

## Webometric analysis of Nigerian university websites

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### Abstract

*This paper considers a web space built on a set of the university websites of Africa's most populous nation -- Nigeria. The investigation conducted reveals a weak connectivity in the set of official websites of Nigerian universities. However, the connectivity becomes stronger when all the university websites are taken into account. It increases significantly with the addition of the only found web communicator to the university websites -- National Universities Commission -- the sole body that approves the establishment of higher educational institutions in Nigeria and all academic programmes run by them.*

### Keywords

*University website; Nigeria; Hyperlinks; Webgraph; Webometrics; World Wide Web*

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### Introduction

Investigations of the interaction of websites via hyperlinks are one of the important fields of webometrics (Thelwall et al., 2012). While it may seem that web developers randomly put links pointing to the pages of other sites, in fact, the developers' behavioral models are accurate enough to be successfully used, for example, in the information retrieval algorithms of Google and Yandex (Brin and Page, 1998; Segalovich et al., 2006).

In webometrics, great attention is paid to investigations involving the web resources of research institutes and universities. On one hand, they are means for publication of open information accessible to all web users, and they perform communication functions both between the institutions themselves and between scientists. On the other hand, such web resources have quite a rich history of development and the results of these investigations can serve as an analogue for the investigation of other web spaces.

For example, investigations of the academic web spaces of three countries -- UK, Australia and New Zealand -- found that hyperlinks between university websites are distributed by discrete power law distribution with some anomalies (Thelwall and Wilkinson, 2003). There is a trend of geographical proximity of the placement of hyperlinks between university sites in UK (Thelwall, 2002) and Canada (Vaughan and Thelwall, 2005). Pechnikov (2010) considers the interaction between the official websites of Russian classical universities. It was found that the strongly connected component of the webgraph contains slightly more than half of the websites studied. A webgraph of 2000 Spanish university departments and research groups constructed by Ortega and Aguillo (2007) shows that the strongly connected component contains only 699 sites.

A reflection of cooperation between universities and governments, business organizations and other institutions in the UK by means of hyperlinks is discussed by Stuart et al. (2007). It is noted that there are significant differences in the proportions of the number of hyperlinks, depending on the owners of the source and target pages.

Nigerian university websites, as well as the universities themselves, are very young compared to those of European countries like UK, Germany, France, Spain, and Russia. Therefore, the academic web space of Nigerian universities is an interesting experimental platform for the study of the relationship between universities and the reflection of cooperation between universities and other institutions in Nigeria. We hope that the results of investigations carried out in this article can be of particular value to the government bodies of the Nigerian education system, the university managements and website developers.

This paper focuses on two questions:

1. What is the academic web of Nigeria?
2. What is the academic web structure of Nigeria?

## **A description of the investigation**

### **1. Some terms and definitions**

Given the fact that webometrics is quite a young scientific field, here are formally some concepts that will be used hereinafter.

*Definition 1.* Website (site) -- a set of HTML-pages and web documents connected by internal hyperlinks, and which have a unity of content identified on the Web by its domain name.

With this approach, the names *name1.ng* and *name2.name1.ng* are separate sites despite the fact that *name2.name1.ng* is a sub-site of *name1.ng*, and the organization that owns *name2.name1.ng* is likely a subdivision of the organization that owns *name1.ng*.

External outbound link (or simply *outlink*, as opposed to *internal hyperlink*, connecting pages of the same site) is a hyperlink pointing from that site to another. Outlinks pointing to the same external address with the same context (for example -- an anchor) can be found on different pages of one site. A common example is a link pointing to a higher organization or to the site of the developer of an official website.

*Definition 2.* A unique external outbound link is a hyperlink from a set of hyperlinks that have the same address and context, and which is located on the page that has the highest level; while the level of the initial page of a site is considered the highest level. Hereinafter, we will consider only unique external outbound links, so the words 'unique' and 'external' will be omitted in most cases.

