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## The Development of KPI for Measuring Internet Performance Quality

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### Abstract

Key Performance Indicators (KPIs) are measuring tools that can track performance. Most of the early researchers focused more on service quality and few others on performance dimensions from the management perspective. This performance measurement approach is incomplete as it neglects system users from the measurement. Therefore, there is a need to develop more performance indicators used to measure and benchmark internet performance based on users' satisfaction. To achieve this, the researchers studied different standard Information Technology (IT) indicators as well as the indicators pertaining to the environment within Universities. An extended enterprise user satisfaction model was applied by deriving the generic process and sub-process of the university. The means and ends of the variables were identified and the components were derived by applying general system theories. Nine performance dimensions and their performance indicators with content and attributes were derived. The developed performance indicators would help Benchmark internet services in the University of Ibadan. The Performance Indicators would provide concepts and guidelines on how to measure performances based on users' satisfaction, facilitating easy decision making.

**Key words:** Key Performance Indicators (KPIs); Internet Performance; University Internet Network Benchmarking (UINB).

### Introduction

For an institution to grow, it has to apply the principles of business, by focusing on the key performance indicators. According to [1], "performance indicators can be a very useful tool in helping to answer the questions: how do you know what you are achieving and how your service can improve its performance?" A Performance Indicator can be a vital tool that maintains high organizational efficiency and effectiveness[2-4].

As recently identified by the Management of the University of Ibadan, accurate feedback is necessary for internet service improvement within the university. Combining the right set of parameters and indicators to generate the right feedback for performance evaluation is very crucial for service improvement [5,1]. However, as far as internet performance is concerned, there are various factors to be considered. Internet performance can be measured

from different users' perspectives. It could be measured from the network Administrator's perspective or from the internet user's perspective.

However, recent internet performance measures have been based on the network administrator's perspective. The network administrator is equipped with various tools to measure, and monitor the internet performance with regards to the current network infrastructure reading and not on the user perception of service. This situation is out of place as the measure of internet performance should be tailored more for the user.

Performance indicators have been widely used in different fields and a lot have been developed based on the indicators within the fields. Performance indicators have been developed mostly in the areas of health [6-8]; Education [8,9]; knowledge management [4], ICT used in Education[9-11] and business [12]. This is because the need for



reliable and consistent performance indicators was recognised in these areas, and these needs were converted to the fulcrum around which performance indicators were constructed.

According to [13] "Individuals, departments, and companies must track their performance in order to have a baseline and comparator for improvement over time. KPIs (Key Performance Indicators) are a great baseline for understanding historical performance, setting future expectations, and keeping the team on the competitive edge"

In 1991, Robert Eccles predicted that within the next five years, there would be a shift from treating financial figures as the foundation for performance measurement. Every company will have redesigned how it measures its business performance to focus on a broader set of key performance indicators as the foundation. The private and public sectors have welcomed the idea, to a greater or lesser extent which further reveal the importance of performance measurement in the financial sector [14].

From the educational perspective, indicators are concrete items that predict the outcome of educational operations and describe the important features of an educational system [15]. Scholars differ in their views of educational indicators, but many schools classify educational performance indicators into five models[16], while the educational indicators are divided into three, input, process and output in an integrative educational system [15, 17-19]. Kaufman [20] included products and outcome as indicators. Bunting and Cloete [18], used South Africa as a case study to develop performance indicators for higher education that would help measure institutional performance that would spell out in clear and precise ways. The performance indicator focused on was student output. These performance indicators can contribute to institutional improvement and stakeholder groups having access to information that can help them shape the course of the institution. According to different fields practitioners and academia, it is believed that for a complex and varied educational domain, many systems of indicators are needed to be constructed to provide a correct picture of education [14, 21,22].

For a manager, indicators are tools for evaluating and measuring the operational performance of a system [16, 23]. Lin and Wei [4] intended to discover the main elements related to the KPIs of knowledge management and propose items that can be considered when evaluating both short-term and long-term knowledge management performance. Lin and Wei concluded that strategy, and planning, implementation and process, knowledge and performance evaluation must be stressed when

appraising the key performance indicators. The ICT sector is not left out. However, research is ongoing in developing KPIs in ICT. Atkinson [24] explored a broader set of performance measures that led to establishing a framework and process for implementing a performance measurement system in an IT department within the context of the UK Health Service. The performance indicators were customers, suppliers, employees, processes, technologies and innovation with past performance measures, and financial measures.

