

How to measure employee carbon footprints: Part 1: Sample SOA implementation architecture

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This article describes an IBM® project to track employees' carbon emissions, using an SOA solution with WebSphere® Business Monitor, WebSphere ESB, WebSphere Integration Developer, and WebSphere Process Server.

Introduction

Many organizations in the world today, large and small, private and public, are trying to understand their environmental impact. In doing so, they are soliciting expertise and counsel from companies such as IBM, who have been trailblazers in this space. These organizations are looking at every aspect of their operations, including but not limited to, supply chain management, manufacturing, logistics, energy management, and waste management. Each area has a set of defined and measurable green house gas (GHG) emissions, on which the majority of these organizations tend to focus their resources and energy.

The solution described in this paper tries to compliment that approach, by also looking at the environmental impact of a company's employee workforce. It is well understood that in the exercise of their functions, employees have a significant impact on CO2 emissions. Whether they telecommute, work from a traditional office, or travel to meet with customers, employees have direct and indirect emissions associated with their activities. This paper clearly articulates what those emissions are, and to measure, track, and manage them. Our solution is based on an open SOA architecture that allows for not only measuring the carbon emissions, but also tracking other key performance indicators, vital to running any successful business.

Solution description

We can group employees by how they emit carbon in the exercise of their functions as:

Travelling employee: These employees create direct and indirect emissions. *Direct emissions* are described as activities that result directly in CO2 emissions. Flying, driving a rental car or taking a taxicab would fall into that category.

Indirect emissions are described as activities that are one or more steps removed from direct emissions. Staying at a hotel or using a specific number of IT devices are such activities, because the hotel provides its customers with lighting, HVAC, water treatment, laundry services, etc. All

of these amenities require a certain amount of electric consumption, in turn delivered by a utility generating it from one of its plants. The electricity production process will typically result in a certain amount of CO2 emission per KWH generated. The same would apply to the IT devices used by the employee. They require a certain amount of electricity to run, but for large servers or storage devices, they would also require cooling capacity to run efficiently. Again, all of these activities translate into indirect emissions.

Commuting employee: For employees that commute to a traditional office, the same model applies. The commute causes direct emissions, whether via a personal car or some type of public transportation. Within the office building itself, indirect emissions comprise provided lighting, heating and cooling of the building and the IT infrastructure used by the employee to perform his or her job.

Telecommuting employee: Our solution assumes that the employee works in his or her home, which is maintained primarily for family use. In other words, for simplicity's sake we assume that the home is not being heated or cooled or has any special lighting that is necessary for the employee to perform their job functions. The only indirect emission that are attributed to the mobile employee, are those associated with his or her work computers. This avoids solving the complex problem of having to determine how much of the employee's monthly electric bill is actually attributed to the person having to work from home.

Carbon calculations and solution assumptions

Calculating carbon emissions is a function of many variables. An example of that function would be calculating the carbon footprint of an airplane trip. Typically carbon emissions are a direct consequence of burning fossil fuels or some type of flammable material (coal, wood, etc). In this case, jet fuel is consumed to power the airplane's engines. So we would have to know how much fuel was burned from destination A to B, if we wanted to know the exact amount of CO2 emitted into the atmosphere. To know that, we would have to have access to a very long list of data: aircraft type, engines' type, weight of the aircraft, how many passengers were on the flight, and weather conditions, just to name a few. Obviously other than the airlines, no one has that type of information readily available. So we based the carbon calculation on industry averages, in this case the airline industry.

The same approach applies to the calculation of the carbon footprint of a server. The server consumes a certain amount of electricity. That electricity is provided by a utility company, which may rely on many sources for power generation. So to know exactly what the server's carbon footprint is, one would have to know its physical location (city and state), who is supplying the power, and when that power is being consumed. Once again, this turns into a complex proposition. So we also calculate the carbon footprint based on industry averages, which are derived from various empirical data sources.

