

Green Computing and Sustainability of Information Technology in the Environment

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1. Summary

- Green Computing or green IT, refers to environmentally sustainable computing or IT.
- Dr. San Murugesan a Senior Consultant defines the field of green computing as:
 - "the study and practice of designing, manufacturing, using, and disposing of computers, servers, and associated subsystems such as monitors, printers, storage devices, and networking and communications systems efficiently and effectively with minimal or no impact on the environment".

1. Summary

- The goals of green computing are:
 - to reduce the use of hazardous materials,
 - maximize energy efficiency during the product's lifetime, and
 - promote the recyclability or biodegradability of defunct products and factory waste.
- Research continues into key areas such as making the use of computers as energy-efficient as possible, and designing algorithms and systems for efficiency-related computer technologies.

2. History of Green Computing

- The term "green computing" was probably appeared after the Energy Star program was launched by the U.S Environmental Protection Agency in 1992.
- Energy Star is designed to promote and recognize energy-efficiency in monitors, climate control equipment, and other technologies was. This resulted in the widespread adoption of sleep mode among consumer electronics.

2. History of Green Computing

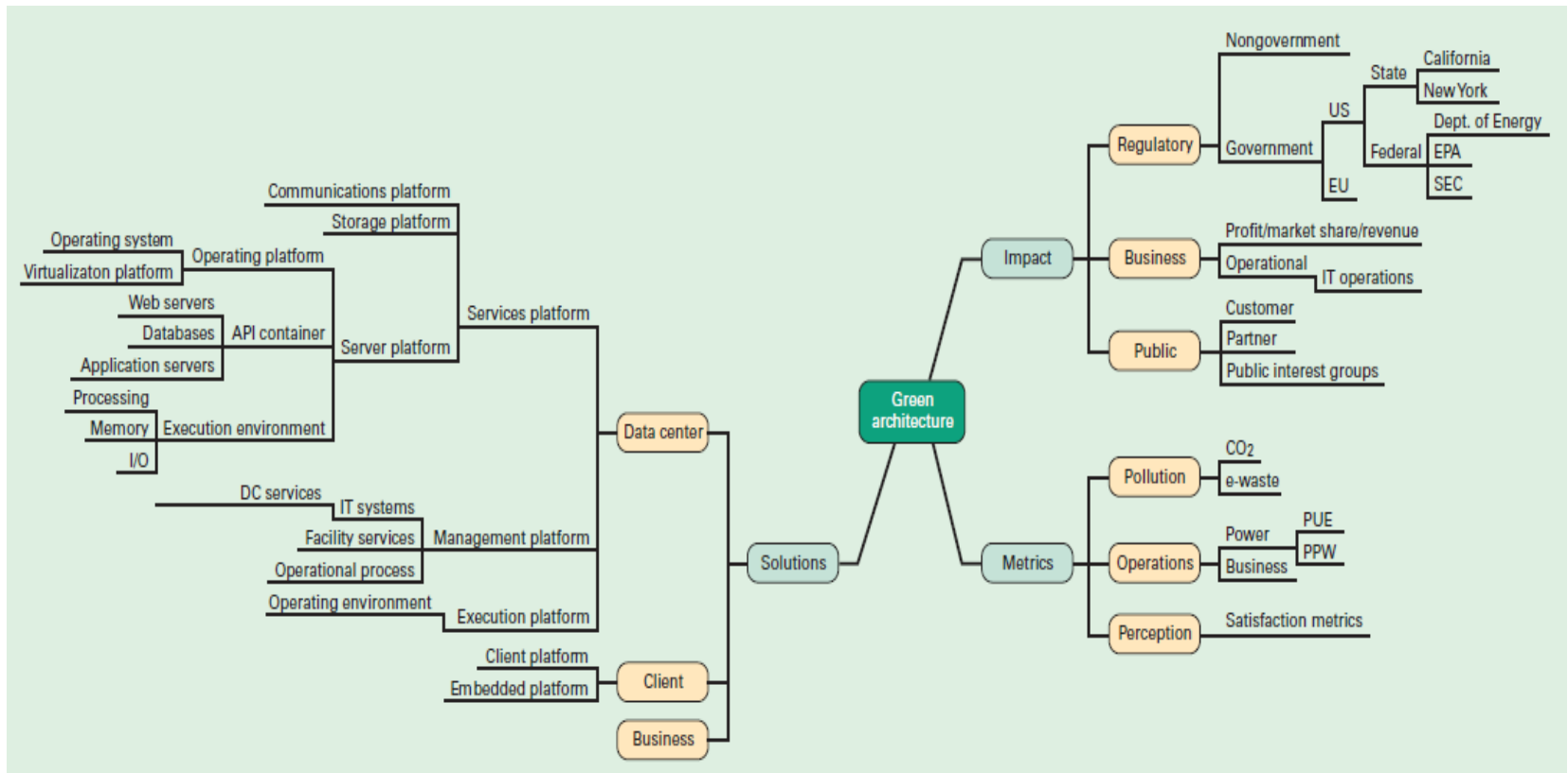
- Energy-efficiency researches at the National Energy Research Scientific Computing (NERSC) Center and the Computational Research Division (CRD) at Berkeley Lab suggest designing and building computer and storage technologies that will benefit scientists, consumers, and the environment.
- The research team is exploring subjects in computer architecture, algorithms, and mass-storage-system designs to improve the energy efficiency of scientific computations.

