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Green Computing in Communication Networks

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ABSTRACT
Currently in networking field green computing technology has made a great impact in the environment, which makes it more efficient and proper use of network resources and less consumption of energy. The concept of Green computing technology in communication network is explained here. The computing technology is considered over communication network and this communication network is broadly categorized as infrastructure (wired) and wireless networks, also called as ADHOC network in which mobile nodes and sensor nodes are responsible for communication. In this work there many different technologies are discussed which emphasize on green computing, related to both the type of communication network and also provide an overview of network energy saving studies in different areas which are involved in data transformation.

General Terms
Green Network Technology, Energy efficiency.

Keywords
Green Computing in computer networks, Energy consumption in datacenters, efficient memory usage, low radiations in cellular network through green technology.

1. INTRODUCTION
The Reduction of unnecessary energy consumption is becoming a major concern in communication network because of economical, environmental and marketing reasons. Due to this primary issues are considered, which discuss about why to save energy, where it should be applied and on what point of views it is been considered[1].There has been tremendous growth in communication networks market both in infrastructure and wireless field. The number of users demands for data service through cloud application for their own requirement, where as in cellular network [2] subscribers demands for cellular traffic have escalated astronomically with the introduction of Android and iPhone devices. Green networking is the practice of selecting energy-efficient networking technologies and products, and minimizing resource use whenever possible. With the introduction of device as stated above, the next-generation wireless networks are expected to provide high-speed Internet access on-demand [3]. Due to this requirement of performance the popularity of the iPhone and other types of smart phones is doubtlessly accelerating the process and creating new traffic demands, such as mobile video and gaming. In IT service sectors and organizations data services are significantly increasing the energy consumption of communication networks without increasing revenues. In wired networks the need of multitalented operations on network to provide services to their customers will be the challenging issue. And in case of wireless mobile network services [4], as the operator and manufacturer perspectives, there are increasing energy costs with larger base station site densities and rising energy price trend.

As per definition of green computing for communication network given previously, it is been abbreviated as green communication network [9]. green communication network comprises a variety of electrical equipment, including network devices, network peripherals, customer electronics, electrical fans or other cooling systems, and more. Figure 1 shows a block diagram of the solutions for green communication networks in which efficiency of the hardware devices as an organic system plays an essential role in reducing the energy consumption of the system, even by exploiting advanced communication techniques power transmission efficiency can be significantly improved.

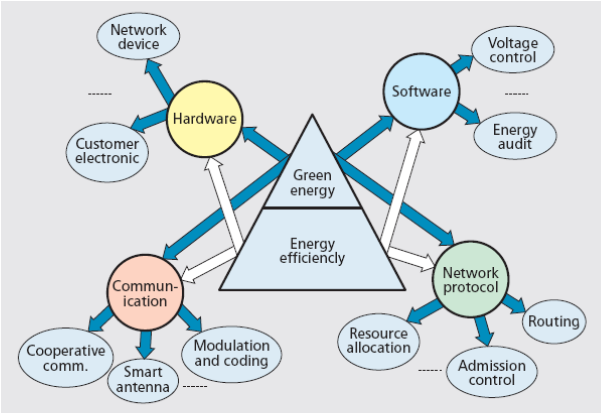


Fig 1: Solutions for green communication networks [9]

The main purpose of green computing is to investigate new computer systems, computing model and applications with the low-cost and low-power-consumption and promote the sustainable development of economy and society. Due to the explosive growth of the Internet and decreasing cost of computer hardware leads to requirement in development of variety of applications from different domains. As human beings increasingly depend on the IT systems, the problem of energy consumption in IT industry becomes more acute. Although green computing is becoming increasingly important in communication network systems, it has challenging problems to network designers.

