Using GIS in Designing and Deploying Wireless Network in City Plans

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Abstract

Site Surveys play a very important role in the successful and efficient deployment of wireless networks. The first step is to understand the basic goal of a wireless network, which is mainly to provide an appropriate coverage and throughput to all end users with high efficiency, full coverage and reasonable cost.

Site Surveys is very important for the sake of planning and designing a wireless network specifically in outdoor networks, to provide a wireless solution that will deliver the required wireless coverage, data rates, network capacity, roaming capability and Quality of Service (QoS). The survey usually involves a site visit to test for RF interference, and to identify optimum installation locations for access points. This requires analysis of building floor plans, inspection of the facility, and use of site survey tools. Interviews with IT management and the end users of the wireless network are also important to determine the design parameters for the wireless network.

Wireless Local Area Network (WLAN) can be implemented and deployed using different techniques and methodologies, starting from site survey to launching. The main problems are that some areas may not be covered well and the high cost of equipment.

This paper discusses a technique that helps determining the best location for access points using GPS system, in order to choose the optimal number of access points. This technique has a positive impact on the cost. Another important factor is the type of antenna, which has a very important effect on both cost and coverage issues.

Keywords: Security, Sensors, Access Points, Wireless, Antenna, GPS and GIS.

1. INTRODUCTION

Wireless Local Area Network (WLAN) becomes as one of the measure requirement at home, business and city plans. Nowadays you can see additional diagram added to other traditional architecture papers showing the location and cabling of the access points. Furthermore, some countries that are establishing new cities consider the wireless coverage and deployment in their designs.

1.1. Wireless Network

Wireless frequencies are open band transmitted via wireless access points (AP) and routers, which means they are designed to be used by anyone using a wireless receiver. The signal range of an AP as illustrated in figure 1 shows that signal strength can extend beyond a building perimeter.

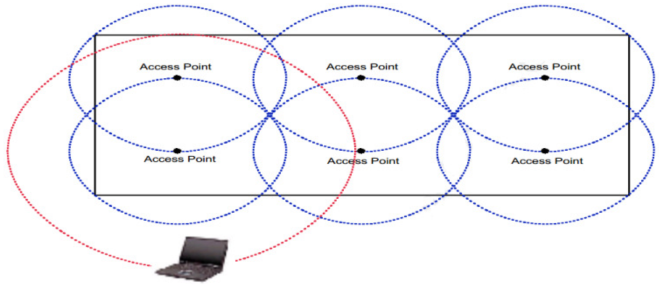

FIGURE 1: WLAN Coverage can often overrun a building's boundaries [1].

WLAN has been widely used in many sectors ranging from corporate, education, finance, healthcare, retail, manufacturing, and warehousing. According to a study by the Gartner Group, approximately 50 percent of company laptops around the world will be equipped for WLAN by 2006 [2]. It becomes a very important technology; since it is connecting the people together and makes the whole world as a small village, furthermore, it satisfies the needs for installation flexibility, mobility, reduced cost-of-ownership, and scalability. Generally, the basic goal of a wireless network is to provide appropriate coverage and throughput to all end users while keeping interference to a minimum.

1.2. Wireless Site Design

Site Survey is needed to ensure the successful and efficient deployment of wireless networks.

Wireless site survey means sometimes walk-testing, auditing, analysis or diagnosis of an existing wireless network, particularly one which is not providing the level of service required.

Site Survey determines many important factors such as the signal coverage, throughput requirements, interfering sources, dead spots. That helps to determine:

1) what equipment to purchase
2) Access points locations
3) how to configure each access point for optimal coverage

Site Survey is not only required for new installations, but also for existing installations; to know the number of access points required and locations and to verify the number of access points required versus the number actually deployed.

Site survey is divided into three main phases [1], the first phase starts before purchasing. For outdoor WLAN the following should be known:

Approximately how many users require wireless network
If there as any interfering source such as radar installations
If there is any building/floor blueprints available
This phase will help us later to choose the location of our antennas.

