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Disposing and Recycling of Electronic Wastes (E-Wastes) through Green Computing

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The paper talks about the Green Computing as the future of computing in the 21st century and a way to control electronic wastes (E-waste) so as to conserve the environment. E-waste is defined as "the waste electrical and electronic equipment, whole or in part or rejects from their repair and manufacturing process, which are intended to be discarded". Green Computing is the study of designing, manufacturing/engineering, using and disposing of computing devices in a way that reduces their environmental impact. Today, many organizations use the Green Computing Lifecycle when designing and implementing green computing technologies. Many governmental agencies have continued to implement standards and regulations that encourage green computing.

In India, the e-waste management is in a state of concern throughout the country. It has now become the fifth largest producer of e-waste in 2016 behind the United States, Japan, China and Germany.

This paper also talks about the survey that is conducted showing the awareness of green computing among the general public in Delhi NCR region. Also, the perception of the people towards educating not only the children but also the waste collectors about the hazards of not disposing e-waste is also studied.

Keywords: Green Computing, E-waste, Hazardous Components, Waste Electrical and Electronic Equipment (WEEE), Ministry of Environment and Forest (MoEF), Recycle, Reduce, Reuse.

INTRODUCTION

E-waste or electronic waste has been defined as "the waste electronic and electrical equipment, whole or in part or rejects from their repair and manufacturing process, that are intended to be discarded" while electronic and electrical equipment are defined as 'the equipment which is dependent on electro-magnetic fields or electrical currents to be fully functional'.Today, most of the developing countries are suffering with the problem of rapidly increasing e-waste and they have to have new and effective e-waste management systems for the end of the life Information and Communication Technology (ICT) products to avoid the threat on the environment and the mankind.

International Telecommunication Union (ITU) has accepted the fact that the regulations in many developing countries to cover the areas of Waste Electrical and Electronic Equipment (WEEE) are inadequate as they exclude key topics and key stakeholders like the informal sector. The collection, recycling, recovery and associated activities of e-waste management by the informal sector having little or no knowledge about techniques, precautions etc., cause more damage to their health and environment.

Green computing is defined as the environment friendly and environmentally responsible use of computers (desktops and laptops) and their resources. In larger aspects, it is also defined as the study of designing, manufacturing or engineering, using and disposing of computing devices in a way that minimizes their environmental impact.

Green computing focuses to accomplish economic viability and enhance the way computing devices are utilized. Green IT practices include the enhanced disposal and recycling procedures and development of environmentally sustainable production practices and energy efficient computers. The primary aim of such a program is to account for the "triple bottom line" (Planet, Profit, People), an extended spectrum of values and criteria for measuring societal and organizational success. The other objectives are as same as that of green chemistry; which is trying to maximize energy efficiency during the product's lifetime, promote recyclability or biodegradability of products and factory waste and decrease the use of dangerous materials. Hence, a green computing initiative program should be systemic in nature and address progressively sophisticated problems. The elements of such a solution may comprise items like

**Executive Tata Technologies Ltd.*

management restructuring, disposal of e-waste, regulatory compliance, end user satisfaction, telecommuting.

INDIAN SCENARIO OF E-WASTE MANAGEMENT

In last few years, India has emerged as one major IT hub and the consumer electronic market has grown in an exponential rate. According to Manufacturers Association of Information Technology (MAIT) the Indian PC industry is growing by 25% compound annual growth rate. Study reports that in 2007, 2.2 million computers were made obsolete and 14 million mobile handsets replaced. The e-waste generated was estimated to be 332,979 tonnes out of which 144,000 tonnes was recyclable and actually e-waste recycled was 19,000 tonnes. The e-waste processed contained 7000 tonnes of TV and 12000 tonnes of computers. It was also estimated that around 50,000 tonnes of e-waste was generated through import besides 332,000 tonnes generated domestically.

According to a study conducted in 2016, though India has become the second largest mobile market with 1.03 billion subscribers, but it is also the fifth largest producer of e-waste in the world after the United States, Japan, China and Germany. The country discards roughly 18.5 lac metric tonnes of e-waste each year with 12% of the total e-waste generated being telecom equipment alone.