*Definition 3.* A target set is a set of investigated sites, identified by unique domain names, given by a direct enumeration.

Here we must make the following note. When we talk about an element of the target set, we mean a domain name that identifies a site. Therefore, saying that a site belongs to the target set implies that a domain name that identifies that site belongs to the target set.

*Definition 4.* The web neighborhood of the target set site is a set of web resources of the owner of that site, which are independent websites.

A web neighborhood, in turn, consists of direct and hidden web neighborhoods. Sites included in the direct web neighborhood are sub-sites of the target set site, while the sites from the hidden web neighborhood have domain names that are not sub-sites of the target set site.

*Definition 5.* A set of web neighborhoods -- a union of web neighborhoods of all the target set sites. It is clear that a set of web neighborhoods is also a union of subsets of direct and hidden web neighborhoods.

*Definition 6.* An accompanying set (with respect to a given target set) is a set of sites not included in the target set and the web neighborhood set in which there are hyperlinks located in the target set sites.

*Definition 7.* A unit of analysis is a set of sites considered as an integral whole, one of which belongs to the target set, while others are its web neighborhood.

## **Webometric tools used**

As noted by Thelwall and Zuccala (2008), there are two sources of information about hyperlinks between websites -- commercial search engines and personal crawlers. Crawlers are mainly used for research at the national level because scanning of university websites is time

consuming. Nwohiri (2011) has shown that search engines (Google, Yahoo!, Bing) poorly index Nigerian educational sites. Therefore, for the collection of outlinks and assessment of the sizes of Nigerian universities, we used the beta version of the BeeBot crawler (Pechnikov and Chernobrovkin, 2011). In this case, Nigerian websites served as a test set. Scanning of sites was conducted up to the 5th level, and so, the quantitative characteristics specified further for some sites are values below that level. In most cases, five levels of scanning were enough to process all of the pages and hyperlinks of sites.

## **Investigation techniques**

The main part of the investigation was conducted using the methodology developed for Russian web spaces (Pechnikov, 2010). First, an initial set of sites (in our case -- the websites of universities in Nigeria) is defined. Then, a target set is created from this set. After this, the BeeBot crawler (Pechnikov and Chernobrovkin, 2011) is used to scan the target set sites in order to create a database of external hyperlinks (outlinks). This database is analyzed and then an accompanying set is created from it. After the accompanying set has been created, a set of web neighborhoods is created from it. Afterwards, this set of web neighborhoods is excluded from the accompanying set, and the resulting set is divided into two subsets. The first subset is a set of web communicators, that is, sites from and to which there is quite a large number of links pointing to and from the target set sites. A web communicator must have at least one hyperlink pointing from it to the target set sites. The second subset, which includes all of the remaining sites, is called a cover set.

By so doing, the entire university web is represented as a union of four sets: the target set, the set of web neighborhoods, the set of web communicators, and the cover set. These sets are investigated in more detail in order to understand their structures and the relationships between their elements. The web space webgraphs are then constructed. The target set sites, the unit of analysis, and the web communicators are marked as the vertices of the webgraphs, while hyperlinks between these entities are marked as the edges of the webgraphs. Other accompanying set sites are dropped from further consideration because they do not affect the connectivity of the webgraphs.

## **Websites of Nigerian universities**

### **1. Nigerian universities and the target set**

According to the National Universities Commission of Nigeria, the country, as of 2011, has 118 universities, including 36 federal, 37 state, and 45 private universities (NUC, 2011). Finding the domain names of the official websites of these universities was quite a task. Owing to the fact that the list of domain names listed in NUC (2011) was incomplete and inaccurate, the list was adopted only as a basis and was repeatedly supplemented and improved during the investigation process. Improvement of the list continued, but in the article, we stopped with a target set containing 97 domain names of the official websites of Nigerian universities. Examples of the target set sites are [www.atbu.edu.ng](http://www.atbu.edu.ng) (Abubakar Tafawa Balewa University, Bauchi), [www.wusto.org](http://www.wusto.org) (Wesley University of Science & Technology, Ondo), [www.wduniversity.net](http://www.wduniversity.net)

(Western Delta University, Oghara). Of these 97 universities are 30 federal universities, 27 state universities and 40 private universities.