The second phase is the planning phase in which we have to know the purchased equipment and from where the wireless deployment starts; in order to reduce the time and effort needed to deploy a wireless network. For example the outcome of this phase is to know number of access points needed and their signal coverage, location of the access points and interference occurring between the deployed access points. The result of this phase can be represented by figure 2, in which we see the site divided into zones or station, each of them containing many access points

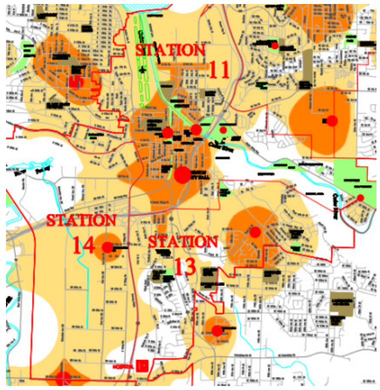

FIGURE 2: Phase 2 Output [13].

The last step is the surveying phase is the measurements, in which Wi-Fi Planning tools (such as NetStumbler software [8] and Global Positioning System (GPS)) are used. The output of this step is shown in figure 3, and the GPS to determine the coordination of the locations. The result should be reviewed well before any permanent; since not only the signal strength (which is a feature of the signal, and some techniques of intrusion detection [3] depends on it) is measured but also the signal to noise ratio and noise, to see if there is any source of noise (ex. from radar system). In addition, a visualize report can be generated (as figure 4) to assess the level of signal strength in the different location of the site, and to know the signal strength levels, as seen in figure 5 [6].

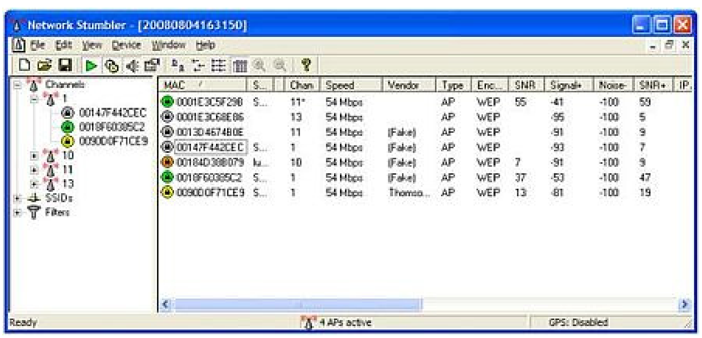

FIGURE 3: NetStumbler Snapshot.

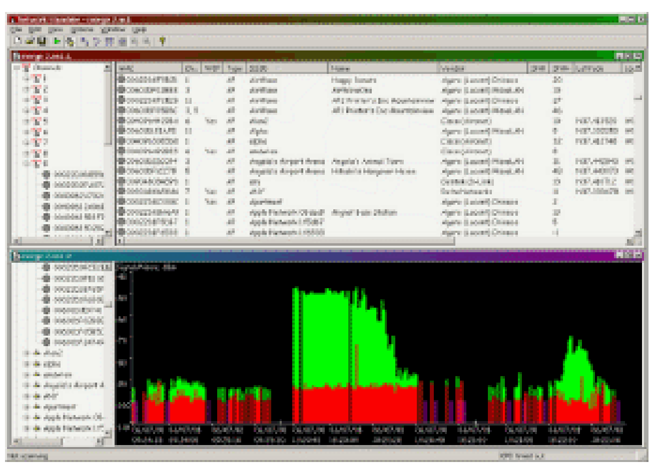

FIGURE 4: NetStumbler Signal Strength Representation.

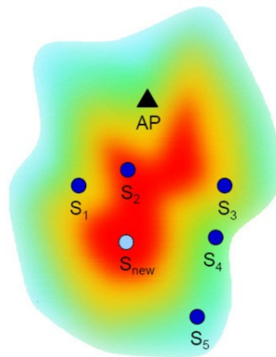

FIGURE 5: Signal Strength Levels.

2. OUR WORK

This paper discuss a technique that helps in determining the best location for access points using GPS and GIS systems, in order to choose the optimal number of access points. This technique has a positive impact on the cost.

Another important factor is the type of antenna, which has a very important effect on both cost and coverage issues.

A new phase can be added to site survey is the Geographical Information System (GIS) technology.

