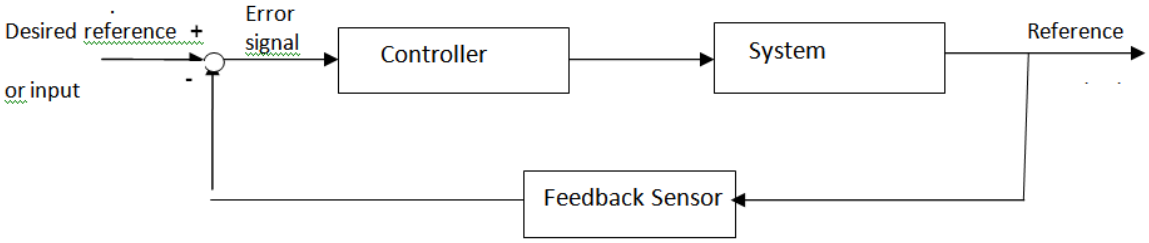

Fig. 2.0 Feedback Loop illustration

This procedure is a widely used application of ***control theory*** which is an interdisciplinary branch of engineering and mathematics that deals with the behavior of dynamic systems with inputs. The external input to a system is called the reference. The usual objective of a control theory is to calculate solutions for the proper corrective action from the controller that results in system stability. The inputs and outputs of a continuous control system are generally related by differential equations. If the equations are linear with constant coefficients, a transfer function relating the input and output can be obtained by taking their Laplace transform. The transfer function is also known as the system function or network function.

Control systems may be thought of as having four functions; Measure, Compare, Compute and Correct which are carried out by the elements; Detector, Transducer, Transmitter, Controller, and final Control Element. A car's cruise control for example , is designed to maintain vehicle speed at a constant desired or reference speed provided by the driver. The controller is the cruise control, the plant is the car, while the system is the car and the cruise control. The system output is the car's speed, and the control itself is the engine throttle position which determines how much power the engine generates. This motor control mechanism is mapped to the GPS location data stored in the database in order to pinpoint a particular client's location.

4.2 Servo Motors

The first servomotors were developed with synchros as their encoders. Much work was done with these systems in the development of radar and anti-aircraft artillery during World War II.

Servo motors (fig.3.0) are generally an assembly of four things: a DC motor, a gearing set, a control circuit and a position-sensor (usually a potentiometer). The position of servo motors can be controlled more precisely than those of standard DC motors, and they usually have three wires (power, ground & control). Power to servo motors is constantly applied, with the servo control circuit regulating the draw to drive the motor. Servo motors are designed for more specific tasks where position needs to be defined accurately such as controlling the rudder on a boat or moving a robotic arm or robot leg within a certain range. Servo motors do not rotate freely like a standard DC motor. Instead the angle of rotation is limited to 180 Degrees (or so) back and forth. PWM is used

for the control signal of servo motors. However, unlike DC motors it's the duration of the positive pulse that determines the position, rather than speed, of the servo shaft. A neutral pulse value dependant on the servo (usually around 1.5ms) keeps the servo shaft in the centre position. Increasing that pulse value will make the servo turn clockwise, and a shorter pulse will turn the shaft anticlockwise. The servo control pulse is usually repeated every 20 milliseconds, essentially telling the servo where to go, even if that means remaining in the same position. This makes it suitable for position precision in this location based project.

Fig. 3.0 Servo Motor

The function of the servo is to receive a control signal that represents a desired output position of the servo shaft, and apply power to its DC motor until its shaft turns to that position. It uses the position-sensing device to determine the rotational position of the shaft, so it knows which way the motor must turn to move the shaft to the commanded position. The power source must be constantly applied; the servo has its own drive electronics that draw current from the power lead to drive the motor. The control signal is pulse width modulated (PWM), but here the **duration** of the positive-going pulse determines the **position** of the servo shaft.

4.3 CAMERA ROTATION/POSITION CONTROL USING SERVO MOTOR

The angular position of a body about an axis could be defined as an angle $\theta(t)$. We can then calculate the angular displacement θ, the angular velocity $\boldsymbol{\omega}$, and the angular acceleration $\boldsymbol{\alpha}$ to consider when evaluating the rotational kinematics of a problem. The common assumption which applies to problems involving rotation about a fixed axis is that angular acceleration is constant, from which we could derive equations for angular position, displacement and velocity of a rigid body experiencing a rotation about a fixed axis using calculus.