Nigeria has 36 states and 1 Federal Capital Territory, which are divided into 5 regions under geographical and ethno-cultural lines: North, Southwest, Southeast, South-South, and the so-called Middle Belt. The 97 universities under investigation are fairly distributed into four regions: the North has 15 universities, the South-South – 17, Southeast – 16, and the Middle Belt – 20. An exception is the Southwest region where there are 29 universities. Most (83 universities) of the target set websites have .edu.ng as their top-level domain, five websites have .net and .org as theirs, three – .com, and one – .gov.ng.

The size of sites as determined through scanning is quite small: 55 sites have up to 200 html-pages, 23 sites -- from 201 to 1000, 16 sites -- from 1001 to 10000, and only 3 sites have 10300, 14400 and 17500 html-pages. The number of outlinks is also small: 56 sites have up to 10 of these links (five sites among them have no outlinks at all), 28 sites -- from 11 to 100 outlinks, 10 sites -- from 101 to 1000, and only 3 sites have 1100, 1900 and 2100 outlinks. These numerical characteristics enabled us to scan each site not further than the 5th level since almost no outlinks were found at the 5th level. The database of outlinks built by scanning the target set websites contains 9500 outlinks from 102,000 pages.

## 2. Web neighborhood

Analysis of the database of outlinks built by scanning the target set sites enabled us to discover 138 websites that are members of the web neighborhood set. After further analysis and scanning of these sites, their number was reduced to 127 because 11 sites were found to be non-functioning. Out of the 127 websites, 74 were direct while 53 were hidden web neighborhoods. For example, the web neighborhood of the official website of Bayero University ([www.buk.edu.ng](http://www.buk.edu.ng)) contains 4 sites:

- Advancement Office ([alum.buk.edu.ng](http://alum.buk.edu.ng)),
- Student Union Government ([www.sug.buk.edu.ng](http://www.sug.buk.edu.ng)),
- E-Learning ([elearning.buk.edu.ng](http://elearning.buk.edu.ng)),
- Central Online Information Management System ([www.bukportal.edu.ng](http://www.bukportal.edu.ng)). The first three sites are direct web neighborhoods, while the last -- is hidden.

The number of sites included in the web neighborhood set is as follows: 103 sites have up to 200 html-pages, 19 sites -- from 201 to 1,000, and 5 sites -- from 1,001 to 10,000. Number of outlinks: 86 sites have up to 10 (25 sites among them have no outlinks), 26 sites -- from 11 to 100 outlinks, 12 sites -- from 101 to 1,000, and 3 sites have 1,690, 2,810 and 2,860 outlinks.

## 3. Units of analysis

Aggregation of the web resources of each university implies transition from the official websites of Nigerian universities to units of analysis. It is obvious that the numerical characteristics of units of analysis are usually higher than that of official sites. For example, the official site of the previously mentioned Bayero University contains 1,010 pages and has 36 outlinks, and all the 4

sites from the web neighborhood has 295 pages and 11 outlinks. Thus, the unit of analysis of Bayero University has a total size of 1,305 pages and 47 outlinks, that is, indicators of the official site grow by about a third.

There was no such a growth for 50 Nigerian universities because no web neighborhoods were found for them. However, the web neighborhoods of the remaining 47 official sites greatly increase the overall base for analysis. Table 1 shows the average number of html-pages and outlinks from official sites and units of analysis divided in three groups (federal universities, state universities and private universities).