Developed countries find it profitable to send e-waste for reuse/ recycling to developing nations because of economic disparities e.g. cost of recycling of a computer in US is $20 whereas in India it is $2. So, the import of e-waste to India has got enough chance to jump high. In India, there are around 10 states that contribute to 70% of the total electronic waste generated in the country, whereas approximately 65 cities generate more than 60% of the total electronic waste.

IINITIATIVES TAKEN BY LEADING CORPORATES IN INDIA

HCL Info systems Limited, India's premier information enabler and country's leading ICT system integrator and Distribution Company, today commenced its 'Green Bag' Campaign. The Campaign will cover 99 'HCL Touch' centers across major metros and mini-metros in India. HCL will be enabling its 'HCL Touch' centers across the country, to accept e-waste under the 'Green-Bag' Campaign under its 'EcoSafe' environmental initiative. The campaign, will encourage people to dispose-off their end of life IT equipment including computers, keyboard, scanner, printers etc. in an environmental friendly way. The EcoSafe initiative aims to create awareness on environmental issues and educate customers to responsibly dispose their e-waste. HCL has also tied up with leading electronic waste collection and recycling service providers in India.

To promote recycling of e-waste, Nokia India launched a 'Take Back' campaign where customers can drop their old mobile phone in the company's stores and win gifts. The take-back campaign is focused at educating mobile phone users on the importance of recycling electronic waste. As a part of this initiative, Nokia encourages the users to dispose their used handsets and accessories such as handsets and charges, regardless of the brand, at any of the recycling bins set up across Nokia Priority Dealers and Nokia Care Centers.

Figure 1 : Nokia Take Back Initiative Ad of Recycling of E-Waste

Samsung Electronics also started with an initiative called STAR (Samsung Takeback And Recycling) program to encourage recycling of e-waste. This program recycles several electronic items like laptops, refrigerators, televisions, mobiles, washing machine, etc. that are no longer useful. 'Samsung Take-back And Recycling' (STAR) program is an initiative towards leading a more conscious life and making an awareness towards conservation and optimization of resources.

Figure 2: Samsung's Initiative of Recycling E-waste

This program also tells the consumer and the general public where to recycle the e-waste depending on the location of the consumer anywhere in India. Samsung Electronics strictly adheres to the Management and Handling Rules, 2011 notified by the Ministry of Environment and Forest (MoEF).

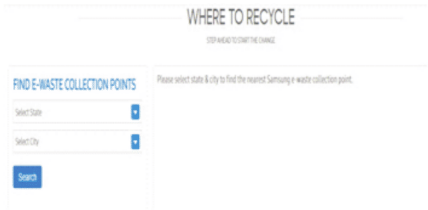

Figure 3: Samsung's Provision of telling people Where to Recycle E-waste

ADVANTAGES OF GREEN COMPUTING

- Conserving resources means less energy is required to produce, use, and dispose of products.
- Green computing even includes changing government policy to motivate recycling and lowering the use of energy by individuals and businesses.
- Reduced energy usage from green computing techniques converts into lower carbon dioxide emissions, originating from a reduction in the fossil fuel used in power plants and transportation.
- Reduce the risk existing in the laptops such as chemical known to cause cancer, nerve damage and immune reactions in humans.
- Saving energy and resources saves money.
- Individual Green Computing and System Wide Green Computing is the best possible way to practice Green Computing. Companies implementing System Wide Green Computing and employees and individuals practicing individual green computing techniques help in a long way in creating an impact to save the planet.

DISADVANTAGES OF GREEN COMPUTING

- Green computing could actually be quite costly.
- Some computers that are green may be underpowered.
- Low initial cost, quick technology change and with planned obsolescence has resulted in a rapid growing surplus of unused hardware around the globe.

LITERATURE REVIEWS

Parmar V P, Pandya A K and Kumbharana C K intheir paper titled "Optimization of Energy Usage for Computer Systems by Effective Implementation of Green Computing" had attempted to identify "Optimum usage of computers so that there is least impact on the environment". The findings of the study suggested that wastage part of computer systems also creates environmental problems due to carbon synthesized materials. The environment is also facing problems like the global warming, Greenhouse effect and the ozone layer is becoming thin. Hence, an effort was made to deal with such problems by effective implementation of technologies and which is also known as Green Computing.