2. HISTORY OF GREEN COMPUTING
The importance of green technology was made evident when computing attained critical mass in the early 1990s. In 1992, the U.S. Environmental Protection Agency launched Energy Star, a voluntary labeling program which is designed to promote and recognize energy-efficiency in monitors, climate control equipment, and other technologies.[5]Energy Star applied to products like computer monitors, television sets and temperature control devices like refrigerators, air conditioners, and similar items. This resulted in the

widespread adoption of sleep mode among consumer electronics. The term "green computing" was probably coined shortly after the Energy Star program began; there are several USENET posts dating back to 1992 which use the term in this manner. Concurrently, the Swedish organization TCO Development launched the TCO Certification program to promote low magnetic and electrical emissions from CRT-based computer displays; this program was later expanded to include criteria on energy consumption, ergonomics, and the use of hazardous materials in construction. A landmark event in the history of green technology is the 1997 Kyoto Protocol [6] for the United Nations Framework Convention on Climate Change. The European Union's adoption of Restriction of Hazardous Substances (RoHS) [7] in February 2003 is a landmark in the history of green computing. The Green Electronics Council established in 2005 focused on special issues related to electronics and sustainability, and sought constructive paths.

This green computing concept emerged naturally as businesses find themselves under pressure to maximize resources in order to compete effectively in the market. This movement arose mainly from economic sentiments rather than political pressure [8]. Strategic Leaders take into account the social and environmental impacts of new and emerging technologies. Aside from minimizing costs, this particular movement also takes into account other factors such as marketing and branding. Unlike the position held by tactical increment lists, strategic leaders recognize the need to overhaul some existing policies or structural makeup of the organization. This can be seen in recent efforts to make IT personnel directly responsible for managing, minimizing and ensuring efficient energy expenditures.

3. GREEN COMPUTING IN IFRASTRUCTURAL NETWORK

As the new generation networking environment is taking shape, energy efficiency has pervaded the network infrastructure as a whole, to such extent as to become part of the network design criteria, and to carry across multiple networking domains for the achievement of a general target. A common opinion among green networking community is that the sole introduction of low consumption silicon technologies may not be enough to for drawing ahead current network equipment towards a greener networking environment. As a consequence, the problem of energy efficiency of networking environment is a concern as in other green computing areas.

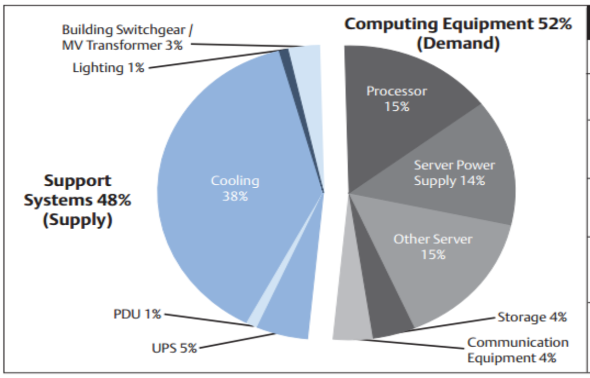
In the Infrastructural network, consumption of power, bandwidth and memory and resource utilization is the key issue. In large data center which is a facility used to house computer systems and associated components, such as telecommunications and storage systems the power consumption of these housed components are considered to start the energy saving process because everybody knows that data centers are becoming one of the major consumer of electricity in the industrialized world and the trend is set for it to rise even higher.

3.1 Power utilization in datacenters

Green Datacenters mainly focused on reducing energy use while serving the explosive growth of the Internet. Most data centers use just as much non-computing or "overhead" energy (like cooling and power conversion) as they do to power their servers. When social networking has come into operation, it had a quaint 10 million or so users and the one main server site. Today, the information generated by nearly one billion people requires outsize versions of these facilities, called data centers.

Most data centers, by design, consume vast amounts of energy in an incongruously wasteful manner, interviews and documents show. Online companies typically run their facilities at maximum capacity around the clock, whatever the demand. As a result, data centers can waste 90 percent or more of the electricity they pull off the grid. If we compare the average data center with the average office we can see that a data canter consumes around fifty four times more energy on a square meter by square meter basis. Each 600x600 mm floor tile on an average computer room floor represents the equivalent of 1.2 tons of carbon dioxide released into the atmosphere every year.