**Table 1. Average number of html-pages and outlinks by groups of universities**

Group of universities	Number of sites	Official sites		Units of analysis	
		HTML-page	Outlinks	HTML-page	Outlinks
Federal universities	30	1,607	131	2,313	209
State universities	27	369	24	697	294
Private universities	40	1,102	128	1,242	165
All universities	97	1,054	98	1,422	215

It can be concluded that aggregation of official sites and web neighborhoods into a unit of analysis significantly increases the number of pages and outlinks: for example, the number of pages increases by almost a third for all universities, and the number of outlinks -- by more than twice. Note also that state universities witness the greatest growth -- number of pages almost doubled while the number of hyperlinks increased 12 times. There is a reason for such a sharp jump. The average number of pages on a university official website is close to 1000, while outlinks -- about 100. At the same time, the average number of pages on the official website of state universities is significantly less than the average (370 pages and only 24 outlinks). Therefore, adding to an official website a fairly large number of its web neighborhood sites significantly impacts on the percentage increase.

**Table 2. Average number of html-pages and outlinks by regions**

Regions	Number of sites	Official sites		Units of analysis	
		HTML-page	Outlinks	HTML-page	Outlinks
North	15	1,583	67	1,625	75
Middle Belt	20	639	52	692	63
Southeast	16	591	16	630	18
South	17	1,019	101	1,245	140
Southwest	29	1,342	189	2,360	544

Associating universities by regions also reveals a number of interesting features (see Table 2). Note that the largest average size of an official site and number of outlinks was found in universities located in Southwest Nigeria (1,342 and 189). This region also has the greatest increase in these values during transition to units of analysis (2,360 and 544), almost twice by size and thrice by hyperlinks.

The University of Ibadan, which is of great interest, is a good example of the organization of an information web space of a university. The official website of this university [www.ui.edu.ng](http://www.ui.edu.ng) contains 1,350 pages and 615 outlinks, which in itself is a good indicator. In addition, there are 21 web neighborhood sites among which are sites of faculties, colleges, libraries, portals for students and applicants, administrative websites, the websites of research centers and projects. They all have domain names in the [ui.edu.ng](http://ui.edu.ng) zone, that is, they are websites of the direct neighborhood of the official website [www.ui.edu.ng](http://www.ui.edu.ng), and thus significantly improve the characteristics of the University of Ibadan in search engines. The total number of pages on these sites is over 3,000, while the number of outlinks is more than 1,100, which is almost twice more of the same characteristics of the official website.

The sites of the University of Ibadan are strongly connected among themselves -- a total number of more than 750 hyperlinks. This is confirmed by the adjacency matrix shown in Table 3, where the number '1' means there is at least one hyperlink between a pair of sites.

Returning to the main subject, it can be concluded that web neighborhoods greatly and positively influence the webometric characteristics of the web resources of Nigerian universities. In addition, 74 sites of direct web neighborhoods add 24,148 html-pages and 4,913 outlinks, while 53 sites of hidden web neighborhoods add 6,778 html-pages and 6,224 outlinks. Note that analysis of the web space of Nigerian universities using standard search engines would not have revealed hidden web neighborhoods, and, therefore, such analysis would be very incomplete.