Lakshmi S.V.S.S, Sarwani I Sri Lalita and Tuveera M. Nalini in their paper titled "A Study On Green Computing: The Future Computing And Eco-Friendly Technology" had attempted to identify "The future of green computing". The findings of the study suggested that green computing represents a responsible way to address the issue of global warming. The business leaders can also contribute positively to environmental supervision and protect the environment while also reducing energy and paper costs by adopting green computing practice.

Noble V, Verma P, Gupta A in their paper titled "Managing Garbage of the Digital World" had attempted to identify "the Indian scenario for E-waste management". The findings of the study suggested that the components present in laptop and mobile batteries and other electronic devices are hazardous in nature and must be disposed carefully. The e-waste generated was estimated to be 332,979 tonnes out of which 144,000 was recyclable and actually 19,000 tonnes of e-waste was recycled. The 3R concept of Recycle, Reduce and Reuse is used widely in various institutes and organizations.

Dharna K, Massey R in their paper titled "Management of Rise in E-waste due to Demonetization" had attempted to identify "the management and understanding of E-waste at distinct levels". The findings of the study suggested that there are 3 distinct levels: at personal level, at corporate level and at the government level. At these 3 levels, the society has different roles like at personal level, as the citizen of India, at corporate level, as major companies' Corporate Social Responsibility (CSR) and at government level, as the central government as well as state government. The problems and solutions have also been discussed at these 3 levels.

Dixit M S in her paper titled "Scope and Issues of Green Computing in networking: A Research" had attempted to identify "the various approaches and technologies of Green Computing that can be used by the organizations in the field of networking". The findings of the study suggested about how Energy, Memory and other network resources are efficiently used for environmental and economical perspective by attempting the green technology in communication network. Green IT programs are representing fundamental economic along with environmental sense; it is understandable why organizations are exploring green computing options with such extreme interest across the IT industry.

Wong M H, Wu S C, Deng W J, Yu X Z, Luo Q, Leung A O W, Wong C S C, Luksemburg W J, Wong A S in their paper titled "Export of toxic chemicals – A review of the case of uncontrolled electronic-waste recycling" had attempted to review "the concentrations of persistent organic pollutants". The findings of the study suggested that incomplete combustion of electronic waste in open air and dumping of processed materials are the major sources of various toxic chemicals and when compared with different countries, the environment is highly contaminated by these toxic chemicals derived from the recycling processes.

NnoromI C, Osibanjo O in their paper titled "Overview of electronic waste (e-waste) management practices and legislations, and their poor applications in the developing countries" had attempted to identify "the huge challenges faced by the developing countries in the management of e-waste (electronic waste)". The findings of the study suggested that the change in attitude by governments, appropriate legislation dealing specifically with electronic waste, control of electronic waste dumping, implementation of Extended Producer Responsibility (EPR) and transfer of technology on sound recycling of e-waste are the main problems in effective management of electronic waste in the developing countries.

Vashishtha V, Gupta A, Sarwar S in their paper titled "Green Computing: An Approach of Saving Energy by Computer Virtualization" had attempted to identify "virtualization as an approach to green computing". The findings of the study suggested that green computing has the goals to maximize energy efficiency during the product's lifetime, to reduce the use of hazardous materials and to promote the biodegradability or recyclability of factory waste and unused products. Virtualization, Green Data Center, Cloud computing, grid computing, Power optimization are the technologies of green computing.

Aggarwal S, Garg M, Kumar P in their paper titled "Green Computing is Smart Computing- A Survey" had attempted to identify "The use of green computing as the future of computing". The findings of the study suggested that as more and more companies include some form of reporting on their goals and achievements in the area of CSR, there is a growing awareness among business leaders that greening their IT practices offers the double-win of reducing costs while demonstrating a positive environmental commitment.

Chopra A, Sharma S, Kadyan V in their paper titled "Need of Green computing to improve environmental condition in current era" had attempted to identify "the needs of green computing to conserve the environment". The findings of the study suggested that over the years the idea of green computing has attracted the world due to its environment benefits. At present green computing is under the consideration of businesses organizations and IT industries to improve environmental conditions for the better living of human being. It is an effective approach to protect our environment from the harmful effects of toxic material used during the manufacturing of computing devices.

RESEARCH METHODOLOGY

Descriptive research methodology is being used in the study. Within descriptive research, cross sectional research methodology is used to study the sample from the given target population. The sampling design was Non-Probabilistic Convenience Sampling and a survey was conducted with a sample size of 150 respondents all over Delhi NCR region. It was carried out through a set of structured questionnaires to gather information through a survey from the sample which was convenient selected from the target population.