Emerson Network Power [11] modeled energy consumption for a typical 5,000-squarefoot data center depicted in Figure 2 and analyzed how energy is used within the facility. Energy use was categorized as either "demand side" or "supply side."



Category	Power Draw*
Computing	588 kW
Lighting	10 kW
UPS and distribution losses	72 kW
Cooling power draw for computing and UPS losses	429 kW
Building switchgear/MV transformer/other losses	28 kW
TOTAL	1,127 kW

Fig 2: Analysis of a typical 5,000-square-foot data center shows that demand-side computing equipment accounts for 52 percent of energy usage and supply-side systems account for 48 percent [11]

3.2. Bandwidth shared among Datacenters

Data centers are typically provisioned for peak workload, and run well below capacity most of the time. Traffic varies daily based on the applications used. Rare events like cable cuts or celebrity news may hit the peak capacity, but most of the time traffic can be satisfied by a subset of the network links and switches. These observations are based on traces collected from two production data centers.

Data centre is the foremost ingredient of the cloud computing. Cloud computing is the term used to refer “almost anything “can be accessed [12]. In cloud computing environments, the trusted and non trusted tenants deploy their services in a shared datacenter infrastructure. The services which provided by clouds use a shared data center because physical equipment is expensive, costing over 100 M a year to maintain and because statistical multiplexing using Virtual Machines (VMs) is effective. NetShare [13] a mechanism for data center networks that requires no hardware changes to routers but allows bandwidth to be allocated predictably across services based on weights. NetShare allows managers to use weights to tune the relative bandwidth allocation for different services, providing isolation and statistical multiplexing without changing routers.

The multiple hosts use the services from the multiple cloud vendors. Each cloud vendors are specialized in allocating the resources and rebalancing the overloads. The different bandwidth mechanisms and their usages are listed below as per [14]:

1. Fair-Share Bandwidth allocation
2. TCP
3. Bandwidth Capping
4. Secondnet
5. NetShare [13]
6. Approximate Fairness- Quantized Congestion Notification (AF-QCN)

3.3 Memory storage in cloud

Cloud computing is one of the most explosively expanding technologies in the computing industry today. However it is important to understand where it came from, in order to figure out where it will be heading in the future. Memory storage is one of main concern in cloud computing along with the other services like SaaS (Software as a Service), IaaS (Infrastructure as a Service), PaaS (Platform as a Service) and RaaS (Routing as a Service). In cloud computing environment End-user generates a service request for selecting memory of service based resources required. RAM size is controlled automatically using memory on demand technology. The cloud keeps fixed free RAM size in virtual machine and increases or decreases RAM size when needed. So the users need pay only for used RAM for their services. These are virtual resources, available over the Internet. Instead of storing all the services within end-user’s machine, it is better to allow end-user to use the external memories which are available in the cloud. A transparency mechanism is proposed in [15] in which it enables users to access memories depending on the predefined criteria. Transparency is used as a virtualization, where multiple memories of several resources appear to the user as a single unit. This enables the users to access services in a workflow manner, using different types of memories. It is observed that cloud service based memory utilization has been an effective technique for allocating the memories in a cloud computing environment.

3.4 Hardware Utilization

Typically networking hardware includes gateways, routers, network, bridges, switches, hubs, and repeaters. When it comes to monitoring a network, most of the emphasis traditionally seems to be placed on the servers. Although it is important to keep tabs on your servers' performance, it is also important to monitor hardware devices such as switches and routers. After all, these devices make up the backbone of your network. We need to be able to tell not only that these types of devices are functional, but also that they are not being saturated by excessive traffic. When it comes to monitoring hardware utilization, switches present a special problem. In the normal method for measuring network utilization, a sniffer monitors packets of data as they flow across the network. If nodes on a network are connected by a hub, it is possible to plug a sniffer into an empty port on that hub and monitor all of the traffic that flows through it. This is because all the nodes that are plugged into a hub share a common collision domain. When a node transmits a packet of data, that packet is sent out through the hub's ports and is received by every device connected to the hub.