**Table 3. Webgraph adjacency matrix for the sites of the University of Ibadan**

#	Name	Domain name	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
1	University of Ibadan	www.ui.edu.ng	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
2	Admission Application Portal	admissions.ui.edu.ng	1																					
3	University Advancement Centre	advance.ui.edu.ng	1																					
4	Faculty of Agriculture	agric.ui.edu.ng	1			1				1							1			1	1		1	1
5	Africa Regional Centre for Information Science	arcis.ui.edu.ng	1												1	1								
6	Faculty of Arts	arts.ui.edu.ng																						
7	Centre for Peace and Conflict Studies	cepacs.ui.edu.ng	1																					
8	Centre for Sustainable Development	cesdev.ui.edu.ng	1																					
9	College of Medicine	comui.ui.edu.ng																						
10	Faculty of Education	educ.ui.edu.ng	1		1	1						1					1			1	1		1	
11	Faculty of Law	law.ui.edu.ng																						
12	Kenneth Dike Library	library.ui.edu.ng	1																					
13	International Programmes	oip.ui.edu.ng																						
14	Postgraduate School	pgs.ui.edu.ng																						
15	Faculty of Pharmacy	pharm.ui.edu.ng	1		1	1						1	1							1	1		1	1
16	Portal University of Ibadan	portal.ui.edu.ng																						
17	Research Management Office	rmo.ui.edu.ng																						
18	Faculty of Science	sci.ui.edu.ng	1		1	1						1	1				1				1		1	1
19	Faculty of Social Sciences	socsc.ui.edu.ng	1		1	1						1	1				1			1			1	1
20	STEP B Project	stepb.ui.edu.ng																						
21	Faculty of Technology	tech.ui.edu.ng	1		1	1						1	1				1			1	1			1
22	Faculty of Veterinary Medicine	vet.ui.edu.ng	1		1	1						1	1							1	1		1	

#### 4. Accompanying set and web communicators

An expanded database of outlinks built by scanning the target set websites and the set of web neighborhoods, contains 21,600 outlinks. Analysis of the hyperlinks of the expanded database indicates that the accompanying set in our case contains 6,800 websites to which 20,670 hyperlinks point from the target set sites and the web neighborhood set. (Incidentally, this means that 224 Nigerian university websites (target set and web neighborhood set) are connected among themselves by 930 hyperlinks). However, about 5,500 accompanying set sites have only one link, while 700 sites -- two links from the target set and web neighborhood set. Moreover,



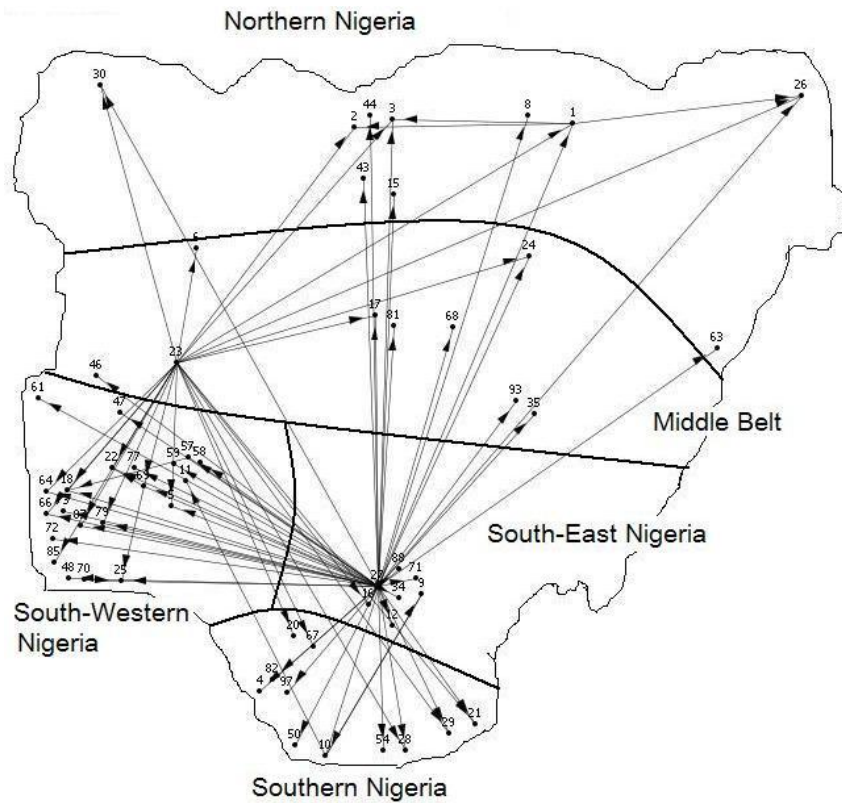
even the presence of more than 100 links pointing to the accompanying set site can only mean that such links are all pointing from the same target set site.