Purpose of the Study

1. To study the usage pattern by the consumers for electronic gadgets like computers, laptops and mobile phones.
2. To analyze the consumer sensitivity towards Energy Saving.
3. To study the awareness amongst the general public about Green Computing.
4. To study whether the waste collectors should be educated of the harmful effects of e-wastes towards the environment and themselves and how to educate them.

ANALYSIS AND FINDINGS

1. ***To study the usage pattern by the consumers for electronic gadgets like computers, laptops and mobile phones.***

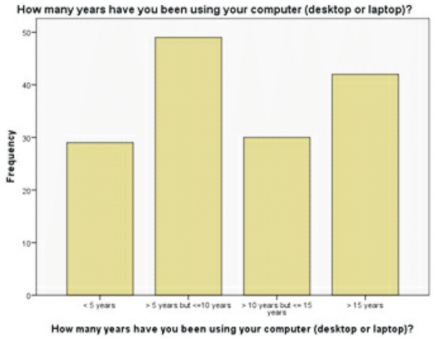

Figure 4: Frequency Chart of Computer Usage

Interpretation:

- 19.7% of respondents use computers for less than 5 years.
- 32.7% of respondents use computers for more than 5 years but less than 10 years.
- 20% of respondents use computers for more than 10 years but less than 15 years.
- 28% of respondents use computers for more than 15 years.

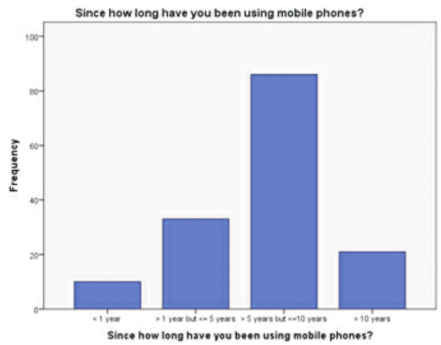

Figure 5: Frequency Chart of Mobile Usage

Interpretation:

- 6.7% of the respondents use mobile phones for less than 1 year.
- 22% of the respondents use mobile phones for more than 1 year but less than 5 years.
- 57.3% of the respondents use mobile phones for more than 5 years but less than 10 years.
- 14% of the respondents use mobile phones for more than 10 years.

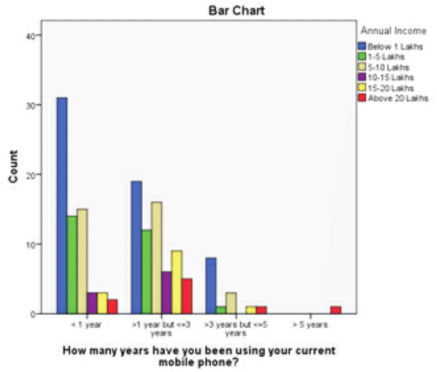

Figure 6: Frequency Chart of Usage of Current Mobile Phone vs Annual Income

Interpretation:

- 44.1% of the total respondents with annual income between 5 and 10 lakhs use their current mobile phone for less than 1 year.
- 32.8% of the total respondents with annual income below 1 lakhs use their current mobile phone for more than 1 year but less than 3 years.
- 7.7% of the total respondents with annual income above20 lakhs use their current mobile phone for more than 3 years but less than 5 years.
- 11.1% of the total respondents with annual income between 1 and 5 lakhs use their current mobile phone for more than 5 years.

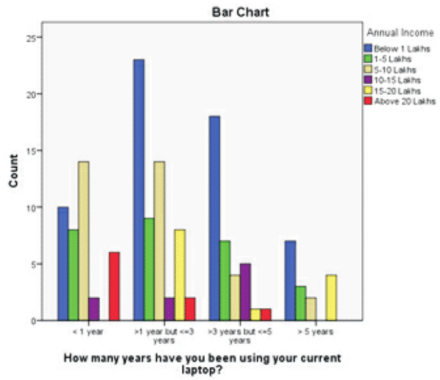

Figure 7:Frequency Chart of Usage of Current Laptop

Interpretation:

- 39.7% of the total respondents with annual income less than 1 lakhs use their current laptop for more than 1 years but less than 3 years.
- 41.1% of the total respondents with annual income between 5 and 10 lakhs use their current laptop for less than 1 year.
- 30.8% of the total respondents with annual income above 20 lakhs use their current mobile phone for more than 3 years but less than 5 years.
- 39.7% of the total respondents with annual income between 15 and 20 lakhs use their current laptop for more than 5 years.