Alexandra and Brad [25] used performance indicators to assess the technical professional performance of IT professionals of different employees and found out that the levels of performance are quite small. Based on the analysis, the computed performance key indicators could be integrated into an online competency assessment tool, since the difference in the levels of performance is fairly small. This shows that, no matter their level of performance, the employees of the IT company had similar features and characteristics. The main factors used were Methodical, Personal-Social and Strategic-Organizational performance indicators.

Drost, Harmsen, Brinkkemper and Versendaal [21] developed a framework for IT performance management of the organisations. To optimize and benefit the IT performance and management was to answer a question on how KPIs are used, why and what are the results? The researchers discovered KPIs are made explicit and measurable and were developed by their employees. Haizan, Alinda and Azizah [22] developed KPIs as a model intended to provide ideas and guidelines for the purpose of measuring ICT support services. The quality of factors and attributes from ICT was reviewed before relevant KPIs were developed. The investigation was done within the context of Malaysian Universities (MUs). While getting the empirical data within the context, interviews were conducted among the ICT support services and stakeholders.

According to [26], "the practical problem of measuring end-to-end Internet performance has received surprisingly little attention". This is true of Nigeria, in the University of Ibadan. In Nigeria, key performance indicators are yet to be developed for the Information Technology of University system [27]. For [28], KPIs consider that all the time, the key performance indicators must be monitored and updated according to the organizational strategic objectives.

Also, in situations where the network administrators are not paid from the bills of the users, they do not consider users when measuring performance. The needs and requirements of all parties involved in the network tend to be

contradictory many times. This observation motivated the need to consider various perspectives and dimensions of performance in network performance measurement. It is necessary to derive performance indicators for each dimension of internet usage and performance measurement given that the university internet infrastructure and usage has been increasing.

The study attempts to develop performance indicators that would help measure end-to-end Internet performance in universities based on users' satisfaction. This will promote the effectiveness of internet services rendered in these universities.

## Materials and Methods

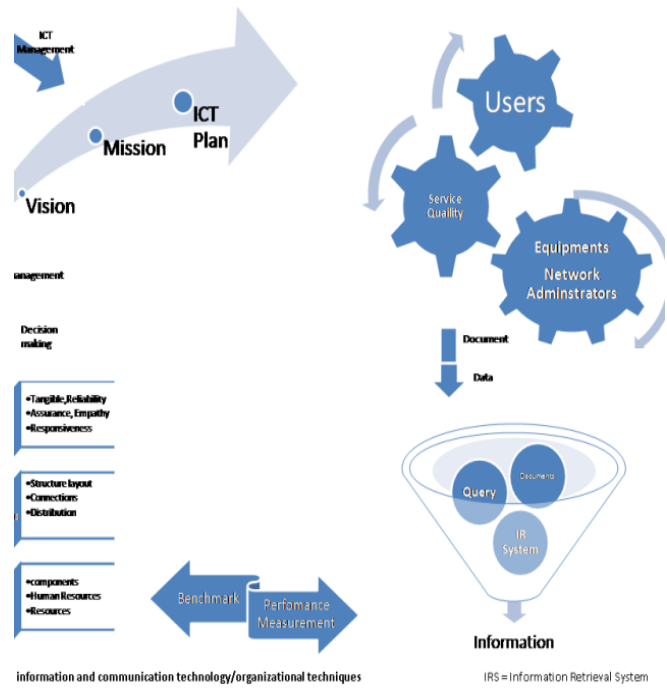
Appropriate performance indicators were developed by studying different standard Information Technology (IT) indicators, and also the indicators pertaining to the environment and the University available. Interviews and Focus group discussion with the network administrators and observations were carried out and an extended University Internet Network benchmarking (UINB) model was built, before deriving basic comprehensive performance processes [29].

