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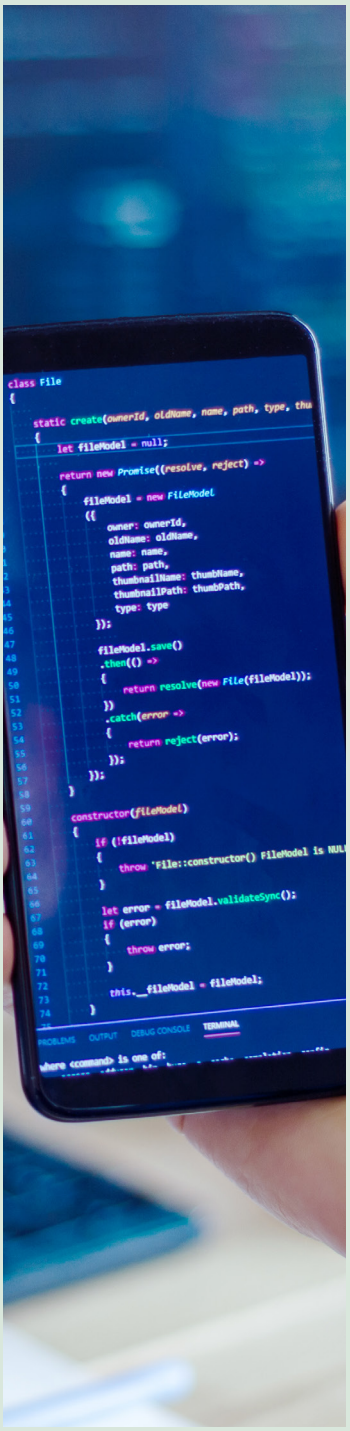

GREEN CODING AND SUSTAINABILITY

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Every line of green code has the potential to reduce the energy consumption. The Software runs on physical hardware that consumes energy which is traditionally generated by buring fossil fules. Thus, software is indirectly responsbile for green house gases emissions **(GHGE)**.

According to Evans Data Corporation, there are around **26.9 million[1] software developers** worldwide. At this time, most of the developers don't have tools to measure the energy consumptions due to the applications or they are not aware of the carbon footprints of the applications. **You can't improve, that you can't measure.** So, it is very important to have tools that enable developers to measure the energy consumption by server components like CPU, memory, disk, network, etc. where the applications are hosted. These tools can help developers to identify the source code hotspots that lead to increased energy consumption, thus helping developers to write and deliver efficient software.

As per an estimate, the computers, data centers and networks consume around **10%[2] of the world's electricity.** The choices of algorithms, design and platfroms used to write, build and run the code decide the longterm sustainability of the applications.

The advancement in technologies like **Cloud Computing, AI, 5G, IOT and Block Chain** have accelerated digitization allowing businesses to expand at global scale. It is projected that **Information and communications technology** could **consume around 21%** of the global electricity[3] **demand by 2030.** Assessing key trade-offs between carbon emissions and business objectives such as growth,scalability and flexibility is a complicated task which needs to be cautiously addressed. In this paper we have shared an ABCD framework that can help in building sustainable applications using green coding and human-centric sustanable design approach

Green application design and development practices

An approach to reducing the Carbon footprints from software applications can be easily understood using the ABCD framework presented below

- A – Algorithm for efficiency
- B – Build consciously
- C – Consume effectively
- D – Dashboards for continuous monitoring

Algorithm for Efficiency

1. The amount of compute resources used by applications depends on the efficiency of the algorithms used. Same tasks can be completed with less energy using efficient algorithms.
2. An efficient algorithm can route network traffic to energy efficient data centers thus saving energy.
3. Efficient Green algorithms can help in predictive maintenance of systems thus avoiding outages.
4. Continuous improvement of algorithm efficiency has been helping in reduction in the time taken for data processing by smartly reducing the amount of data processes by isolating the dark data.

Build consciously

1. Engineering teams should make language, framework, and product choices after carefully assessment of their sustainability scores. (Consider the scope 1,2 and 3 emissions as well).
2. Build and run the applications on energy-efficient data centers
3. Optimize applications to deliver more compute power per unit of energy input.
4. Options like Cloud Native, Multi-cloud, and Hybrid cloud architecture can help to build green sustainable solutions.

