"SAPS" INNOVATIVE SYSTEM FOR THE AERIAL ALTITUDE PLATFORM SKY MESH NETWORK IN RURAL & DISASTER AREAS

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ABSTRACT. Communications play a significant role in rural and disaster situations since they provide critical information to audiences and organizations, during natural or unnatural disasters, disrupted communications that require a speedy deployment communication networks to carry out necessary relief, in fact, the traditional techniques fail to provide access to the Internet in rural and isolated areas. In order to improve the communication system performance in isolated areas an aerial altitude platform system (AAPS) could be used. But this mechanism has encountered problems of precariousness due to strong winds; this challenge hinders network deployment due to loss of the line of sight (LoS), so a smart antenna platform system (SAPS) base station is suggested. In this paper we demonstrate, for the first time, that the SAPS system provides more stability and accuracy in transmission of radio signals by the use of 3-axis (accelerometer and gyroscope) sensors. The experimental analysis done in this work considers mesh networks and LoS between the mesh nodes with low weight, low costs and high performance.

Keywords: aerial altitude platform, stability, mesh networks, LoS, disasters, rural.

INTRODUCTION

Communications play a significant role in disaster situations since they provide critical information to both national and international audiences (Organization, 2004). Aerial altitude platform systems (AAPS) have the potential to deliver a range of communication services and other applications such as broadband in rural and disaster areas. The aim of the plan is to be capable to provide a high rate of communication directly to the user anywhere in the LoS. The wind speed and flow patterns using, helium-balloons (NABAS, 2007), as a station for a wireless access point in mesh networks requires constancy in the air. High wind speeds have a negative effect on the stability of the communication device signals (Lee, 2005), thus causing difficulties in communications between network nodes. The wind direction altering causes fluctuations in the balloon's position, which directly affects the wireless signals.

According to Hariyanto, the Emergency Broadband Access Network Using Low Altitude platform (EBAN) was faced with the problem in fluctuation of the balloon with high winds (Hariyanto, S. & Widiawan, 2010). The emergency system implementation in disaster areas requires addressing requisites of balloons stability in facing the wind and the fluctuation of the signal, which leads to increases in the data loss between the network nodes and makes the monitoring of these areas quite limited (Lee, 2005).These limitations making use AAPS technology are not effective; particular in mesh networks that necessitate several nodes for deployment. The situation requires construct an innovative mechanism to formulate the signal transmission between mesh nodes more stable, which also enhances the constancy of the photos sent during surveillance. This can be done through the detection of an effective system method that has the aptitude to sense the environmental changes (self-movement system) and disposition under the changes surrounding it, i.e., resist the varying of the antenna direction due to environmental factor changes, and to amplify the reliability of signal transmission between network nodes; choosing an effective approach to reduce these kinds of obstacles .is the crucial point of this paper.

SYSTEM DESIGN FOR SKY MESH ARCHITECTURE

In our experiment, the mesh network was chosen as an option for network data transfer between nodes. Two nodes were used as receiving and transmission stations. The stability of the suggested system has been tested against environmental changes earlier than raising the balloon payload.

Figure 1 describes the aerial platforms and the mechanism employed in this work. The design shows the significant fundamental requirements that must be provided to connect the two areas in communication services, on the assumption that sky station 2 (SS2) is in a disaster area where Internet services necessitate to be provided; essential system requirements are illustrated in the margin of the figure.