Our solution used these averages for every single calculation. The idea was not to seek absolute precision but to offer a scientific method for comparative analysis. In essence, the problem we addressed is: *What is Employee A's carbon footprint today, and what will it be tomorrow for the same set of conditions, when the employee becomes more aware of ways to reduce it?*

Data collection method

To collect the data necessary to calculate the carbon footprint associated with any employee activity, the solution uses a simple, user-friendly interface (UI). The UI is designed to reduce the time commitment to enter data to an absolute minimum. Employees enter their data input once a week, which takes less than 2 minutes for each employee.

The solution, detailed later in this paper, is designed on top of an open SOA framework. It can connect and exchange data with multiple systems, which allows for a more complex approach to getting employee travel and location data dynamically from external systems. But since these systems differ from client to client, the dynamic approach is best developed as part of a client's customization process.

Carbon footprint and other key performance indicators

While measuring the carbon footprint and understanding all its ramifications on any large enterprise's operations is useful, it is most likely not going to be the driving factor in running a profitable business. That is why our solution tracks and projects other key metrics. Currently the solution allows for the import of financial data pertinent to running a services organization. We track revenue, cost, and gross profit metrics against monthly, quarterly and yearly targets and show them side by side with the carbon footprint data. A decision maker can look at all of this information and make decisions on how best to run the organization, financially and environmentally.

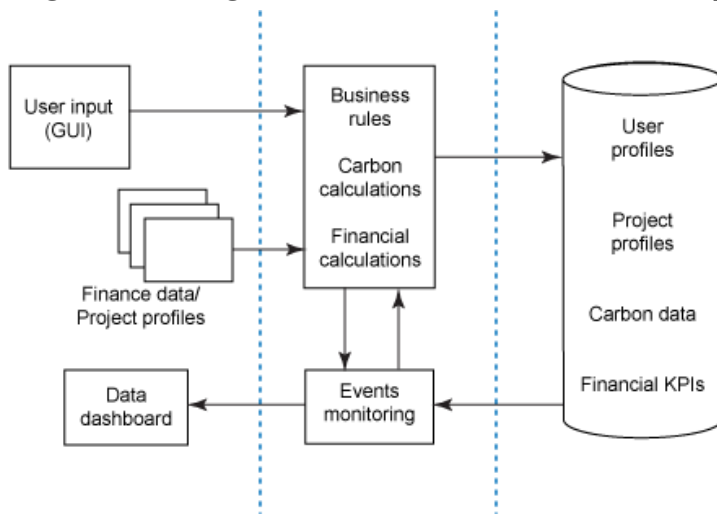
Because the architecture is based on open standards, any you can track other key performance measures as well. We leave it to you to determine what those metrics are, what systems they reside in, and the type of APIs through which they can be accessed.

The solution, by virtue of the products that it is built on top of, lets you study how these metrics relate to each other, and what type of influence they may have on the carbon footprint. It also provides predictive statistical abilities based on historical data gathered within the system.

One metric that we custom developed for this implementation was the Carbon Efficiency metric. It essentially measures the carbon footprint of an individual per dollars of gross profit generated. The net effect of the formula is the normalization of the gross profit generated by individuals that have various billing rates, but will incur similar carbon emissions. Gross profit is defined as revenue generated minus the cost. This metric lets you compare different human resources and how carbon efficient they are in the execution of their job functions.

Architecture decisions

Figure 1: Logical architecture of the Employee Carbon Footprint Dashboard



The application comprises three major layers, shown in Figure 1:

1. The **user interface layer** is used to:
 - Collect employee input.
 - Import financial data stored in already pre approved templates.
 - Import project profiles that contain the IT infrastructure associated with each project.
 - Built on JSF
2. The **business logic layer** comprises:
 - Websphere Process Server, which handles business rules, carbon footprint calculations, and financial calculations.
 - Websphere Business Monitor, which handles events monitoring on all events going through the process.
 - Business Dashboard which shows all of the instance data, key performance indicators, a sophisticated data warehouse that allows for in depth data analysis, and a business user level configuration utility.
3. The **database layer** is used for storage of all application data.