Since the site may cover a large area of terrain or spans multiple buildings, it allows the user to observe the effects obstacles in the network. These obstacles may be naturally found such as trees, valleys and hills; others can be manmade such as buildings. By using GPS we can identify the location of the obstacles which can be counted or considered in small areas, but it is difficult to consider it without other tools such as GIS in open areas like city plans; not for determining the location perspective, but for elevation issue which can't be determined by GPS system. The benefit of this addition (use GIS) can be summarized in two points:

1. Determine 3D coverage area of access points specifically at the location of the obstacles. As in figure 6.

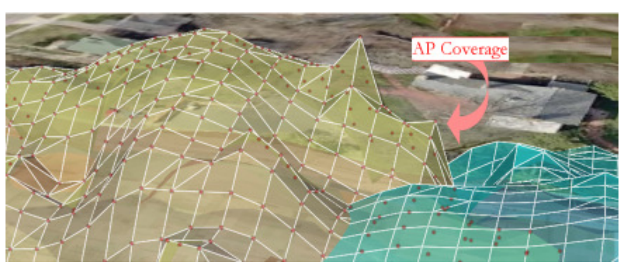

FIGURE 6: Access Points 3D Coverage Areas [14].

2. Determine the type of the antenna to be used, as shown in figure 7, the coverage area of the antennas are different, for example at the top of a top of a hill it is better to use one omini antenna instead of using more than four directional antennas. By this we can guarantee the whole area is covered with signal using appropriate type of antenna for reasonable budget.

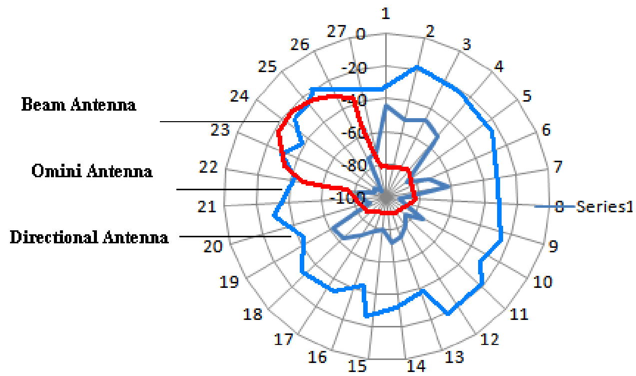

FIGURE 7: Antennas Types.

In order to complete four phases (three main phases and our suggested one) of survey, below is a summary and description of the needed tools:

GPS: to collect location information and to the locations of access points as in figure 8, to complete this task, GPS device is needed such as GARMIN GPS system [9]. In addition, some new GPS system allows the user to export the GPS survey data to Google Earth as in AirMagnet from Fluke [10], figure 9.

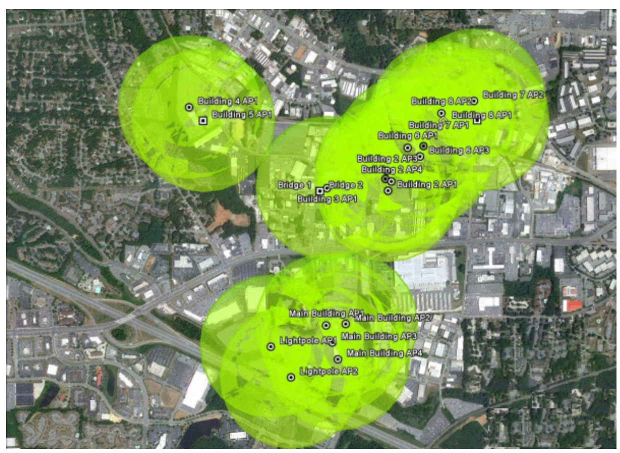

FIGURE 8: Suggested Locations of Access Points [11].

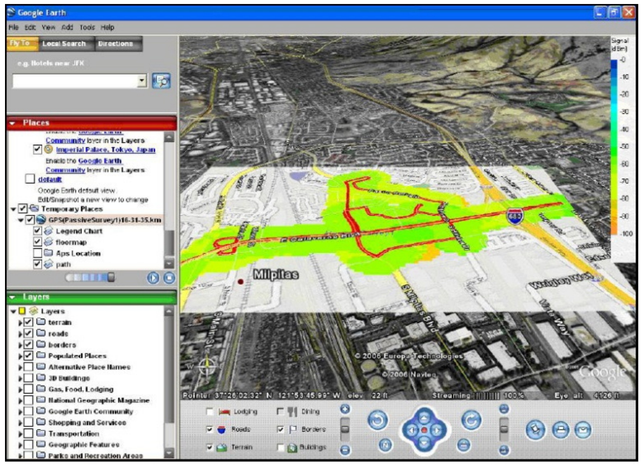

FIGURE 9: AirMagnet from Fluke Survey Result.