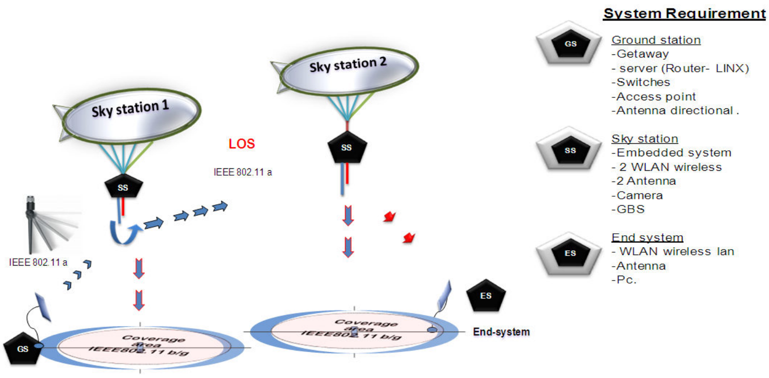


Figure 1.The Proposed Aerial Altitude Platform System Scenario Topology

Hardware System Design

Figure 2 illustrates the overall system design; Figure 2 (A) represents the ground station (GS), which is considered a connecting entrance area to be providing services with the outside world via VSAT, DSL, or any other source obtainable. Figures 2 (B) and (C) illustrate the payload balloon, Figure 2 (B) includes the embedded system optimized for routing signal functions between nodes; this device is associated with two wireless cards: (1) support IEEE 802.11a networking and (2) IEEE 802.11 b/g access points for maximum range. The embedded system is also connected with two external high- power antennas for point-to-point links of frequency bands of 5.8 gigahertz (GHz) and 2.4 GHz. The commercial product dual-radio EnRoute500 can serve as a Wi-Fi access point with a dedicated 802.11b/g radio, an intra-network repeater and router with a dedicated 802.11a mesh enabled radio (Communicate without boundaries, 2010); the specifications are used in communication systems of the AAPS, and correspond with this product.

Experimental Setup SAPS

Wave signals are direct by the antenna transmitter in the ground station to sky station 1 (SS1); in Figure 2 (B) the antenna that attaches to the balloon payload receives a signal from the GS , then the embedded system routes the signal and sends it during the antenna to SS2, at the same time covering the area underside the (SS1). The received signal in SS2 depends on the LoS, to corroborate the reliability of service in the area under SS2. The area coverage range depends on the height of the balloon and the equipment that is used in communication. Reliability of the signal transmission between the mesh nodes depends on the constancy of the source transmitter, which is the focus of discussion for this paper.

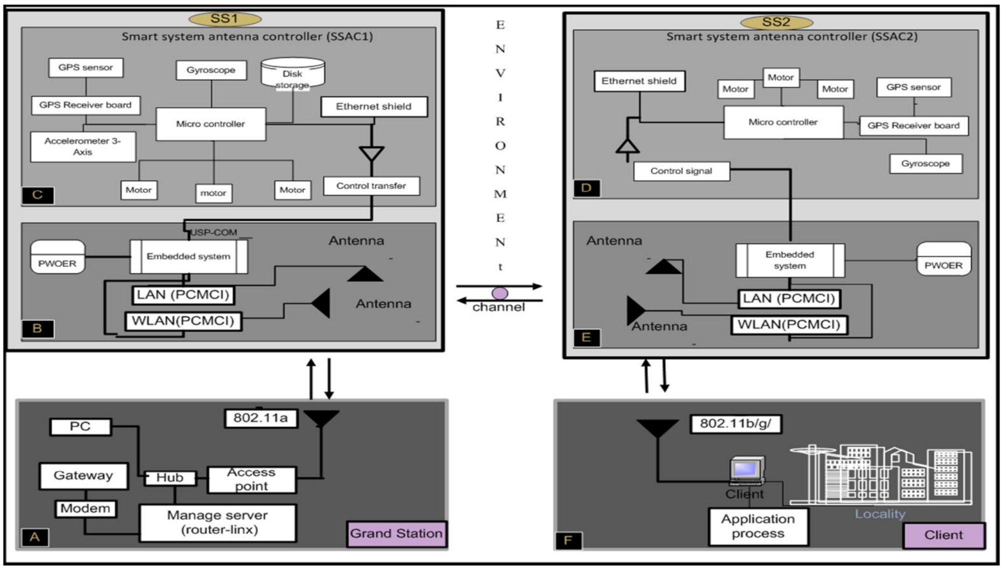


Figure 2.AAPS Physical Architecture Design

For stability of the AAPS, the smart antenna platform system (SAPS) is suggested to insure communication resources to seek the information with the disaster area. SAPS is an integrated system that contains all the essential apparatus to be attached to the balloon; this system is characterized as light in weight, low in cost, and capable to sense external environment changes (self –direction) according to the changes surrounding it .

The SAPS components are illustrated in Figure 3 and 4, which consists of:

a) Movement system control platform.
b) The Global Positioning System (GPS) is a space-based system that provides reliable location and time information for AAPS. GPS sensors with the board shield have been linked to the microcontroller.
c) Embedded system hardware and personal computer memory card international (PCMCIA) – WAN and LAN, shown in figure 4, D2.
d) Figure 4 illustrates the dynamic part of the sub-platform with motors, which is designed to receive the signal that has been sent by the microcontroller, and to organize the movement of the antenna that has been installed in the platform.
e) IP camera system for the surveillance of the disaster area, by wireless network, to survey the information around the disaster area (Shibata, S. &Ogasawara, 2009).