Purposely selected, five key network administrators were interviewed, while another six were engaged in Focus Group Discussions (FGD). Seventy users responded to the users' expectation and perception statement. Altogether, the human sample for the pilot study was eighty-one. The interview guide contained 15 open-ended steering questions aimed at directing the course of the interview. Follow-up questions were asked as the need arose. The steering questions dealt with respondents' concept of performance of the Internet, the Performance Indicators and the ways they were measured.

The Focus Group Discussions (FGD) with Network Administrators was preceded by invitation of the discussants and provision of other necessary logistics by research assistants. During the FGD, the researcher informed the discussants on the purpose of the meeting and gave clarifications where needed. However, the discussion was made flexible by allowing side comments and brief discussions. Then as the discussion progressed, notes were taken by the researcher. Each FGD session lasted for about one hour. The FGD was for Network Administrators.

Structured Interview was scheduled for University Network Administrators to get the documentation details of the University Network. The instrument was based on the structure of the Internet Network, equipment, precaution, maintenance of Network equipment and the staffing.

The Internet performance was monitored for both times when electricity was available and also when electricity was not available. The tests were carried out at the Information Technology unit and at the Departmental level. The researchers also monitored the internet performance at different periods of the day and investigated the internet performance at the different nodes when using wireless and optic fibre networks. Furthermore, the researchers interacted with the Network Administrators and the users, and inspected the equipment on ground. The above step was adapted from the extended enterprise model (Browne et al.) cited by Andersen and Jordan [12]



**Figure 1:** The General Conceptual Framework (UINB Model). Source [29].

A generic model was built to show the pictorial view of the network layout on campus and the generic processes. This was followed by the definition of performance indicators for each dimension of measurement and for each generic process where appropriate, as shown in Figure

## Generic Processes and Sub-Processes

For each process in the Internet generic processes, an indicator for each dimension of measurement was derived. These also served as other steps taken in developing performance indicators. Figure 2 shows the Relation among the different processes of an Internet Setup. This shows the importance of each unit towards the quality of internet performance.