Another modernize tools are tools which came as an application on smart phones, such as NetSpot 2.0. NetSpot is a professional app for wireless Site Survey, Wi-Fi analysis and troubleshooting on Mac OS X, It's FREE and very simple, no need to be a network expert to start using NetSpot [12], and it can be downloaded on iPhone, iPod, iPad and MacBook, as seen in figure 10.

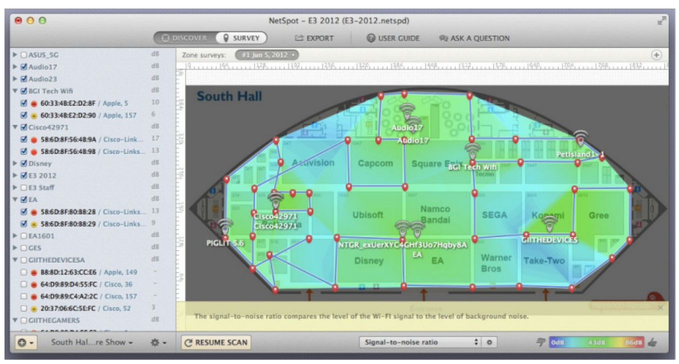

FIGURE 10: Snapshot of NetSpot Survey Mac App.

GIS: The last stage is to sense the elevation. By using GPS, it is possible to know the elevations; since GPS gives three coordinates X, Y and Z access, but to reflect the elevation on a map, GIS map is required in order to investigate the terrain and sense the elevation as a mean to determine the most suitable location of the towers and antenna and to choose the most appropriate antenna type. GIS maps are commercially available on internet, also at every national Geographical center (the Royal Jordanian Geographic Centre (RJGC) [15]) as in figure 11, or can be built by software tool such as Visualize Your Wireless Network [14].

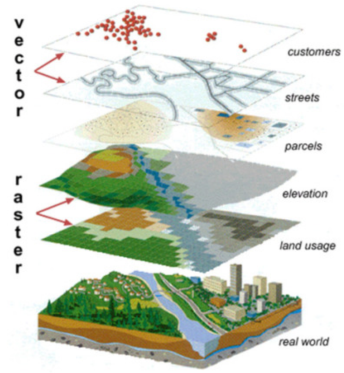

FIGURE 11: GIS Image [16].

3. TEST BID

The implementation of this work has been conducted in a site survey as a prototype, shown in figure 12, in order to be then applied to a wide area.

After the survey is done, the boundaries of the access point zone can be specified, and the optimal number of the access points is determined.

Equipment used during the survey:

- CISCO Aironet 350
- 13.5db antenna
- Laptop with Network Stumbler, AirMagnet and NetSpot software applications.
- External either net card
- GPS

The distance between the source (tower) and the destination (control room) is 200m.

As shown in table.1 there are five columns, distance and bearing derived from GPS, and the rest are from the software.

In order to choose the appropriate type of antenna only the distance and signal will be used to draw the output as shown in figure.13.

Distance	Bearing	Signal	Noise	mbps
0	240	-44	-100	54
20	270	-52	-100	54
20	250	-47	-100	54
30	290	-52	-90	36
40	80	-85	-100	0
40	340	-72	-90	1
40	20	-62	-90	24
60	100	-92	-100	0
60	120	-90	-100	0
60	140	-74	-100	12
80	160	-84	-90	0
80	180	-80	-100	6
80	200	-74	-100	12
80	220	-72	-100	24
100	330	-80	-100	6
100	300	-78	-100	9
100	280	-72	-100	24
100	240	-64	-100	36
100	260	-62	-100	54
120	20	-89	-100	0
120	0	-84	-100	1
120	340	-82	-90	0
140	60	-92	-100	0
140	40	-91	-100	0
160	60	-95	-100	0
200	230	-74	-100	12
200	240	-72	-100	24

TABLE 1: Survey Results.