To transmit the influence of the environmental factors to the communication system, a 3-axis accelerometer with a digital interfaces (Tsuzuki & Fisher, 2010), is used and is fixed to the smart antenna platform control (SSAC) to interact with the outside forces vector (R). The vector R can be measured by the accelerometer, to calculate the coordinate of SAPS, i.e., R x, R y, R z projection of the R vector on the X, Y and Z plane. The position of R for SAPS that the accelerometer measures are transmitted to a gyroscope through the microcontroller that is compatible to work with the sensors being used (Atmel, 2009).The gyroscope is a device for measuring or maintaining orientation based on the principles of the conservation of angular momentum. The coordinates of the SAPS position are sent to the gyroscope to be rotated responding to that change, the gyroscope output data is processed by the microcontroller, and then the signal is sent to motors to correct the SAPS direction.

For the purpose of converting the external movement sensing, (C) programming language was used to interpret the signal from the sensing system to a microcontroller. Figure 3 describes the technical procedures for the mechanism of the system that was used in the SAPS.

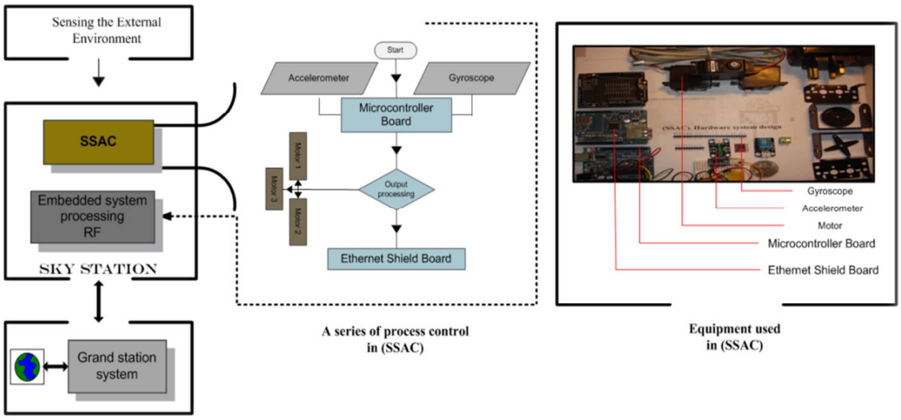
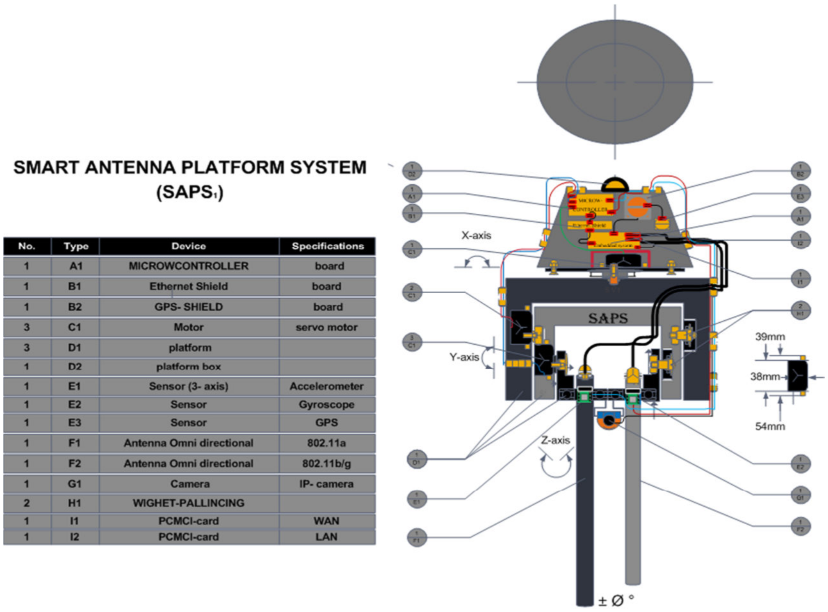


Figure 3.Experimental Setup for SSAC

After discussing the mechanism of the control system unit and its major components, what remain are a compilation of these components into a particular unit and the composition of the essential structure of the system to perform its intended purpose.

Figure 4 describes the design of the SAPS system that is used in the AAPS; the design describes clearly the most essential components of the system and the side table to help clarify each component and its location in the system.