Consume effectively

1. Choose the most efficient services based on application requirements.
2. Choose the cloud providers wisely. Few cloud providers are greener as compared to others.
3. Rightsizing cloud infra and services are the keys to sustainability.
4. Don't overprovision capacity, configure it to scale dynamically based on demand. The cloud services allow scaling up or down in real-time based on demand.
5. Reduce wastages by eliminating applications and services that are no longer required.
6. Remove technology debt on regular basis.

Dashboard for Continuous monitoring

1. Configure alerts and monitoring of resources based on well-defined policies.
2. Measure utilization and optimize it in real time by continuous monitoring through automation using Infra as a Code solutions.
3. Publish the cloud resource utilization reports visible to dev teams via a central dashboard and encourage them to reduce wastages by adopting green coding practices.

There is a huge opportunity for driving **'experience'** and **'innovation'** riding on the wave of digitization. Organizations can adopt **human-centric and people-focused** framework to drive ESG commitments. Following five essential elements bring in the human centric approach to tackle the sustainability challenge.

1. Regenerative future
2. Circular commerce
3. Human experience
4. System of systems
5. Digital Twins

Along with human-centric approach, the green coding, moving to serverless architecture, reducing server and datacenter energy consumption, is at the forefront of discussions for banking and financial services technology teams. Internet Of things, Artificial Intelligence and Data can be leveraged to build interactive dashboards for tracking and monitoring the data center energy usage that can be used in disposition analysis of applications identified for cloud migration.

Green Coding practices

Enterprise applications are build to meet business and customer needs, but the environmental impact due to applications mostly remains as a after thought. Each and every application, it's component and dependencies contributes to the energy consumption that can be address with Green coding. Using the ABCD framework proposed above, energy savings can be realized from every stage of the Software Development Life Cycle. Smart AI driven automations, policies for budgeting, well established payback and chargeback models , and effectively managed resource reuse can help in reducing the energy consumption along with cost for building applications. Overprovisioned capacities based on projected peak demand of applications leads to excessive energy wastages even when the applications are shutdown. The sustainable green digital future can be achieved with a judicious mix of sustainable design choices and balanced business objectives.

Following points should be considered for building Sustainable IT practices and green applications.

1. Adopting Best Practices

- This includes creation of the guidelines, templates, reference material on writing code that consumes lesser energy.
- The Green Breakers i.e. Green Rulesets that detect the violation of green practices and are integrated in the DevOps pipelines to help team identify and improve their code.
- Formulate the metrices that help in calculating the green score the the applications.

2. Green Architecture

- An architecture that is better for environment (less energy consumption and reduced GHG emission) and better for business (reduces costs of IT infra and cloud services) is Green Architecture.
- Making sustainable design choices in the application architecture and design by conducting assessments of all components for their energy consumption levels.
- As a part of application design, the sustainablity assessment should be conducted before selecting Platforms, Frameworks, Products, Technologies or Infrastructure Components in the solutions.
- Sustainability should be a key non-funcational requirements for all applications that should be addressed by implementing green architecture principles.

3. Circular Economy

- Build Reusable Assets and components
- Use automation to reduce manual work

4. Digitization and Modernization

- Green Tech adoption like serverless computing low code platforms can helps in reducing emissions.