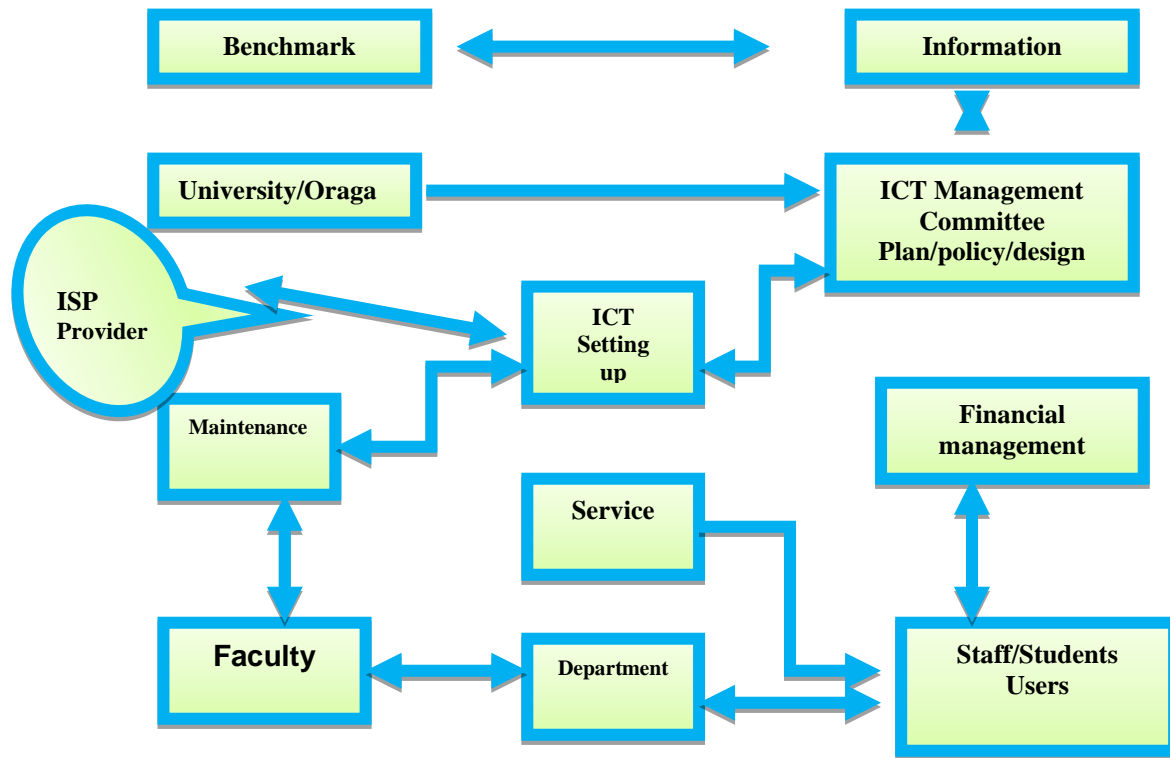


Figure 2: Relation among the different processes of an Internet Setup. Source [29]

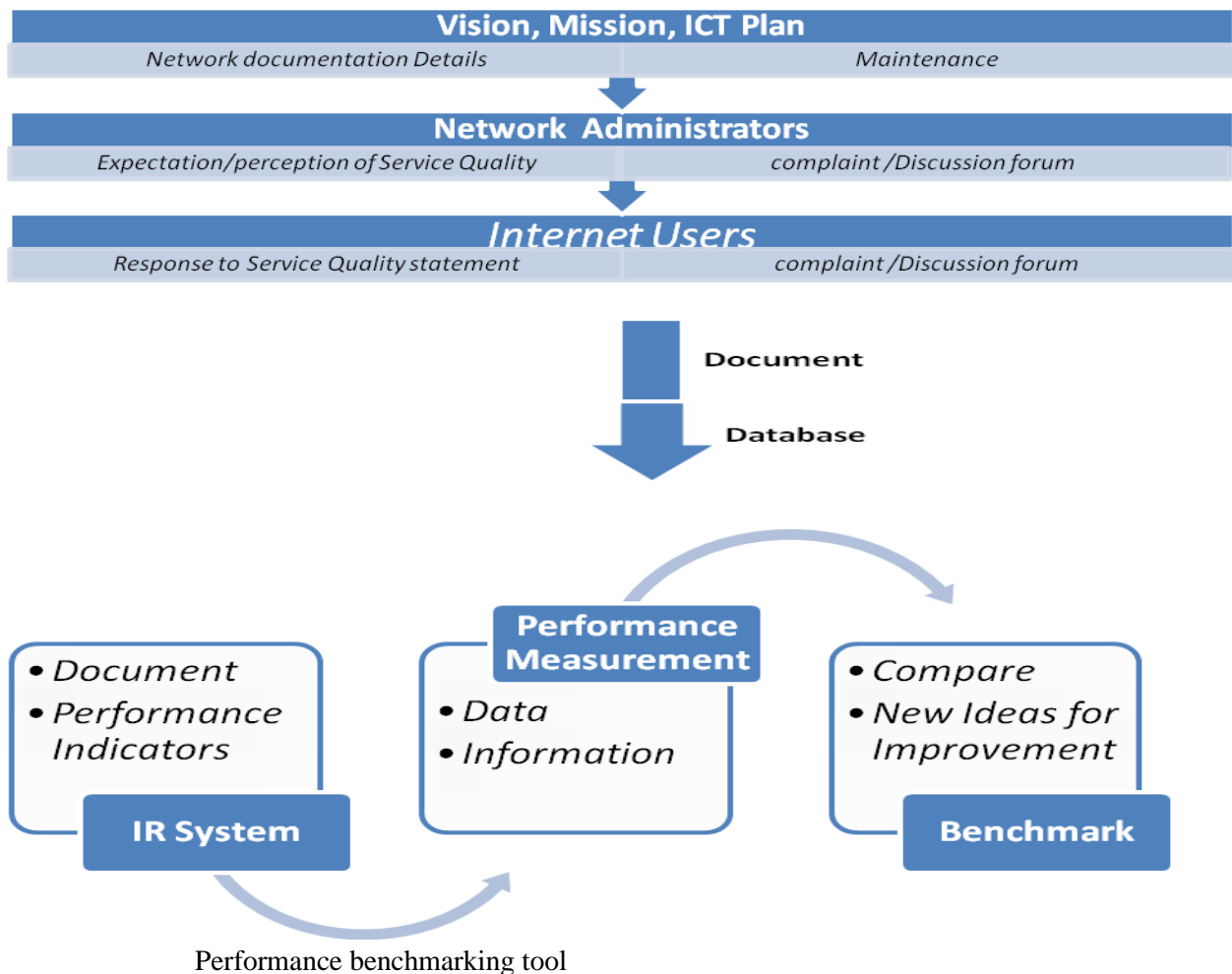


Figure 3: Different areas of information and Data processing. Source [29]