The angular acceleration $\alpha = d^2\theta/dt^2$ . . . . 1.

The integral of α with respect to time gives the angular velocity $\boldsymbol{\omega}$.
i.e.

$(t) = \int \alpha dt = C1 + \alpha t$ . . . . 2.

Where $\boldsymbol{\omega}1$ = angular velocity, and C1 = constant.

The integral of angular velocity as shown in equation (2) with respect to time gives the angular velocity of the camera as follows;

$\theta t = \int \boldsymbol{\omega}(t)dt = C2 + C1t + \frac{1}{2}\alpha t^2$ . . . . 3.

Where C2 is the constant of integration.

This motor control mechanism is mapped to the GPS location data stored in the database in order to pinpoint a particular client's location. Servo motor is preferred in this work because other motors such as ordinary dc motors and steppers for example operate without in-built feedback control mechanism. Stepper motors however can operate in closed loop configuration but results in a costly system design. The servo motor used in this system for camera resource sharing is fixed to the camera mounted at the client station as shown in fig.4.0.

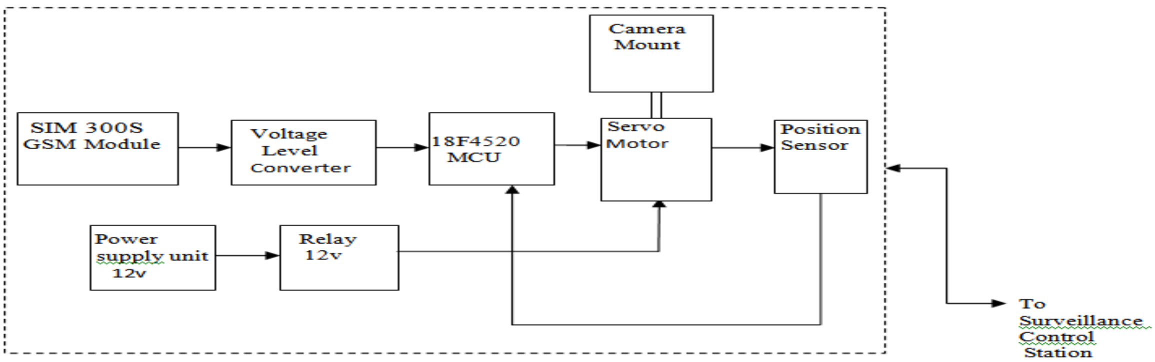

Fig.4.0 Client Station Block Diagram

Table 2: Client Service Charge

	TIME			AMOUNT	
REQUEST_CLASS	**HOURS**	**MINUTES**	**SECONDS**	**US_D ($)**	**NAIRA (₦)**
101A	0.25	15	900	30	9000
201B	0.50	30	1800	50	15000
301C	1.00	60	3600	70	21000
401D	2.00	120	7200	90	27000
501E	6.00	360	21600	110	33000
601F	12.00	720	43200	130	39000

5 Components of the surveillance service Tariff

- **Standing charges**: these are fixed charges that are used to pay for the cost of the connection to the server and the equipment to monitor that customer's or service connection. They are usually charged on a monthly basis.
- **Surveillance charges**: these charges are variable according to request for service duration and are used to pay for the upkeep of the equipment deployed to render video capture and route the data instantly to a secure remote storage location. However, the charges are per camera.
- **Storage costs**: client's video feeds are stored for a default minimum duration of four (4) days, after which the client either moves the video footage to his own server or request for extended storage duration at a fee.

The above component charges put together, gives the total surveillance charge. These are however, subject to amendment at any time with proper notification to subscribers..

5.1 BANDWIDTH CONSIDERATIONS

In computer networks, bandwidth is used as a synonym for data transfer rate, the amount of data that can be carried from one point to another in a given time period (usually a second). Network bandwidth is usually expressed in bits per second (bps), megabits per second (Mbps), or billions of bits per second (gigabits per second, or Gbps). It must however always be noted that bandwidth is not the only factor that affects network performance: There is also packet loss, latency and jitter, all of which degrade network throughput and make a link perform like one with lower bandwidth. A network path usually consists of a succession of links, each with its own bandwidth, so the end-to-end bandwidth is limited to the bandwidth of the lowest speed link (the bottleneck).