2. *To analyze the consumer sensitivity towards Energy Saving.*

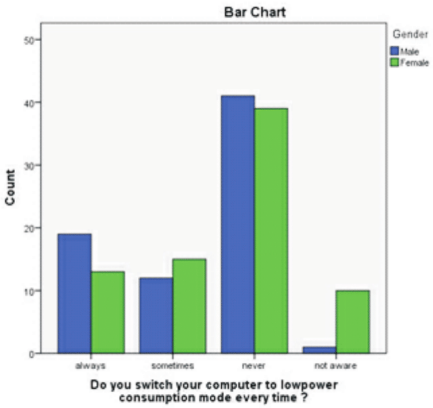

Figure 8: Frequency Chart of Low-Power Consumption vs Gender

Interpretation:

- 56.2% of the male respondents never switch their computers in low power consumption mode.
- 26% of the male respondents always switch their computers in low power consumption mode.
- 19.5% of the female respondents sometimes switch their computers in low power consumption mode.
- Only 1 male respondent is not aware of the low power consumption mode.

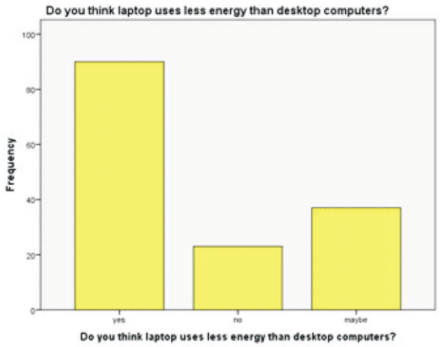

Figure 9: Frequency Chart of Less power usage of laptop than desktop computers

Interpretation:

- 60% of the respondents think that laptop uses less power than that used by desktop computers.
- 15.3% of the respondents do not think that laptop uses less power than that used by desktop computers.

3. *To study the awareness amongst the general public about Green Computing.*

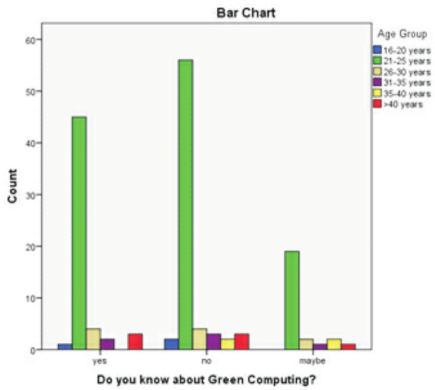

Figure 10: Frequency Chart of Knowing about Green Computing vs Age Group

Interpretation:

- 46.7% of the respondents having the age between 21 and 25 years don't know about Green Computing.
- 40% of the respondents having the age between 26 and 30 years know about Green Computing.

- None of the respondents having the age between 16 and 20 years are in the benefit of doubt in knowing about Green Computing.

4. *To study whether the waste collectors should be educated of the harmful effects of e-wastes towards the environment and themselves and how to educate them.*

Figure 11: Frequency Chart of Frequency Analysis of Dealing with old phone after having purchased a new one

Interpretation:

- 38.7% of the respondents keep their old mobile phones after purchasing a new one.
- 1.3% of the respondents throw their old mobile phones after purchasing a new one.
- 34% of the respondents give their old mobile phones in exchange offers after purchasing new one.

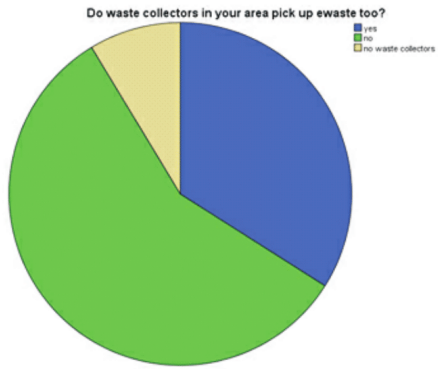

Figure 12: Pie Chart of the Waste Collectors in various areas also pickup e-waste

Interpretation:

- 57.3% of the respondents said that the waste collectors in their area do not pick up e-waste.
- 34% of the respondents said that the waste collectors in their area do not pick up e-waste.
- 8.7% of the respondents said that there are no waste collectors to pick up waste.