**Performance Indicators Necessary**

Another step in developing performance indicators was to design and identify the dimensions of the performance to be measured. Figure 3 shows the different levels of data organisation within the university. It also revealed where and how data was gathered for the subsequent analysis in this work.

Additionally, the philosophy of the University on IT was identified. This step was followed by providing criteria for determining success or failure and determining useful evaluation. The performance indicators usually target means and ends. By ends it means results, consequences, performances, and payoffs. The means refers to how a thing gets done; which includes the processes, the methods, the techniques or resources, the personnel involved, the finances and facilities [20, 30, 31].

For the current study, in order to develop performance indicators that would be useful for

Nigerian universities and not just University of Ibadan. It was important for the researchers to interact with other Network Administrators and identify the following elements:

- Inputs
- Processes
- Product
- Output
- Outcomes

The five elements were classified into means and ends of the University Internet Network in Table 1. In developing performance indicators, the means and ends of the University Internet network variables were identified and the components were derived as shown in table1. This was done by applying general systems theory to the inputs, processes, products, outputs and outcomes to overall quality perceptions.

**Table 1:** Classification of five elements into means and ends

Means		Ends		
Input (Raw material) Available or required resources values and philosophy needs. Aims and objectives which specifically state what is to be achieved in relation to their needs.	Processes (how-to-do-it) methods, means employed to get results (performing a job correctly or using the right tools) Identify each step in the service delivery process and what and how to achieve at each step	Product building blocks of organisational contributions	Outputs (the aggregated products of the system that are delivered or deliverable to society)	Outcomes The effects of outputs on and for society and the community)

**Research Findings**

This was followed by deriving the generic processes after which the performance indicators were developed from the performance dimension. Service quality, user log and complaints problems were analyzed [34]. More of the performance indicators were identified and other measurements of performance were carried out.

*Performance indicators*

In developing key performance’s indicators, the dimensions of performance are identified. The means and ends of the University Internet network variables were identified and the components were derived. This was done by applying general system theory to the inputs, processes, products, outputs and outcomes to the overall quality perceptions. General systems theory is a research paradigm which attempts to facilitate the generalization of behavioural principle across a wide range of organisations that leads to KPIs as internet variables.

**Results and Discussions**

Based on the investigation, study and analysis carried out on the performance dimensions, the performance indicators necessary for University’s internet set up were listed in Table 2. The content of each performance indicator was explained [29]. The research previously identified and described how KPIs on each performance dimension had been carried out to help benchmark an Ideal University Internet Network (IUIIN)[29]. The table showed the Performance dimensions and its performance indicators, that were useful for measuring performance and benchmarking; Table 3 shows the summary of dimensions of performance and its performance indicators based on the University Internet Network.

Table 3 shows the derived attributes of each performance indicator of the University Internet Network. The attributes for each performance indicator were identified and defined for easy measurement or evaluations of the system. The attributes have a particular aspect for measuring the Internet Performance.

**Table 2:** The University Internet Network variables

Means	Ends
<p>Input</p> <p>Finance; availability of funds to implement project as planned by the budget environmental conditions such as resource dependence, complexity, and turbulence. Cables, Fiber optics, Routers, Switches, server, computers, ISP up-to-date equipment and in good working order. Availability of services such as; Help desk, Technical support, Hardware and PC repair, ICT training, information supply ICT, Free software download, Upgrading software/version control Hotline services**</p>	<p>Processes Transactions, communication flow, and coordination patterns (how-to-do-it) methods, means employed to get results (performing a job correctly or using the right tools) Identify each step in the service delivery process and what and how to achieve at each step, Get an ISP, connection Distribution to Faculty, requirements Registration/payment Control Service production process, service accessibility, availability and provider's courtesy, friendliness and willingness to answer questions are aspects of process quality.</p>
	<p>Products building blocks of organisational contributions Internet Access</p>
	<p>Outputs (the aggregated products of the system that are delivered or deliverable to society) Connectivity. Feedback, the ability to send, receive email, download research material on time. Getting the expected services.</p>
	<p>Outcomes Functional and socio psychological goal, benefit, dependability and reliability. The effects of outputs in and for society and the community) Financial Management Meeting deadline of email, research, paper submission, the gain by having more knowledge to teach and having papers for promotion. Being able to meet up in assignments Being satisfied with the expected services</p>