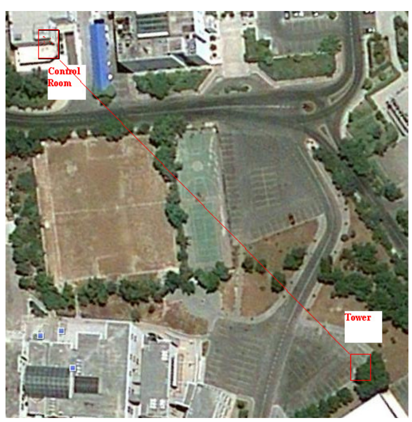

FIGURE 12: Test Bid.

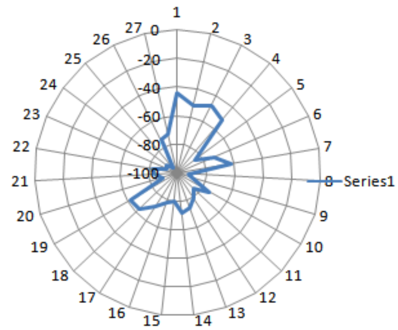

FIGURE 13: Signal Output.

Then by comparing figure 13 with figure 7, it will be easy to say that the used antenna is a directional antenna which is a suitable for that test bid.

As a result of this survey, the boundaries of the access point are identified, which can help to monitor and secure the network. In addition, it can be used for future planning and expansion. Also it can be applied to a complex network which is considered as an additive security layer.

Finally, a new step can be added, which is in the using of GIS maps to determine the elevations, so an appropriate type of antenna will be used in appropriate location instead of using the same type of antenna everywhere. For example, instead of using a lot of beam antennas on a top of a hill, one directional antenna will be used. In this way, it will reduce the cost budget. The idea can be summarized by figure 14.

Furthermore, a last recommendation would be to use real GIS maps instead of creating a map as in figure 6 [14], in which it is not possible to determine the suitable location of the towers and access points. However, a real GIS map offers more details about the type of the land (soil, rock...) in order to specify the most appropriate location.

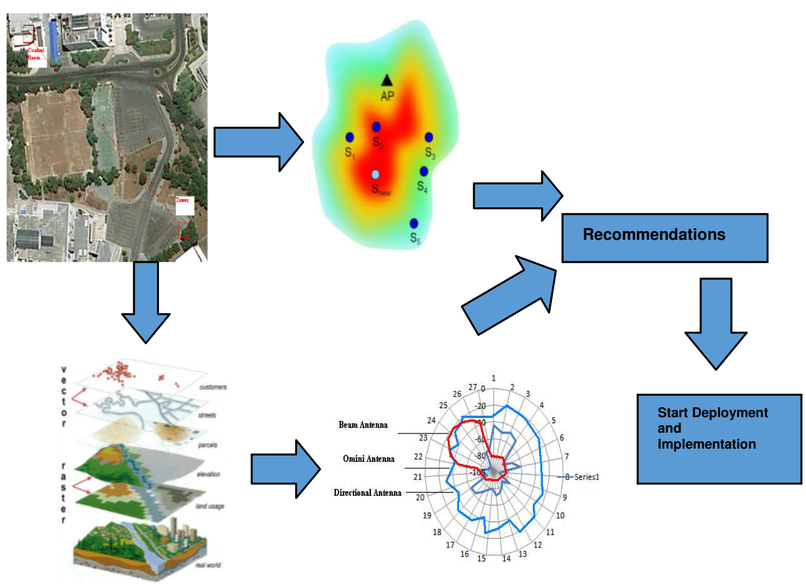

FIGURE 14: Factors effect on choosing Antennas types.

4. CONCLUSION

Today's wireless service providers, managed-service providers, and network infrastructure vendors all consider site surveys as a mandatory and vital part of the WLAN deployment process.

With the Survey and Planner products, users can be assured of quickly deploying an efficient wireless network to satisfy their business requirements. Furthermore, some technologies such as GIS and GPS can help in implementing the site survey in a more efficient way, reducing the cost and strengthening the security.

Users get critical information on the overall signal coverage, real user data from active surveys, user capacity and security of the network.

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