Different applications require different bandwidths. An instant messaging conversation might take less than 1,000 bits per second (bps); a voice over IP (VoIP) conversation requires 56 kilobits per second (Kbps) to sound smooth and clear. Standard definition video (480p) works at 1 megabit per second (Mbps), but HD video (720p) wants around 4 Mbps, and HDX (1080p), more than 7 Mbps. Effective bandwidth which refers to the highest reliable transmission rate a path can provide. This rate can be determined by repeatedly measuring the time required for a specific file to leave its point of origin and successfully download at its destination. The average frame rate used for surveillance recording is 6 - 10 fps (frames per second) . It makes a lot of sense because it provides a fairly smooth playback while minimizing storage costs.

VI. DVR IP Address Setup

The IP address setup of the DVR involves opening up in the router, a port to be used by the DVR. The process referred to as port forwarding makes it possible for remote computers to connect to a specific computer or service on a private network. This allows one to run a web server, game server or a service of one's choice from behind a router. In a typical network the router has the public IP address and computers/servers obtain a private IP address from the router that is not addressable from outside the network. The router bears both the public IP address which is the IP of the default gateway and a private IP which extends to other devices in the Local Area Network (LAN). For example, if the router private IP is 192.168.0.1, then the private IP of other devices connected in the LAN could be anything stepping from after the value of the last digit to the number 255. This means that the private IP of the computer and other devices in the LAN could take 192.168.0.101, 192.168.0.102, 192.168.0.103, …….192.168.0.255.

Typically used for the research work is a UK Link 4-Channel DVR with H.264 video compression technology and in-built free DDNS server, which makes for easy setup.

6.1 Surveillance Video Storage

DVRs are an extremely popular way to store surveillance video. They have the capacity to store hours of footage and the ability to use motion detection to trigger recording. Not only will one have space for much more footage, one's footage will also be more meaningful since one can set up the DVR not to activate recording until motion occurs in front of one's camera. The DVR system discussed in this paper is configured to record only on demand and utilizes its cloud feature to store in a remote location. The surveillance cameras used in this system were connected to a DVR port forwarded via router connected to a computer network and properly configured for remote storage and viewing.

Whether video streaming in any surveillance system is performed on 24x7 basis or on-demand, the system must have sufficient capacity to address three fundamental video parameters:

Quantity—the number and time duration of the video streams
Quality - the image quality of the video streams, expressed in terms of frame resolution (for example, 1280×1024 pixels) and frames per second (fps)
Archiving—the length of time the video streams will be stored

Once the specific balance of video data quantity, quality and archiving required for a given security application is determined, its easy to estimate the amount of storage capacity an SDVR system must include [11]. Table 3 is an extract from surveillance video storage matrix on a 24x7 basis prepared by Seagate company.

Table 3: Video Surveillance storage Matrix (assumes H.264 encoding)

NTSC: Recording Variable: 10fps			Surveillance Hard Drive Capacity					
			1TB	2TB	3TB	4TB	5TB	6TB
176 x 120	Low Quality	# Days	1080	2160	3240	4320	5400	6480
352 x 240		# Days	414	828	1242	1656	2070	2484
704 x 480		# Days	134	268	402	536	670	804
1280 x 1024	High Quality	# Days	40	80	120	160	200	240

NTSC: Recording Variable: 20fps			Surveillance Hard Drive Capacity					
			1TB	2TB	3TB	4TB	5TB	6TB
176 x 120	Low Quality	# Days	540	1080	1620	2160	2700	3240
352 x 240		# Days	206	412	618	824	1030	1236
704 x 480		# Days	66	132	198	264	330	396
1280 x 1024	High Quality	# Days	20	40	60	80	100	120

NTSC: Recording Variable: 30fps			Surveillance Hard Drive Capacity					
			1TB	2TB	3TB	4TB	5TB	6TB
176 x 120	Low Quality	# Days	360	720	1080	1440	1800	2160
352 x 240		# Days	138	276	414	552	690	828
704 x 480		# Days	44	88	132	176	220	264
1280 x 1024	High Quality	# Days	14	28	42	56	70	84

6.2 Port Forwarding on client stations

Port forwarding is a function of network routers that allows a user to configure specific communication ports to be routed to devices on an IP (Internet Protocol) network, such as a computer, DVR, or IP camera [7]. To carry out port forwarding for a surveillance DVR, the router is configured to forward incoming Internet Requests on the port that the DVR uses to be routed / forwarded to the DVR. This enables one to access the DVR remotely over the Internet. The network diagram (fig.5) illustrates a typical home or business network setup that includes a surveillance DVR. If it is for IP camera, the DVR in the diagram is simply replaced with an IP camera and all of the concepts are exactly the same.