The performance dimensions developed with performance indicators gave a better pictorial view of how the system works. This would help identify the most important performance dimensions and indicators that are necessary for improvement. A benchmark database would be developed. The collected data for the benchmarking system would be based on the developed performance indicator and it would be used in monitoring the network of the University in accordance with Smith [32] using its benchmark database to monitor the University network for performance. Cullen [33] also stresses the need for the benchmark database and Performance indicators as obvious and exigent as the important factors needed for proper Benchmarking.

According to Shaw [34], authors from differing management disciplines categorise the various performance indicators that are available. The specificity of the measure was influenced by the level within the University/organization at which the plan is being developed such as, the measure reflecting an important university-wide performance

dimension and leads to improvement. Above all, the measure can be widely communicated to and understood by a wide audience [30, 35].

This paper focused on the development of performance indicators for Internet networks within Universities. The University of Ibadan, Nigeria, was used for the pilot study. The indicators of performance to be measured when benchmarking University Internet Networks were determined. The performance indicators would be used as a guide to ensure that each process is focused on the improvement of an enterprise in all the important aspects of performance. Following the identification of indicators and dimension of performance, the network partners will open up very promising opportunities to benchmark partner's searches and best practice information access. The Networking partners all over Universities would work as a team in helping to build a good Internet Network. Almost all the Universities have Internet Network; therefore, there is the tendency to proceed with the benchmarking performance model.

**Table 3:** Summary of Performance Dimensions and Performance Indicators and its content

<b>Performance Dimensions</b>	<b>Performance Indicators</b>	<b>Each performance indicator content</b>
Network Management	Plan	Researching/plan, Information Communication Technology (ICT)Policy, designing a LAN and Setting up
Service Quality	Tangible Access Communication Responsiveness	<b>Infrastructures</b> such as equipment, facilities, staff outward show Convenient and easy ways of connecting to the Internet Giving feedback, suggestions and having time for users; Readiness to provide Internet and ready to solve problem promptly
	Courtesy Security	Having a character and friendly staff-user relationship. Physical safety for equipment and staff; privacy and confidentiality of users' password and information
Users' Log	Credibility Competence Reliability Distance Session Time Upload Download Terminate Cause IPAddress Network	Integrity and trustworthiness Ability and knowledge to make internet available 24 hours dependable quality Internet The distance between the nodes and ICT centre The session time a user's login The total input a user uses within a given session time The total output a user uses within a given session time The cause of the Internet termination Internet protocol of each address Wireless and fibre optic network
Complaint form	Problem Causes Feedback	The problem a user has while browsing Reason the user is experiencing the problem The rating of Internet performance from users
Maintenance	Routine check Antivirus Documentation Equipment Backup	Number of times maintenance is provided at the nodes Antivirus installed on systems Documentation of failure and success Replacement of Equipment Backing up important document
Equipment	Router Switch Cable Wireless card Fibre Optic Working tools	Condition and Performance of Router Condition and Performance of Switch Condition and Performance of Cable Condition and Performance of Wireless card Condition and Performance of Fibre Optic Tools needed by network administrator
Speed	Throughput Bandwidth Packet loss Latency	Monitoring of the Throughput Monitoring of the Bandwidth Monitoring of the packet loss Monitoring of the Latency
Finance	Funds Bills Support	Vote from the University for ICT Payment by the users (dues) Grants or funds raised
Innovation	Performance	Performance of the innovation process, performance of individual innovations