Only 14 accompanying set sites that are scientifically oriented, have hyperlinks pointing from more than 3 sites of the target set and the web neighborhood set. They are sites such as African Journals OnLine ([www.ajol.info](http://www.ajol.info)), National Virtual Library Project ([www.nigerianvirtuallibrary.com](http://www.nigerianvirtuallibrary.com)) and several others. Scanning these sites showed an almost complete absence of hyperlinks pointing from these sites to Nigerian university sites. Only one site fits the definition of a web communicator -- the National Universities Commission ([www.nuc.edu.ng](http://www.nuc.edu.ng)) -- which has links pointing to 15 Nigerian university sites, and 16 links pointing from 14 university sites. Later, we will show that this single web communicator has a very significant impact on the connectivity of the academic web of Nigeria.

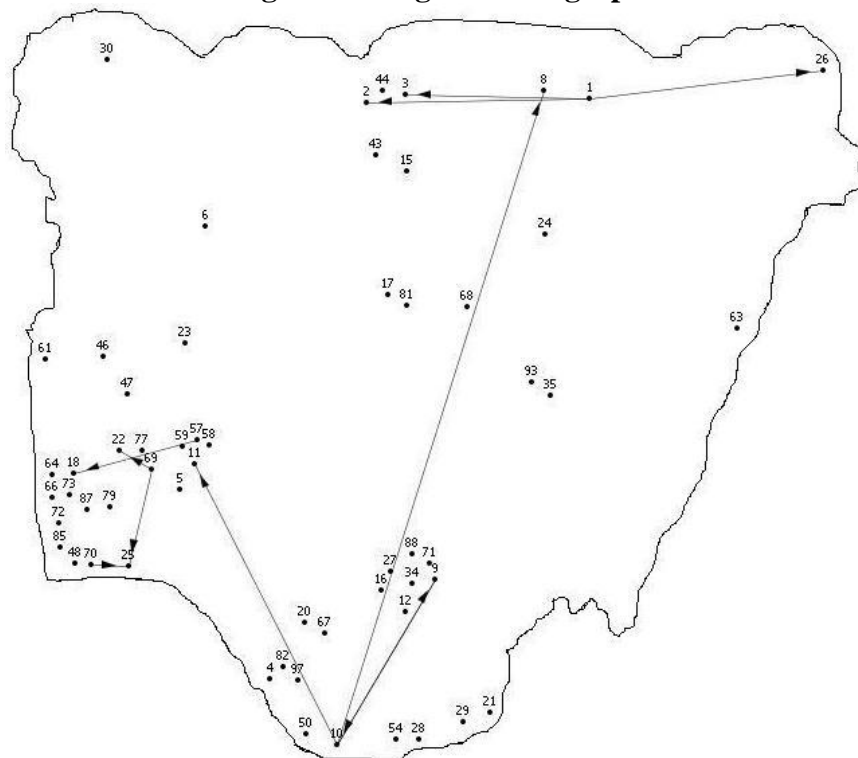
### **Nigerian academic web structure**

Figure 1 shows a webgraph with 79 vertices corresponding to the websites of the target set (not shown are 18 isolated vertices corresponding to the websites of the target set. They have no incoming or outgoing edges). An edge in the graph connects a pair of vertices if there is at least one hyperlink connecting the relevant websites. Regional boundaries are shown in solid lines. The lines are rather arbitrary and do not exactly correspond to the actual geographical boundaries. The number of incoming edges is very small: vertex 25 (University of Lagos, [www.unilag.edu.ng](http://www.unilag.edu.ng)) has 3 incoming edges. Four other vertices have two incoming edges, while the remaining 71 vertices have one incoming edge each (and as already mentioned, there are 18 isolated vertices).