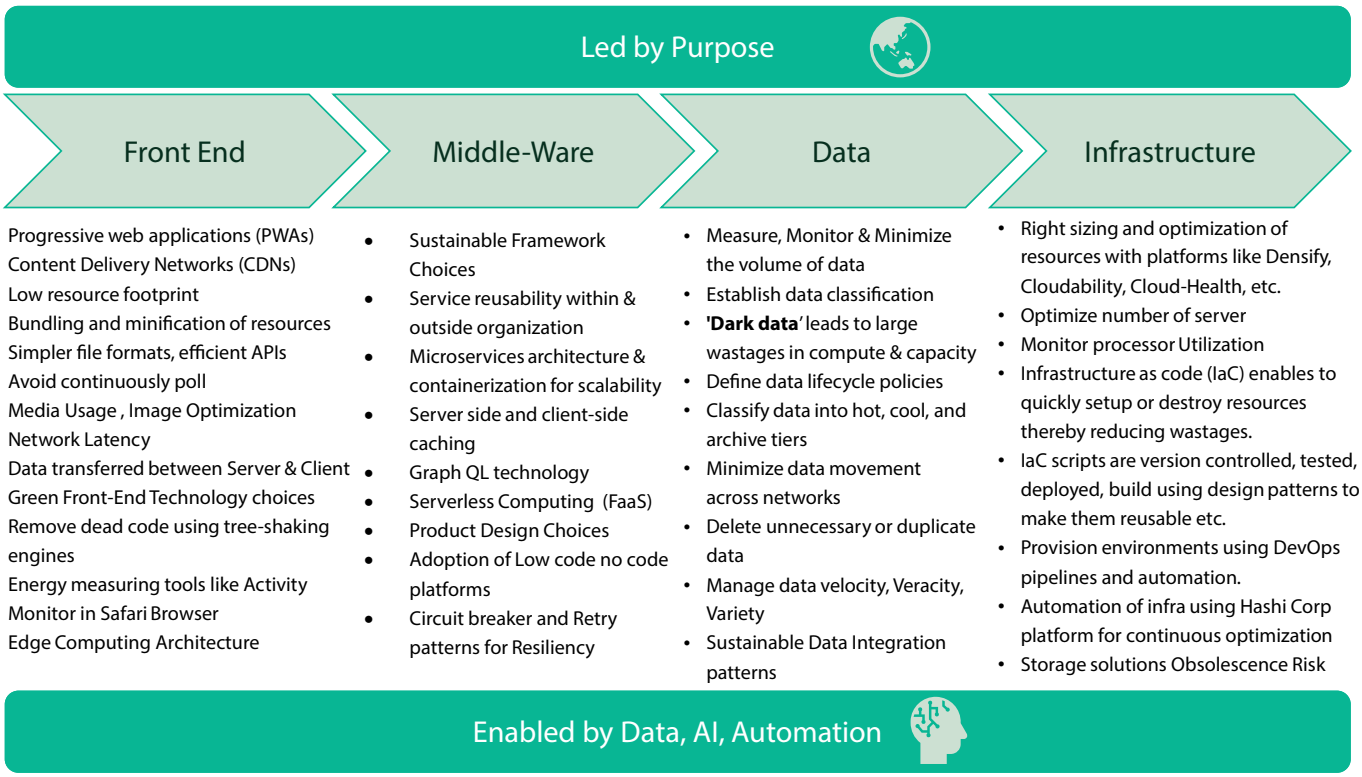
5. Sustainability Dashboard - Energy Monitoring for application components

- Build a Sustainabilit Dashboard for measuring and analytics of emissions from applications.
- Build a cost dashboard that allows you to do a breakdown of costs at resource level for a selected application
- Create the Energy Profiles and Energy Budgets

6. Employee Engagement to instill the Sustainable culture in the DNA of organization.

- Conduct Awareness drives on ESG and climate change.
- Sustainability festival with events like Sustainability Challenge , Sustainablity Pledge , Sustainability Quiz etc can make a huge difference.
- Mandatory ESG Trainings

The green development practices and guidelines can be implemented across all tiers of the application i.e. Front-end, Middleware, Data and Infrastructure. Sustainable Application design should be led by purpuse and enabled by Data , Artificial Intelligence and automation as depcited by the picture below.



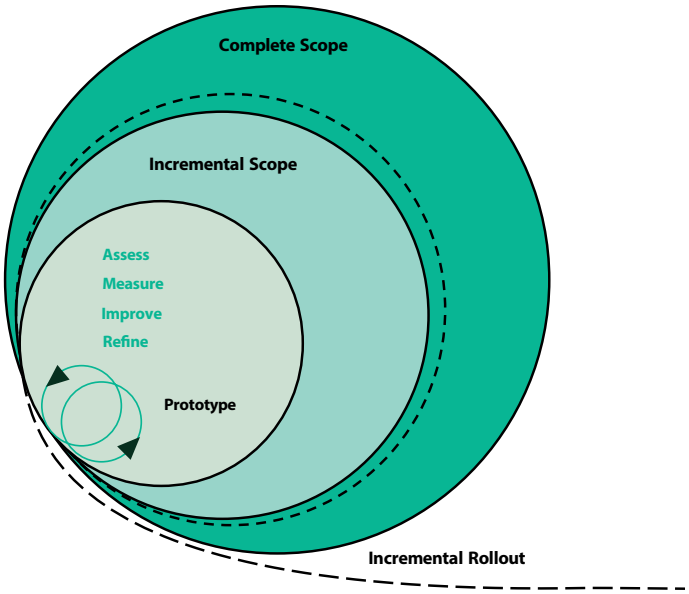
Green Languages and frameworks.