IBM takes an open, standards-based approach to implement the latest advances in today’s flat, converged data center network designs given in its networking solutions [16]. IBM’s Unified Fabric Architecture (UFA) is a fast, smart, interoperable and proven data centre Ethernet network fabric. It is designed to reduce the cost and complexity of deploying physical and virtual data centre infrastructure.

4. GREEN COMPUTING IN WIRELESS NETWORK

Wireless systems, which include cellular phones, have become an essential part of the modern life. With the development of cellular networks, 4G (LTE/WiMAX) has been implemented in order to meet the people’s demand for high information rate. With living standard’s improving, green communication is becoming more focused, for the reasons of less radiation and less communication cost.

4.1 Green antennas for low radiations in Cellular Network

As cellular networks develop, Peer-to-Peer (P2P) wireless networks such as Ad Hoc and Wireless Sensor Networks (WSN) emerge and develop drastically. Techniques based on cooperation and relay has been brought into P2P networks that lack energy. So the problem of minimum energy is put on the agenda, where the problem of minimum energy broadcast draws more attention.

Most wireless and cellular networks adopt an architecture that is based on transceiver Base stations the Green Cellular approach [17] suggests the augmentation of transceiver Base stations with receive only devices. Green Antennas as depicted in figure 3.b are employed to reduce the transmission power of Mobile stations in their proximity. In order to minimize exposure to cellular radiation, the Green Antennas are to be connected to the network infrastructure via wire line or highly directional point-to-point microwave link. This does not require a reorganization of the network but rather implies an augmentation of the existing network with Green Antennas.

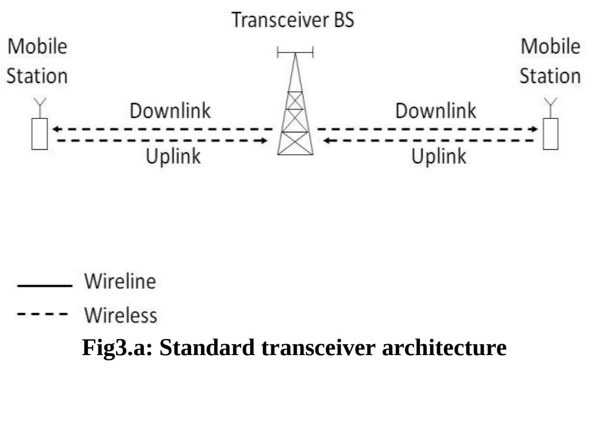


Fig3.a: Standard transceiver architecture

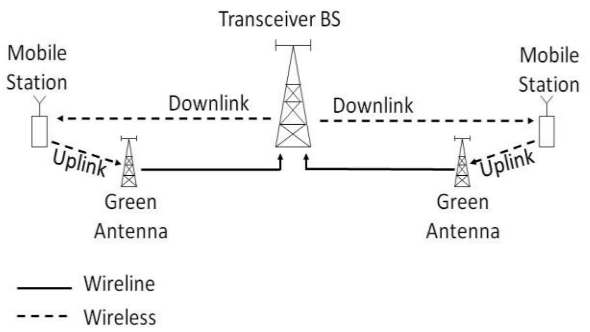


Fig3.b: The Green Cellular architecture

4.2 Power consumption in wireless network

Methods of resolving global warming issues that include the reduction of carbon dioxide emissions are becoming increasingly important. With the power consumed by networks expected to increase rapidly due to significant growth forecast in traffic volumes, green networks that reduce CO2 emissions are becoming increasingly important. In figure 4 the statistics [20] indicate that the RBS (remote base station) is the main source of energy consumption (57%) in the network of a mobile operator. Energy efficient solutions for wireless access networks are mainly concentrated on RBSs.