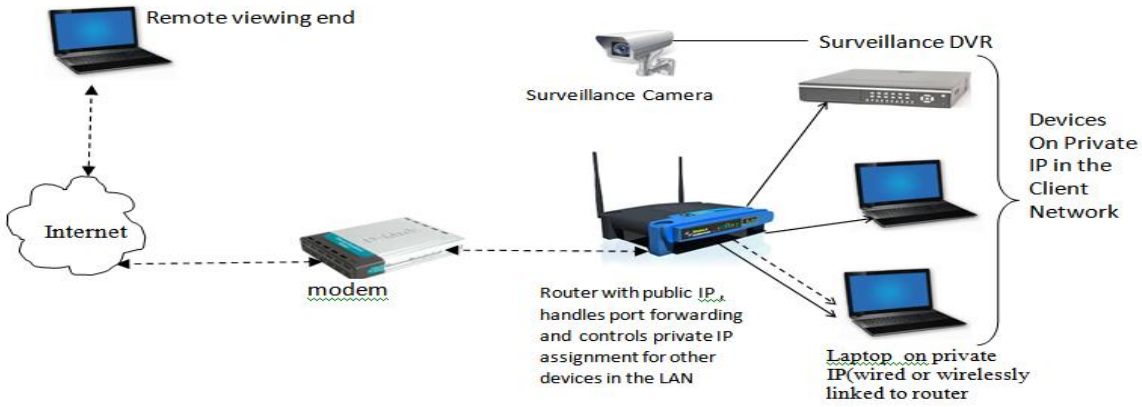

Fig 5.0: IP Referencing Network Diagram

For a client to view his location from the remote viewing end (fig.5.0), the client needs to either type the gateway IP address of his network to be viewed, or a setup host name using dynamic DNS (Domain Name Service).This is followed by a semicolon and the DVR port number i.e. the media port used by the DVR, all in the address bar of his PC browser. With proper configuration, remote access to the surveillance DVR which links the surveillance camera is achieved by the client from any location as shown in fig.6.0.

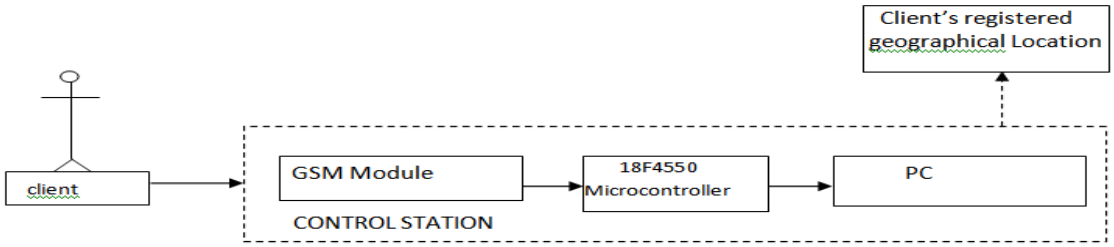

Fig. 6.0: Block diagram view of the client sending request to the control station from arbitrary location.

VII. Benefits of the on-demand Video Surveillance Security System

The On-Demand usage makes it easy to use the service in all scenarios – whether you use a single camera for an hour per day or you have several cameras being used 24x7x30.

The service requires one to simply get the network cameras setup on one's network and subscribe on monthly, quarterly, annually, biennially or life-time basis as one might desire.

The Pay-as-you-go service with On-Demand usage gives a lot of flexibility in managing your costs and usage. Use the service as much (24×7) or as little (a few minutes each day) as you want, when you want. If the service is not requested and/or rendered in a month, the cost is just the fixed charge.