No.	Type	Device	Specifications
1	A1	MICROWCONTROLLER	board
1	B1	Ethernet Shield	board
1	B2	GPS- SHIELD	board
3	C1	Motor	servo motor
3	D1	platform	
1	D2	platform box	
1	E1	Sensor (3- axis)	Accelerometer
1	E2	Sensor	Gyroscope
1	E3	Sensor	GPS
1	F1	Antenna Omni directional	802.11a
1	F2	Antenna Omni directional	802.11b/g
1	G1	Camera	IP- camera
2	H1	WIGHET-PALLINCING	
1	I1	PCMCI-card	WAN
1	I2	PCMCI-card	LAN

Figure 4.Components of Smart Antenna Platform Experimental System

EXPERIMENTAL RESULTS AND DISCUSSION

In this sub-section, we scrutinize the approach for sensing the inclination with three axes for SAPS, and to determine the angle for each axis of the SAPS accelerometer (SA) to a reference position. The reference position is taken as the characteristic orientation of SA with the x- and y-axes in the plane of the horizon (0 gravity (g) field) and the z-axis orthogonal to the horizon (1 g field). Figure 5 shows the direction field for the desired heading generated by the vector equation.

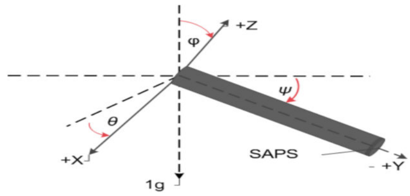


Figure 5.Angles-Inclination Heading Vector in Field Geometry.

The angles of inclination can be calculated using Eq.1, Eq.2, and Eq. 3.The experimental system parameters are based on a published paper (Fisher, 2010).

$$(\mathrm{SA})\text{posission vector in } 3-\text{axis} = \begin{cases} \theta = tan^{-1}\left(\frac{SA\ x, out}{\sqrt{SA^2y, out+SA^2z, out}}\right) & (1) \\ \psi = tan^{-1}\left(\frac{SA\ y, out}{\sqrt{SA^2x, out+SA^2z, out}}\right) & (2) \\ \varphi = tan^{-1}\left(\frac{\sqrt{SA^2x, out+SA^2y, out}}{(SA\ z, out)}\right) & (3) \end{cases}$$

Where θ is the angle between the horizon and the x-axis of the (SA), ψ is the angle between the horizon and the Y-axis of (SA) and φ is the angle between the gravity vector g and the Z-axis. The consequences of the performance of SAPS for sensing the external environmental changes are illustrated in Figure 6, where the X-axis represents the measurement time (0.5) in seconds (sec) and the pulse signal on the axis Y, Table1 shows the experimental parameters that have been adopted by experience. The accelerometer measures sensitivity in a 3-axis direction, for the time period of (0-20) sec in order case of the system stability and for the period of (20-42) sec the direction of system deviation ,that illustrated in the lower part of the diagrams (The line with the arrow in the diagrams shows the launch of the movement the system until the end). Table1 shows the experimental parameters that have been adopted by experience.

The accelerometer in SAPS measures the vibration or acceleration of motion and perform us position R vector in 3-axes, which is the inertial force vector as measured by the accelerometer. The angles of inclination transmit to the gyroscope depend in our algorithm. The gyroscope measures the angles rate changes the defined above, in other words it will output a value that is linearly related to the rate of change of these angles. In short, the microcontroller is constantly reading in data from two sensors, where the output data is sent to the servo after processing to modify the direction of movement to the initial value.

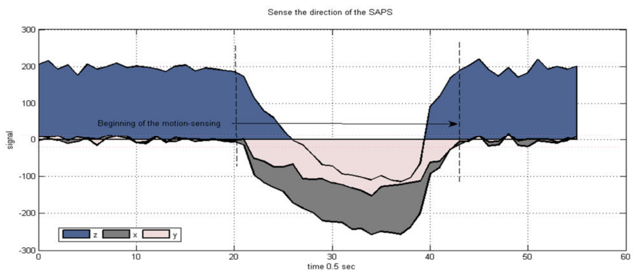


Table1. System Parameters

Parameter	Values
apply voltage range for Acc	2.0 V to 3.6 V
Time movement Experimental	20-42 sec
X axis account numbers.	-300 to 300

CONCLUSION

In this paper, we scrutinize the performance of SAPS for mechanism sensing with three axes. A balloon wireless network aerial platform was suggested to insure communications and to grasp the information within the disaster area, the first stride being to solve the challenge of environmental factors and their impact on the stability of signal transmission from the sky base station to another mesh node, and sensing these effects and turning them into reality in order to develop a mechanism to convert this sensitivity to movement, thereby achieving stability.

The advantages of SAPS are: it contains all broadcast equipment that provides wireless network services, and controlling the system for steadiness signal transmission plus contain the observation tools for the purpose of transferring events from the field directly to the emergency room (disaster control center) for intervention and handling. The innovation has been characteristic as well; light weight, low cost, high performance and can be regarded as an integrated unit for communications that could be adopted in aerial altitude platform systems.

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