The key product in this architecture is Websphere Process Server. There are many reasons why it was chosen for this application, the main being the extendibility that the platform offers. While this paper doesn't really focus on Process Server, here are a few highlights:

- WebSphere Process Server is a high-performance, **business-process engine** that runs critical business processes securely, consistently and with transactional integrity. It helps orchestrate the assets of a business to form highly optimized and effective processes. This capability can help businesses meet their goals by automating manufacturing processes, for example, or efficiently processing insurance claims and financial payments, or running an efficient supply chain. Through the processes it automates, WebSphere Process Server also helps to ensure compliance with the latest industry regulations.
- WebSphere Process Server includes all capabilities of **WebSphere Enterprise Service Bus**, which mediates disparate services and helps maximize reuse of assets wherever they

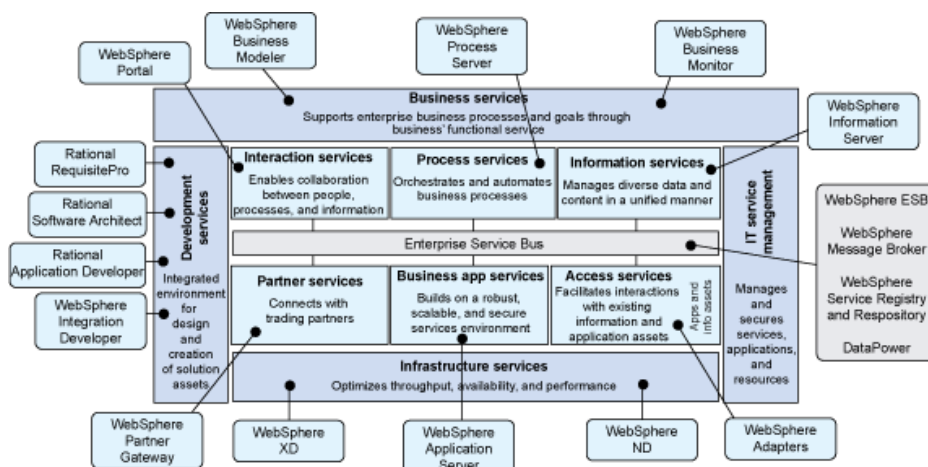
are, regardless of vendor or platform or whether they are built by companies or provided as part of packaged applications. WebSphere Process Server enables maximum reuse of assets through its built-in WebSphere Enterprise Service Bus technology for message-format mediations, transformation and routing.

- WebSphere Process Server combines **process automation** capabilities onto a single, unified server, offering a flexible business-process solution for all process needs. It allows a task to be implemented as a human service or programmatic service. It also allows a document or business object to flow between tasks. WebSphere Process Server is a best-in-class solution for human workflows and worklist management. It also provides for relationship management and event sequencing to synchronize events from disparate systems.
- WebSphere Process Server delivers a rich set of **integration-centric capabilities** from its ancestors. These capabilities include built-in support for transactions (such as two-phase commit), recovery, error handling and capabilities to connect with all major systems and applications through a variety of interfaces that can be based on Web services or Java™ technology, or use messaging as the transport mechanism.
- A **set of adapters** is available with WebSphere Process Server that connect business processes with other commonly used technologies (flat files, Java Database Connectivity [JDBC], File Transfer Protocol [FTP] and e-mail) or packaged applications (SAP, Siebel, PeopleSoft, JD Edwards and Oracle).
- WebSphere Process Server also provides **WebSphere MQ bindings**, enabling processes to access services reliably. WebSphere Process Server has native service bindings for Web services, Java Message Service (JMS), WebSphere MQ, Java, and contains WebSphere adapters, including e-mail, JDBC, flat file, FTP, IBM CICS®, IBM IMS, SAP®, Oracle® applications, Siebel®, PeopleSoft® and JD Edwards®.
- Process solutions are assembled and deployed to WebSphere Process Server using the Eclipse-based companion tool, **WebSphere Integration Developer**.