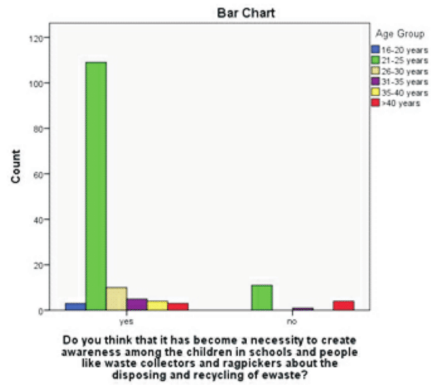

Figure 13:Frequency Chart of Cross Tabulation of Creating Awareness vs Age Group

Interpretation:

- 90.8% of the total respondents of age group of 21-25 years think that it has become a necessity to create awareness among the children in schools and people like waste collectors and ragpickers about the disposing and recycling of e-waste.

CONCLUSION

Green Computing is not only a new trend, it is a technology in itself. The move to become eco-friendlier is more than a means to a better corporate image, it is also the means to reduce cost in an inflating IT budget. Reducing the number of servers using virtualization is considered as one of the best approaches towards Green Computing. For all the organizations and various institutes, being green should be taken as a long-term commitment that could solve the purpose of creating a greener infrastructure. Many of the organizations in the world have started using green methods such as switching off their laptops and computers or keeping them in low power or power saving mode that have saved a lot of cost incurred by the management of the organizations.

From the research done by the circulation of questionnaire in a sample of 150 respondents, it can be concluded that 7.3% of the respondents are not even aware of low power consumption mode in their computers while 53% of the respondents never switch their computers (desktops or laptops) on low power consumption mode. Although 48.7% of the respondents are aware of the risk to the environment because of global warming, carbon footprint, etc., 46.7% of the respondents are not aware of what Green Computing is. Also, 8.7% of the respondents said that there are no waste collectors in their area. This is a state of concern for the people of India where the Honourable Prime Minister Sh. Narendra Modi has been working hard in making the country clean in every aspect through the initiative called "Swachh Bharat Abhiyan".

On the positive note, 67.3% of the respondents think that the main reason for adopting Green Computing is to reduce energy costs. Whereas, 52.7% of the respondents think that the main reason for adopting Green Computing is to conserve limited resources and 53.3% of them think that the main reason is to reduce emissions reducing respiratory problems, acid rain, smog and global climatic change. 38.7% of the respondents keep their old mobile phones after purchasing a new one and 34% of them give it in exchange offers provided by e-commerce sites like Flipkart, Snapdeal, Amazon, etc. Further, 23.3% of the respondents think that the educational institutes have the most positive attitude towards Green Computing. It can also be concluded that 89.3% of the respondents think that it has become a necessity to create awareness among the children in schools and people like waste collectors and ragpickers about the disposing and recycling of e-waste. This is a very good indication of the people towards conserving the environment from hazardous materials present in desktops, laptops and mobile phones.

RECOMMENDATIONS

As from the research conducted above, 89.3% of the respondents think that it has become a necessity to create awareness among the children in schools and people like waste collectors and ragpickers about the disposing and recycling of e-waste. A proper course can be added in the curriculum of the children especially those of primary classes so that they are aware at a very small age and can apply this knowledge in their lives while using computers or mobile phones. All the schools and colleges can also implement IT enabled services and learning methods like more usage of projectors especially in schools for teaching purposes so that the emission of carbon dioxide is minimal. Large IT companies especially computer and mobile phone manufacturing companies should also make policies and guidelines describing the steps and procedures taken by the companies to dispose and recycle e-waste generated during manufacturing.

Google has taken a major initiative towards Green Computing by using a technology called Google green computing. It is a technology which is about energy reserving and carbon footprint of using Gmail via Google Apps. Green computing is still at an introduction stage but it has already established considerable attention towards big and small organizations as well as various institutions all around the globe. Cloud-based services like Gmail allow organizations of all sizes to get these scale advantages of reduced overhead costs, smaller carbon footprint and increased efficiency without requiring the proficiency of an army of data center technicians, hardware designers and software developers.

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