VIII. Considerations of IP Video Surveillance as a Cloud-based Service include;

8.1 Bandwidth Requirements

Cloud surveillance is all about transferring "heavy" video data across different networks. Without proper bandwidth, you have no cloud video surveillance or, even worse, an unreliable solution. If you look at bandwidth as your "pipe" to the Internet, you need a really good "pipe" to get video up to the cloud. Your pipe has both upload and download speeds, which are usually different, and to get video to the cloud you need sufficient upload speed. As an example, a small retail store with five HD (High Definition) cameras might need a 10mbps "upload" pipe to get real-time HD video to the cloud at a subscription rate as high as $200 per month, and probably not more than 1Terrabyte of video storage. There are a number options to deal with this situation including a "hybrid cloud" that stores some HD video locally and some online. Some cloud solutions offer small resolution video storage — which helps with bandwidth issues, but can defeat the purpose of HD cameras. More advanced cloud video surveillance solutions optimize video for all different connection speeds and also offer "data forming" as well as "bandwidth management." This ensures that one's internet connection is not taken over by just video, so that other processes can equally work without interruption.

8.2 Storage Requirements: Demand for digitally based surveillance systems is increasing at an unprecedented rate. Google cloud storage for example features Google Drive which offers 15GB free storage plan, 100GB at $1.99 per month, and 1TB at $9.99 per month. A storage solution which must be a centralized archive which stores multiple video streams and ensures that users have continuous, random access to current and archived video footage is increasingly needed.

8.3 Accessibility and Ease of Use : A cloud video surveillance platform should have a simple to use interface such that it works on almost any web browser, computer, tablet or smartphone, without custom software or plug-ins. This reduces installation and complexity of use.

8.4 Speed: A key value of cloud video surveillance is the ability to access it when you need it and with reasonable quality, especially when it comes to viewing live video i.e in real-time.

8.5 Management : involves customer handling with respect to far and near locations, multiple cameras, months of video, internet connectivity. Ability to detect and notify when a gadget is down.

8.6 Security : The evolution of the cloud itself is an evolution on trust — moving business services we are used to doing ourselves to other companies to handle. It is simply putting trust in those cloud platform companies such as Microsoft, Google and Amazon companies. One could argue that one's video surveillance is safer in the cloud than on one's own computers.

8.7 Scalability: A cloud video surveillance solution should not only be able to support one or one million cameras or servers, but also make supporting any amount in between fast and simple to do. Consider a cloud video surveillance solution that is self-configuring and designed to work with hundreds of different cameras and almost any network infrastructure. It should reliably be able to grow from one location with five cameras to hundreds of locations with thousands of cameras then back down again according to the client's needs without unnecessary protocols.

8.8 Pay-As-You-Go (Self-Service) : This refers to the ability to use and pay for only what you need, when you need it. Consider a cloud video surveillance solution that enables you to quickly and easily increase and decrease cloud services and storage on demand, as needed, without penalty or long-term contracts.

8.9 Update-ability: One of the amazing advantages of cloud solutions is that system improvements, new features, bug fixes and security upgrades can be rolled out to an entire enterprise automatically or on-demand. This insures that the solution can respond quickly to changing conditions such as new security threats or new requirements like analytics or integration with other technologies such as
access control or Point of Sale (PoS) systems. Not only should software and cloud services be upgradeable, but hardware devices such as cloud servers and edge recorders should benefit from this service as well.

8.10 Transferability : A feature that allows client's content migration to another cloud video service provider in case client wishes to make a change.

IX. CONCLUSION

Advances in technology has led to emergence of new crime techniques which necessitates state-of-the-art solution that utilizes standard LAN and Internet Protocols (IP) in conjunction with GSM technology in such a way as be a combat match in fighting current crime techniques through "shared-resource" in security services. A highly scalable and flexible nouvelle Video surveillance-as-a-service (VSaaS) platform has been developed to proffer solution to the rising demand for video surveillance service due to general rise in safety, security, and theft concerns in the world today. Surveillance Camera optimization has also been achieved by means of servo motor control to rotate cameras to desired positions and achieve wider surveillance video coverage of subscribers.

X. RECOMMENDATIONS

The federal government should reorganize the country's intelligence system and build a capable and more proactive security apparatus in Nigeria through conscious interest in collaborating with tertiary institutions of learning and research institutes on evolving solutions to security matters. This will help put commensurate check on incessant invasions, bombings, robbery, kidnapping and violent crimes by hoodlums in the country. In as much as it could be quite costly on the government, the fact remains that the cost and effect of insecurity in Nigeria for example is incomparable to the cost of setting up better security apparatus to combat the current state of crime in the country.

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