Employee Carbon Dashboard and SOA

Figure 2 shows the IBM SOA foundation products:

Figure 2: IBM SOA Foundation Architecture



Version 1.0 of the application has a limited focus, namely to:

- Calculate the employee carbon footprint
- Import financial data from a pre-defined spreadsheet template
- Import project profile data with associated IT infrastructure from another pre-defined Excel template
- Present all of that data side by side in an interactive dashboard for analysis.

Therefore the number of products and capabilities from Figure 2 were kept to an absolute minimum. Figure 3 shows the chosen products and the functionality that they provide.

Figure 3: Products leveraged from the SOA stack for Employee Carbon Dashboard

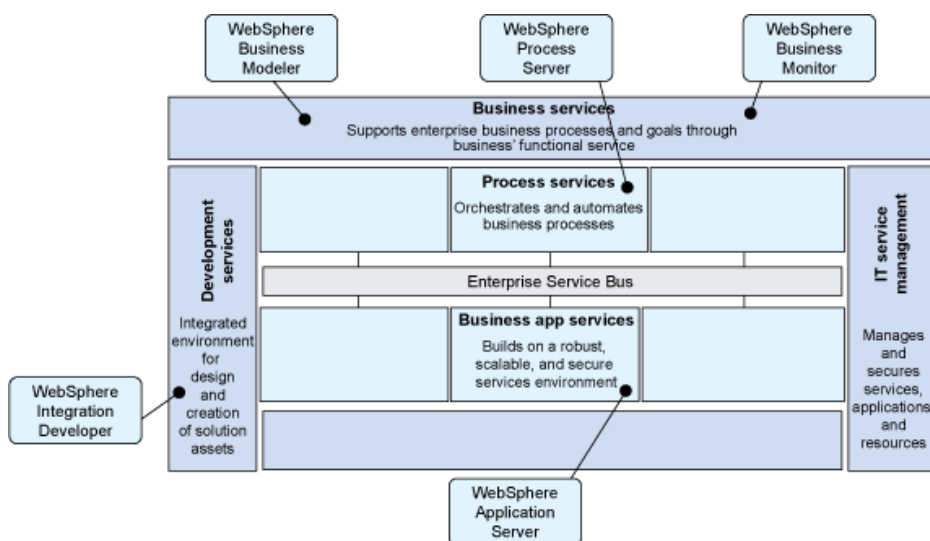


Figure 3: Products leveraged from the SOA stack for Employee Carbon Dashboard

- **WebSphere Business Modeler:** used to model the various human processes and business rules associated with the carbon calculations.
- **WebSphere Business Monitor:** used to listen to all of the events generated by Process Server, such as the carbon calculation results, financial data calculation results, and KPI calculation results. We used its Business Space dashboard to display all of the events data and conduct analysis.
- **WebSphere Integration Developer:** used as the development platform. We used it to create all the business rules, and various calculations, as well as the UI.
- **WebSphere Process Server:** used to create all of the business logic and business rules.

Employee Carbon Dashboard 2.0

Many customers that will implement this solution will most likely customize it to fit their internal enterprise architecture. Given the flexibility of the underpinning framework, the possibilities are almost endless. This sections looks at a few of our ideas that take advantage of the open SOA Foundation framework.

User Data

If the manual employee data input mechanism is not suitable for your internal use, you should consider other alternatives. Many vendors out in the marketplace today offer solutions that are based on the GPS location chip embedded in cell phones. You could download the data from the GPS locator to a central server and import it synchronously or via batch mode into the application. You could then develop business rules to turn location data and employee profiles into carbon emissions. This would ultimately solve the commute part of the equation and its cumulative carbon footprint. Privacy issues would have to be considered and dealt with appropriately.