**Table 4:** Attributes of each performance indicator based on the University Internet Network

Performance Dimensions	Performance Indicators	Attributes each performance indicator
Network Management	Plan	Is the LAN design of the standard? Researching/plan, Information Communication Technology (ICT) Policy, designing a LAN, Setting up an ICT policy, plan, vision, mission, and strategies to prevent & eliminate gaps
Service Quality	Tangible	<b>Infrastructures</b> such as equipment, facilities, staff outward show
	Tangible	No. of modern equipment in place
		No of centralized licensed antivirus
		No. of up-to date Antivirus on user systems
		No. of times maintenance is carried out within a month
		No. of times documentation is carried out when the system is good or bad
	Access	Convenience and simple ways of connecting to the Internet
		Giving feedback, suggestions and having time for users;
		No. of staff to give customers individual attention
		No. of operating hours users have to browse
		No. of the operating hours made available
		List of necessary equipment users should have
		Communication
		No. of training programmes for their users
		List of specific needs of their users
		No. of the users' need understood
		No. of users' need solved
		Readiness to provide Internet and ready to solve problem promptly
		No. of easy flexible access staff users have per day
		No. of easy flexible access to student users per day
		No. of easy flexible access to University community
		An IUIN should offer users the exact internet services they have paid for
	Responsiveness	Time internet service is not available
		The time communicated to users when the services are faulty
	Assurance	Index of willingness to help users in a courteous manner
		An IUIN should never be too busy to respond to customers' requests
		Index instils confidence in staff
		Access to the Internet 24 hours in the Faculty/Department/Units same as the ICT office
		No of regular training for staff within a year
		No. of staff with skill course certificate (innovative and creative skills, technical skills and communication skills)
	Security	Physical safety for equipment and staff; privacy and confidentiality of users' password and information
	Credibility	Integrity and trustworthiness, information on usage guide line.
	Competence	<b>Ability</b> and knowledge to make Internet available
	Reliability	No. of staff involved in developing and maintaining ICT
		No. of staff involved in offering excellent services to users
		No. of reward received by staff developing and maintaining ICT
		No. of reward received by staff offering excellent services
		No. of successful completed service as per time frame User satisfaction index based on service implemented
		internet quality speed satisfaction index User satisfaction index based on internet quality speed
		No. of hours internet is available
		24 hours dependable quality Internet
Users' Log	Distance	What is the distance between the nodes and ICT centre?
	Session Time	No of session time a user login
	Upload	The total input a user uses within a given session time
	Download	The total output a user uses within a given session time
	Terminate Cause	What is the cause of the Internet Termination?
		No of times Internet Terminates
	IP Address	Internet protocol of each address
	Network	What type of Network (Wireless and fibre optic)
Complaint form	Problem	No of complaint.



		What problem does a user experience while browsing?
	Causes	What is the cause of the problem the user is having?
	Feedback	The rating of Internet performance form users
Maintenance	Routine check	Number of times maintenance is provided at the nodes
	Antivirus	What antivirus is installed on systems?
	Documentation	No. of failure period within a day No. of success period within a day
	Equipment	No of Equipment replaced
Equipment	Backup	What important document are you backing up?
	Router	Rate Condition and Performance of Router
	Switch	Rate Condition and Performance of Switch
	Cable	Rate Condition and Performance of Cable
	Wireless card	Rate Condition and Performance of Wireless card
	Fibre Optic	Rate Condition and Performance of Fibre Optic
Speed	Working tools	No of latest aid tools needed by network administrator
	Throughput	What is the expected output? What is the current output?
	Bandwidth	What is the expected Bandwidth? What is the current Bandwidth?
	Packet loss	What is the expected packet loss? What is the current packet loss?
	Latency	What is the expected Latency? What is the current Latency?
Finance	Funds	Vote from the University for ICT
	Bills	Payment by the users(dues)
	Support	Grants or funds raised What is the budget?
Innovation	Performance	Performance of the innovation process, performance of individual innovations No. of units with complete documentation clear work process No of projects No. of completed projects with documentation. No. of services with complete documentation No. of periodically maintenance a year No. of maintenance documentation
	Type of Services	No. of type of service available to showcase per year No. of users have access to the showcase No of service market to university communities No. of users making use of the services

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