2. History of Green Computing

- Kathy Yelick, NERSC Director, explains the importance of this work:
 - “Power is the most important problem in computing today, not just at the high end, but from hand-held devices and laptops to data centers and computing centers like NERSC.
 - Power density within chips has forced the entire processor industry to put multiple cores on a chip, and within centers, the total system power is a major component of cost and availability.”

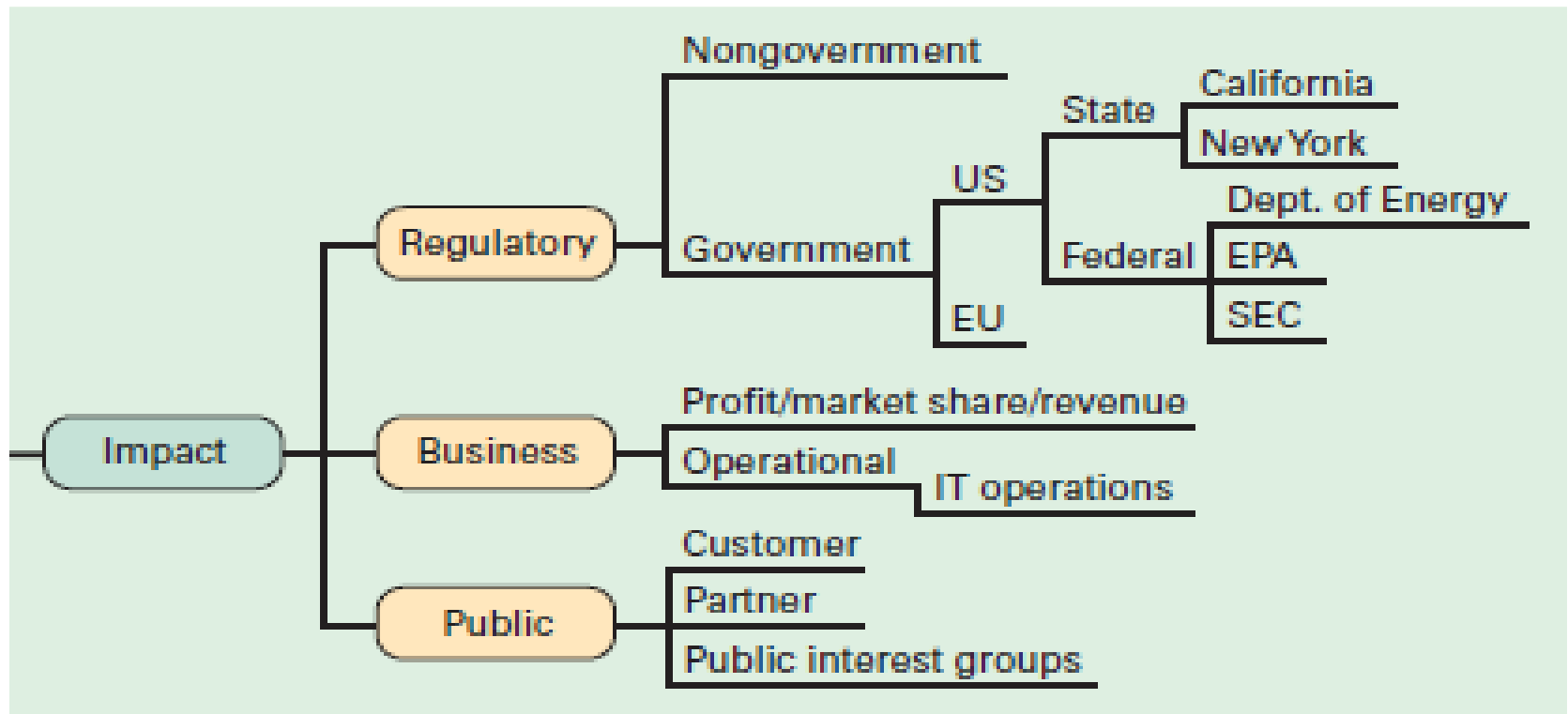
3. Green Computing Architecture

Figure 1: An Ecosystem is a View of Green Computing's Architectural



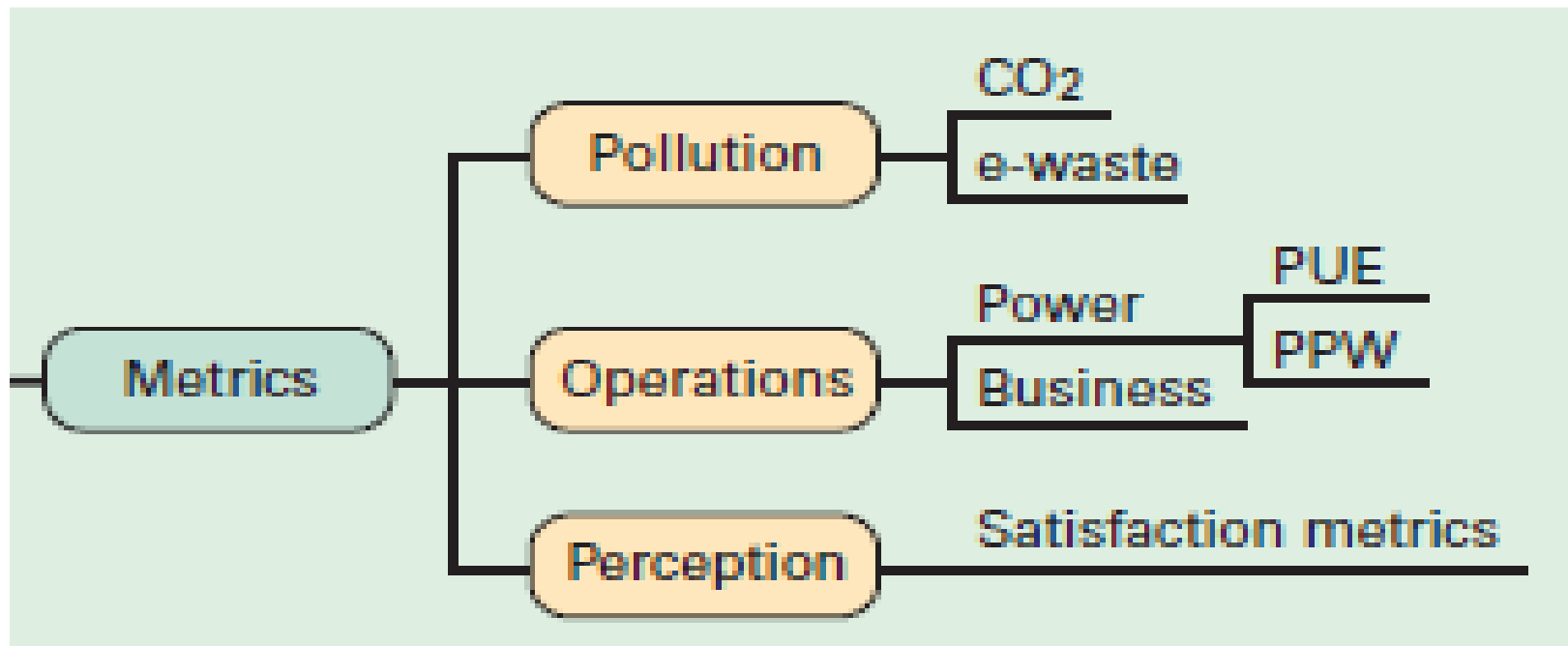
3. Green Computing Architecture

Figure 2: Impact of Green Computing



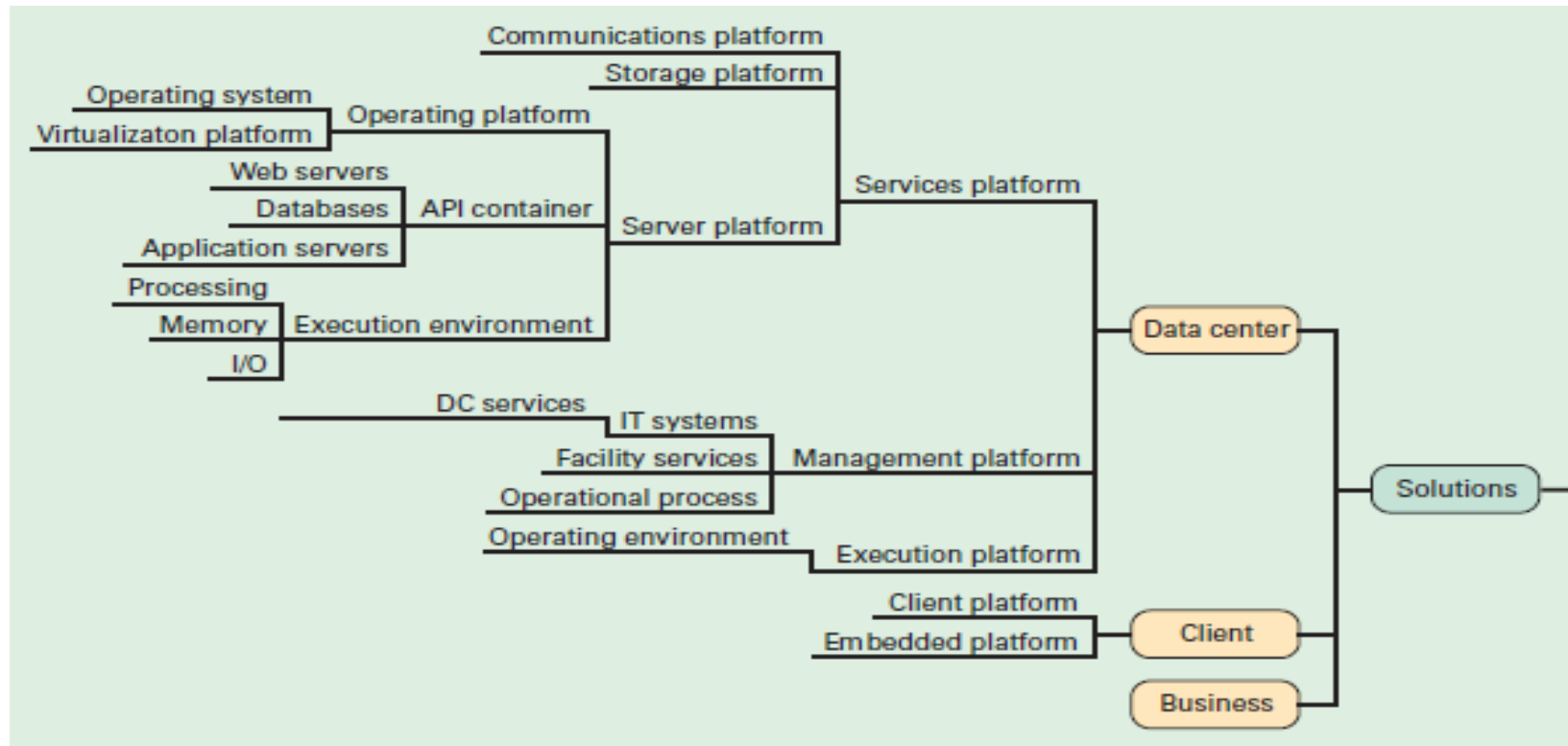
3. Green Computing Architecture

Figure 3: **Metrics** of Green Computing



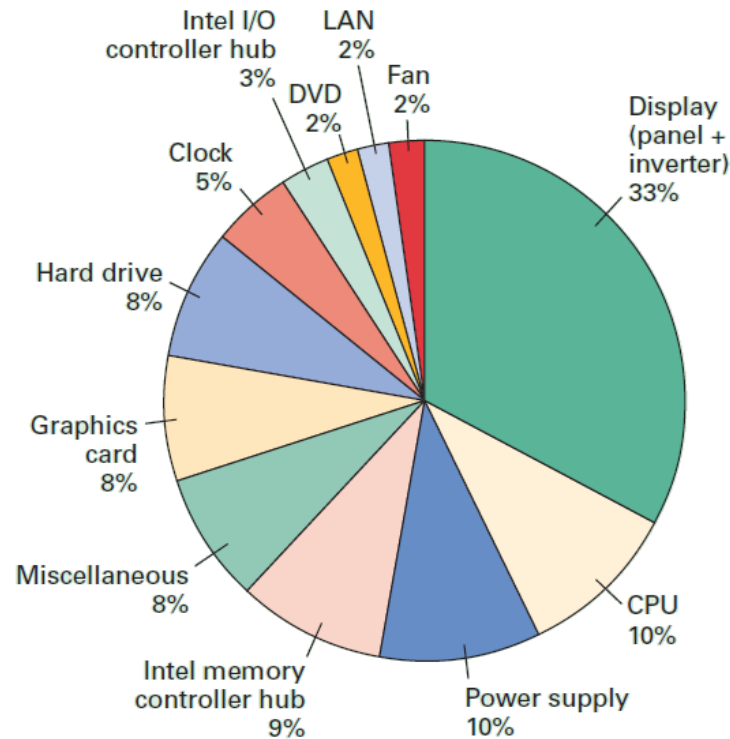
3. Green Computing Architecture

Figure 4: Solutions Green Computing



3. Green Computing Architecture

Figure 5: Power Consumption in An Average Laptop [4]



4. Approaches to Green Computing

- **Virtualization**
- **Terminal Servers**
- **Power Management**
- **Power Supply**
- **Storage**
- **Video Card**
- **Display**
- **Operating System Issues**
- **Materials Recycling**
- **Telecommuting**

5. Steps to Green Computing

1. Develop a sustainable green computing plan

