# The Impact of Improving Software Functionality on Environmental Sustainability

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# Objective

- To analyze the impact of transforming legacy systems with respect to new business demands on the energy consumption.

- To rise awareness of environmental sustainability among IT studies/ practices and green software.

# Why this Study Matters…

- Green IT is an ideal way to address the environmental issues in order to achieve environmental sustainability.
- The most significant and immediate reductions come from hardware solutions.
- Rare cases in which they focus on software. However, software also plays an important role having a considerable impact on energy consumption.
- Applying Green IT concept to the existing software to meet business demand or designing sustainable software is a complex task.
- Improving existing software functionality or leveraging legacy systems according to end-users' requirements has a significant impact on environment.
- Trade-off between improving software functionality and reducing energy consumption of a software product needs to be investigated.

# Background

- Effects of IT on environmental sustainability were structured mainly in three levels. Direct, indirect and rebound effect.
- Most of the studies almost completely ignore the rebound effect. Software development plays a specific role in creating rebound effects.
- A software system does not directly consume energy, it intensely affects the hardware functioning.
- Most of the studies have been done on the hardware and Life Cycle Assessment for computers, mobile phone networks, monitors, data center and power minimization by architectural designs.
- There is a lack of models and descriptions regarding environmental sustainability in the area of computer software.
- "GreenSoft" model for software products, sustainable metrics and criteria for software design and development

# Background

- Maintenance, modernization and replacement and software reengineering and modernization focus on retargeting, revamping, use of commercial components, source code translation, code reduction, and functional transformation.
- NASCIO survey in 2008 major driving force of moving towards modernization of IT systems and applications is green IT initiatives with 28 %.
- Keeping the software on demand and with high quality levels in respect to end-users' requirements create a conflict in terms of software energy consumption.
- Each integrated quality feature is accompanied by increasing levels of energy consumption.

# Case Study

## *Description of Software under Study*

- DB2 for Linux, UNIX and Windows Version 10.1
- Focused on measuring efficiency of the DB2 workload in the presence and absence of the data compression feature.
- Data compression reduces storage requirements, improves I/O efficiency, and provides quicker access to the data from the disk.

## *Adaptive data compression Feature*

- Utilizes a number of compression techniques leading to significant reduction of storage space.
- Its usage can lead to CPU overhead associated with compression and decompression of the data.

# Workload Description and Case Study Setup

- Reference workload TPC-H (Transaction Processing Performance Council) industry standard for measuring database performance.
- Workload: A set of business-oriented ad-hoc queries-1GB of raw data and 240 distinct queries.
- Lenovo ThinkPad T60 laptop with 3GB of RAM.
- Two hour interval.
- Counted the number of statements executed in a given time interval.
- Measured the amount of electricity consumed by DB2 running in the following two configurations:
  - Without compression
  - With compression
- The workload has been executed against each configuration three times to estimate measurement error.

# Results and Discussions

Table 1 : Workload and database characteristics with and without adaptive compression feature

| Database Feature | Average Statement Count per hour | Average Electricity Consumption (kWh) | Space Consumption (Mb) | Compression ratio | Watts per statement per second |
|---|---|---|---|---|---|
| **No compression** | **415 ± 1.8%** | **0.035 ± 0.5%** | **1168.2** | **100%** | **302** |
| **Adaptive compression** | **814 ± 4.0%** | **0.045 ± 0.0%** | **455.6** | **61%** | **199** |

Compression ratio = (1-*compressed size*/*uncompressed size*)

*Work performance (in terms of energy) =Energy consumption/Work completed*

# Results and Discussions

- Compression of data reduces tables' size by 61% and leads to 97% performance improvement in comparison with the reference configuration.
- Slowest configuration of the database is with the No compression.
- Compression feature increases overall power consumption by 29% (in comparison with the reference configuration).
- Energy consumption per unit of work is reduced by 34%, due to increased query throughput.

# Conclusions

- Considering environmental sustainability legacy system modernization regarding increasing the system functionality has a mixed effect on energy consumption.
  - consumption per unit of time increasing; consumption per unit of work deceasing.
- The amount of savings for the production system will vary with system's setup and with associated workload.
- The need for energy consumption from software especially from legacy systems which has strong end-user demand and there is a strong need for more input from software engineering on how to greening software toward creating more sustaining environment.

# Future Work

- Individual effects and joint effects of different features on energy consumption will be examined.

- Trade-off models can be examined in software development regarding environmental sustainability.


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