The initial impression that the webgraph in Figure 1 has a good connectivity is false. Of the 79 vertices of the graph, 72 are pendant vertices (they have only incoming edges). Vertex 23 (University of Ilorin, [www.unilorin.edu.ng](http://www.unilorin.edu.ng)) has 23 outgoing edges, while vertex 27 (University of Nigeria, Nsukka, [www.unn.edu.ng](http://www.unn.edu.ng)) -- 46 outgoing edges. Removal of outgoing edges from these two vertices leads to a complete "disaster" (Figure 2) -- 65 more isolated vertices emerge.



**Figure 1. Target set webgraph**

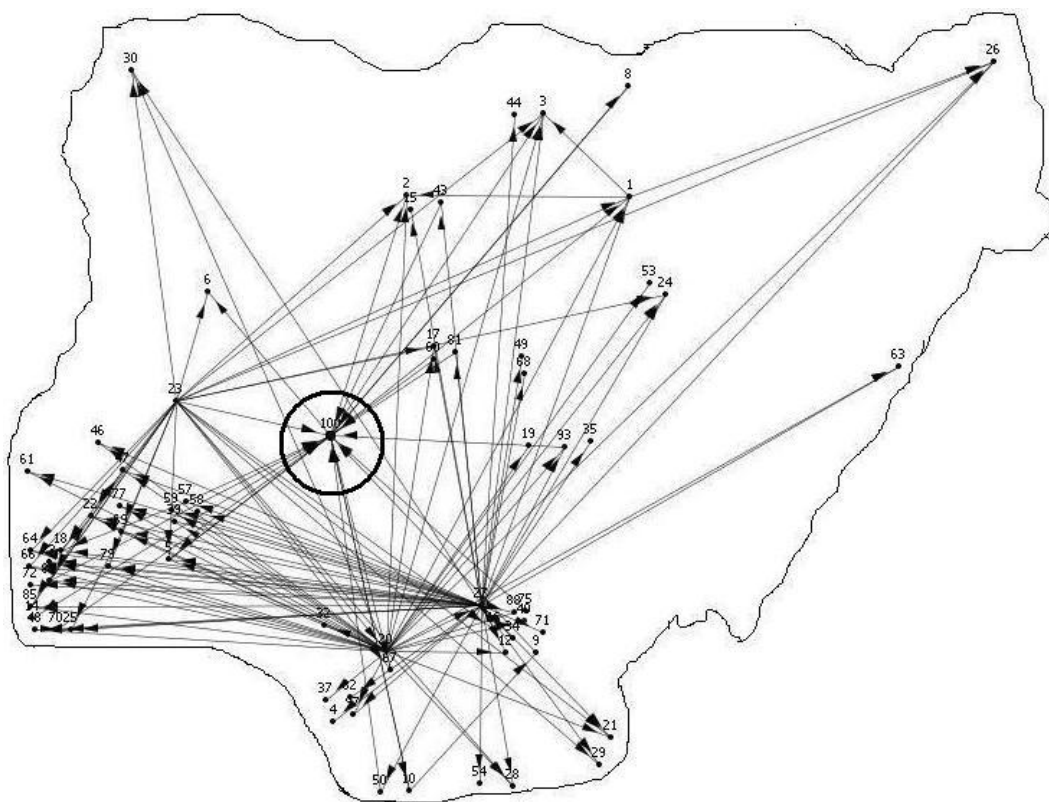


**Figure 2. Target set webgraph without vertices 23 and 27**

The webgraph connectivity is significantly improved if we replace the webgraph vertices with the units of analysis of the respective universities and add to them the only found web communicator (Figure 3).

The website of The 2011 edition of Nigerian University Games (nuga2011.uniben.edu) included in the unit of analysis '20' (University of Benin) is a good example of the effect on improving the connectivity of the webgraph. Indeed, there are some doubts as to its thematic focus, since the site is dedicated to the Nigerian University Games, held in 2011 at the University of Benin. Nevertheless, we left it as a good example of a communication activity for universities.

Still, the most significant improvement in the connectivity of the webgraph is achieved by adding to the webgraph the only found web communicator -- the website of the National Universities Commission (in Figure 3. it is given the number '100' and is highlighted by a circle).