1. Recycle

2. Make Environmentally Sound Purchase Decisions

1. Reduce Paper Consumption

2. Conserve energy

6. Future of Green Computing

- The plan towards green IT should include new electronic products and services with optimum efficiency and all possible options towards energy savings.
- Faster processors historically use more power. Inefficient CPU's are a double hit because they both use too much power themselves and their waste heat increases air conditioning needs.
- The waste heat also causes reliability problems, as CPU's crash much more often at high temperatures.

7. IT's Environmental Impact

- Each stage of a computer's life, from its production, throughout its use, and into its disposal, presents environmental problems.
- Manufacturing computers and their various electronic and non-electronic components consumes electricity, raw materials, chemicals, and water, and generates hazardous waste.
- All these directly or indirectly increase carbon dioxide emissions and impact the environment.
- The total electrical energy consumption by servers, computers, monitors, data communications equipment, and cooling systems for data centers is steadily increasing, which increase in energy consumption results in increased greenhouse gas emissions. Each PC in use generates about a ton of carbon dioxide every year.

7. IT's Environmental Impact

- Computer components contain toxic materials. Increasingly, consumers discard a large number of old computers, monitors, and other electronic equipment two to three years after purchase, and most of this ends up in landfills, polluting the earth and contaminating water.
- The increased number of computers and their use, along with their frequent replacements, make the environmental impact of IT a major concern.
- there is increasing pressure on us - the IT industry, businesses, and individuals - to make IT environmentally friendly throughout its lifecycle, from birth to death to rebirth. As many believe, it's our social and corporate responsibility to safeguard our environment.

8. Cloud Computing and Green Computing

- The term cloud computing is based on an infrastructure and business model whereby - rather than being stored on your own device - data, entertainment, news and other products and services are delivered to your device, in real time, from the internet.
- The creation of computer Tablets (e.g. iPad) and smart phones has been much anticipated by a world with an ever-increasing appetite for mobile computing devices as a way to connect, interact, learn and work.
- These devices rely upon cloud-based computing to stream video, download music and books, and fetch email.
- Millions access the 'cloud' to make use of online social networks, watch streaming video, check email and create documents, and store thousands of digital photos online on popular web-hosted sites.

8. Cloud Computing and Green Computing

- Google, Facebook and Yahoo are the most famous cloud-based companies to demonstrate the potential of a cloud platform.
- Its ambitious project to create a digital library will be entirely hosted by servers storing most of the world's published work, all in digitized form.
- The cloud is growing at a time when climate change and reducing emissions from energy use is of paramount concern.
- With the growth of the cloud, however, comes an increasing demand for energy. For all of this content to be delivered to us in real time, virtual mountains of video, pictures and other data must be stored somewhere and be available for almost instantaneous access.

9. Conclusion

- In this paper, we reviewed the most important work on green computing and its impact on the environment.
- We have first defined green computing and discussed the history of green computing.
- Then, a green computing's architecture suggested by Yuh-Shyan Chen and Chih-Shun Hsu [4] is presented.
- Approaches to green computing are discussed.
- Five steps to green computing are listed and the future of green computing are presented.
- Finally, the impact of cloud computing on green computing is presented.