- The code based on algorithms that requires minimal energy consumption during execution is termed as Green Code.
- The choices of application frameworks, languages, cloud providers, products and platforms should be made after careful assessment of their sustainability score.
- Generally, the newer versions of products and frameworks are efficient and reduce the energy consumption as compared to legacy products. Thus, it is recommended to continuously reduce the technical debt there by improving sustainability.
- Based on research , the **"greenest"** and most efficient languages are C, C+, Rust, and Java, although Java shoots up the memory usage.

Way to Sustainable IT and Green Coding

An enterprise needs to focus on building capabilities, tools, and accelerators in following areas

- **Focus on Data Management Solutions** - Ability to measure, monitor and minimize the data by differentiating between the good data and dark data.
- **Focus on Application Resiliency** - Using AI Ops based intelligent, self-healing system design and site reliability engineering (SRE) principles application resiliency can be improved. Provision tools and accelerators that enable organizations to conduct the resiliency assessment of the application for Architecture, Monitoring, Automation, Redundancy, Infrastructure, Change Management, Security and Validation pillars.
- **Build Sustainability Toolkit** – Sustainable Innovation approach based on Design Thinking and Prototyping, Automated Assessments, Green Breakers, UX Behavioral sustainable design patterns library, Sustainable value propositions, Functionality vs Sustainability trade off analysis, and Sustainability dashboard.
- Setup a dedicated Sustainability Practice unit within organization to focus on ESG Compliance and Regulatory aspects related to Sustainability reporting.
- **Sustainability by Design** approach should be adopted, and it should include website optimization, optimization of digital estate, full-spectrum digital optimization and new digital behavior creation.
- **Practical Sustainability Approach**- Organizations to adopt the technology driving human-centric approach that suits their culture to drive sustainable growth. Infosys Practical Sustainability Framework that provides a good insight into the human-centric approach for sustainability.
- **Carbon Footprint Journey and Iterative Approach has been depicted below.**



The way to sustainable IT includes following stages Discover, Define, Assess, and Implement. Through the iterative approach this can be slowly rolled out across the organization.

Accelerators in the sustainable IT Journey

- **Open-Source Carbon Emissions Calculator** - Cloud Carbon Footprint is an open-source tool that helps to calculate the Co2 emissions based on the Energy data.
- **3rd Party Products and Platforms**
  - Densify - Densify product has great capabilities for cloud and container optimization. It delivers optimization-as-code and uses machine learning to automate the rightsizing and optimization process continuously. Dynamic rightsizing the cloud resources saves compute power and energy
  - CoGo - Connecting Good: It is a Green fintech that provides the carbon footprint monitoring to create tangible action on climate every time someone spends. Cogo app "nudges" customers to make easy, positive lifestyle changes to help lower the footprint and offset the rest.
  - Other 3rd party platforms for carbon foot printing include Doconomy, Sopht, etc.
- **Tools Offered by Cloud Service Providers for measuring Carbon Emissions**
  - Azure Cloud - Microsoft Impact Dashboard helps in providing the insights of Co2 emissions due to usage of Azure services.
  - **AWS Cloud** - Sustainability Pillar was added in the Well Architected framework in 2021 by AWS to highlight the importance of Sustainability. Also, AWS has launched Customer Carbon Footprint Tool . AWS Customers can use it to Track, measure, review, and forecast the emissions.
  - **Google Cloud** - GCP has launched a dashboard that provide details of Carbon Emissions due to various services.

Building Sustainable Digital Future

For the better tomorrow, organizations should advocate for the **digital path** –the path to sustainable and inclusive growth for everyone. Organization should strive to build the sustainability IT culture. The developer experience should increase productivity and establish sustainable behavior. With Sustainable design, green coding, and riding on the wave of Industrial revolution 4.0, organizations can create better digital future for everyone.

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About the Mentor

Viral_Thakkar
AVP - Senior Principal Technology Architect

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10 Green Programming Languages

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