The other part of the equation would be travel. Most organizations have developed or use some third party travel management system. That data could be leveraged to calculate the carbon footprint for each employee's trip.

Process

Every facet of a company's operations can be defined in the form of a business process. Manufacturing, logistics, supply chain management, energy management, recycling and waste management all break down into succinct business processes, with human tasks and interventions. These business processes need to be defined, modeled, implemented, managed and monitored, which is what the SOA framework is designed to do best.

There is a growing need amongst many companies driven by either regulatory obligations or customer demands, to produce "greener" products and services. Since these products or services are the ultimate deliverable of these business processes, calculating their cost and associated carbon footprint are key to achieving the "green" label.

Version 2.0 of the application can be extended to track these processes, their efficiency, cost, and associated carbon footprint.

Energy Consumption

Energy resources are becoming more and more expensive as businesses have to take a hard look at their consumption levels. Most companies are starting to pay attention to their utility bills for physical structures, data centers, and manufacturing plants.

Specifically when it comes to IT and its impact on energy consumption, here are some sobering statistics:

- **Analysts predict that by 2010 IT will account for more than 50% of an organization's electrical consumption**
- IT directly accounts for 2% of global CO2 emissions. That's as much as the airline industry (Source Gartner)
- Under current efficiency trends, national energy consumption by servers and data centers could nearly double again by 2011 (Source U.S Environmental Protection Agency, Report to Congress on Server and Data Center Energy Efficiency Public Law 109-431, August 2nd 2007)

- Average resource utilization <10% = \$140B excess server capacity (Source U.S Dept. of Energy, IDC)
- According to Gartner, By 2008, 50 percent of current data centers will have insufficient power and cooling capacity to meet the demands of high-density equipment
- 1 W of application computing requires 27 W of power (Source Springboard Research)

IBM offers many solutions to help monitor energy consumptions for buildings and data centers. Version 2.0 of the application could be expanded to track various energy consumption sources, not only related to office buildings but also to data centers.

Given the complexity of the undertaking, a comprehensive understanding of what needs to be tracked, and the decisions that need to be made based on the presented data, would drive what the final architecture looks like. There other products within the IBM Software portfolio that are specifically designed for those purposes.

Version 1.0 IBM internal implementation

IBM currently has an internal implemented with Version 1.0 of the application. Approximately 100 IBMers from various organizations are submitting their travel, commute or telecommute data on a weekly basis. The project is broken up into 2 phases. The first phase is designed to raise awareness about carbon counting and getting employees to get into the habit of submitting their data promptly and accurately once a week.

When that phase is over, we plan to implement conservation measures such as:

- Promoting telecommuting
- Cutting back on the number of IT devices used to what is strictly needed
- Encouraging employees to consider the use of public transportation or at least car pooling
- Finding more efficient ways to travel, and to do so only when absolutely necessary.

Phase 2 is designed to measure the effect of these conservations measures on the overall employee carbon footprint. The outcome of the project is to see whether awareness translates into behavioral change, and whether that change translates into a carbon footprint reduction.

Conclusion

We designed the IBM SWG Employee Carbon Footprint Dashboard to estimate the environmental impact of an organization workforce. We also leveraged the underlying technology to couple those measurements with other key metrics, namely financial ones. The application was built on the open IBM SOA framework to allow for customization and interaction with other external systems.

In the age of scarce and valuable energy resources, and a raging debate about how behavior affects the environment, this solution helps businesses start addressing some of these issues. Whether they are driven to it by certain regulatory obligations or by customer demand, most businesses are finding themselves having to deal with these issues sooner rather than later.

In future parts of this series, we will describe in detail how we implemented the Employee Carbon Footprint, including how we used WebSphere Process Server, WebSphere Integration Developer, WebSphere Business Modeler and WebSphere Business Monitor.

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