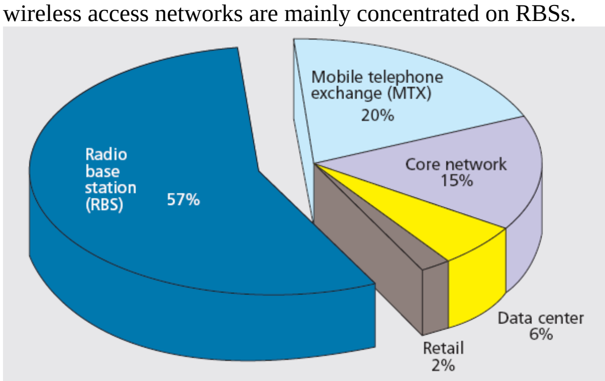


Fig 4: Energy consumption composition of a mobile operator

4.3 Power aware routing in sensor (ADHOC) networks

Sensor networks have an important impact in meeting environmental challenges. Sensor applications in multiple fields such as smart power grids, smart buildings and smart industrial process control significantly contribute to more efficient use of resources and thus a reduction of greenhouse gas emissions and other sources of pollution [18]. The use of distinct mechanisms to make routing decisions is a common topic in the literature of wireless sensor networks. Artificial Intelligence (AI) is one of these mechanisms and different techniques have been proposed to improve the decision making process of routing protocols. A suitable AI technique to be implemented in sensor nodes is fuzzy logic, which has been proposed to improve the performance of diverse aspects of wireless sensor networks.

Several strategies are commonly employed for power aware routing in WSNs (Wireless Sensor Networks) [19]:

- Minimizing the energy consumed for each message
- Minimizing the variance in the power level of each node
- Minimizing the cost/packet ratio
- Minimizing the maximum energy drain of any node

5. TECHNOLOGIES ASSOCIATED WITH COMMUNICATION NETWORK

5.1 OpenFlow - Elastic Tree, a network-wide power manager

It is a system for dynamically adapting the energy consumption of a data center network. Elastic Tree consists of three logical modules - optimizer, routing, and power control. The optimizer's role is to find the minimum power network subset which satisfies current traffic conditions. Elastic Tree requires two network capabilities: traffic data (current network utilization) and control over flow paths which uses OpenFlow technology. OpenFlow is an open API added to commercial switches and routers that provides a flow table abstraction

5.2 Google-green-computing

The technology is about energy savings and carbon footprint of using Gmail via Google Apps—Google's cloud-based messaging and collaboration suite, versus housing local servers to manage the same email. These cloud services allow organizations of all sizes to reap these scale advantages of increased efficiency, reduced overhead costs, and smaller carbon footprint without needing the expertise of an army of software developers, hardware designers and data center technicians. For a small office of 50 people, choosing Gmail over a locally hosted server can mean an annual per-user power savings of up to 170 kWh and a carbon footprint reduction of up to 100 kg of CO2. Larger organizations show smaller, though still impressive efficiency gains.

5.3 Intel Xeon Processor - Data Center Optimization

The energy-saving strategies developed by CERN openlab and used by CERN, the world's largest physics laboratory, as it deploys massive new computing resources to support the most powerful particle accelerator ever built. It describes how CERN is increasing the total performance capacity of its 35-year-old data center up to five times by moving from older servers based on single-core processors to newer servers based on the latest 45nm Intel Xeon processors, which have four cores per processor. According to CERN, this move is increasing the useful life of its data center by about two years. CERN has also made changes to its tendering process, its data center layout, its power and cooling strategies and its software development techniques. All of these changes are focused on getting more total performance while consuming less total energy.

6. CONCLUSION

In this paper we tried to briefly address the concept of green computing over communication network. This work suggests about how Energy, Memory and other network resources are efficiently used for environmental and economical perspective by attempting the green technology in communication network.

This paper aimed at providing an up-to-date survey on Green computing over communication network which discuss about the strategies for green computing used in both wired and wireless networks. All these strategies explain about how green computing technology can be used over network to mainly reduce power consumption which is a major concern for network operators to not only reduce the operational costs, but also to reduce their environmental effects.

All material on each page should fit within a rectangle of 18 x 23.5 cm (7" x 9.25"), centered on the page, beginning 2.54 cm (1") from the top of the page and ending with 2.54 cm (1") from the bottom. The right and left margins should be 1.9 cm (.75"). The text should be in two 8.45 cm (3.33") columns with a .83 cm (.33") gutter.

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