**Figure 3. Webgraph on a set of units of analysis, with the site of National Universities Commission added**

The webgraph constructed based on the set of units of analysis of university sites with the site of National Universities Commission added, has the following graph-theoretical properties:

- number of vertices: 98,
- number of edges: 114,
- number of isolated vertices: 30,
- number of pendant vertices: 39,
- number of vertices that make up the maximal weakly connected components: 68,
- number of vertices that make up the maximal strongly connected components: 5.

The composition of the strongly connected components consists of vertices corresponding to the four universities -- Federal University of Technology (Akure), Federal University Dutse (Jigawa State), Federal University Ndufu-Alike (Ebonyi State), Federal University Otuoke (Bayelsa), -- and the National Universities Commission.

## **Discussion and Conclusion**

Our investigations showed that the Nigerian university web is generally a weakly connected set of 230-250 small websites with few outlinks. Such a sad description of the situation -- it may seem at first glance -- should not make us be pessimistic about the development of Nigeria's university web since its potential is already noticeable today.

Note that the official websites are means for publication of information open and accessible to web users and they perform communication functions between organizations (owners of such sites) and people (Berlin Declaration, 2003). Here it may be noted that all the Nigerian universities investigated have their own portals for teachers, students and university entrants. In addition, there is a good internal organization of the informational web spaces of several universities, the best of which is the University of Ibadan that can act as an example for many other universities.

Certainly, it is not very good when 150 university websites (out of 250) have less than 200 pages. However, the small sizes of many sites imply not really the absence of appropriate content at the universities, but the initial stage of development of the Nigerian university web (which has long been passed in America and Europe and is almost completed in Russia about 5 years ago). The small number of both inlinks and outlinks is a natural consequence of the small sizes of university websites, although this is not the only explanation. But here, Nigerian universities have the initial starting advantage over many other countries due to the fact that English is Nigeria's official language.

Thirty universities not having hyperlinks connecting them to other universities in Nigeria is also not a good sign. If you add to them 38 universities that have only incoming links, the picture looks really bad. However, it is worth paying attention to a very important factor: over the last 20 years, 68 new universities were established in Nigeria, with 32 of them between 2006 and 2011. Thus, it is not only the university web space that is at the initial stage of development, but also the university educational space of Nigeria. This fact is underscored by our investigation results as all the universities mentioned earlier with the largest number of inlinks and outlinks (and large number of pages) are federal universities established over 25 years ago.

The poor development of the university education space apparently has effect on the total absence of the websites of scientific conferences, joint projects, and regional councils of vice-chancellors in the university web space of Nigeria. We do not claim that such events and organizations are totally absent in Nigeria, but we are saying that they are not reflected on the Web. Meanwhile, these sites act as web communicators in the university web (Pechnikov, 2010).

This investigation allows making some recommendations to the management and IT experts of Nigerian universities.

First, a number of measures should be adopted to improve the system of domain names of Nigerian university websites. It is advisable that all universities should switch to the use of edu.ng as their top-level domains. Domain names and synonyms designating the same web resource (compare [www.aust-abuja.org](http://www.aust-abuja.org) and [www.aust.edu.ng](http://www.aust.edu.ng)) should be avoided.

Secondly, all the resources of a university constituting the neighborhood of the official website of that university should be direct neighborhoods of the official website, that is, their domain names should be sub-domains of the official website and they should be connected to the official website by direct and inverse hyperlinks.

Thirdly, special attention should be paid to the creation of web communicators. For example, in the case of a conference involving a large number of Nigerian universities, the conference website should contain links to the official websites of the participating universities. The same recommendation applies to all universities participating in the conference. Besides, the existing web communicator -- the website of National Universities Commission -- whose features are very poorly used today, should not be forgotten.

We hope that implementation of these recommendations will make the web resources of Nigerian universities better recognized in search engines, and improve the connectivity of the academic web space of Africa's most populous nation.

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