DIGITAL SERVICE EFFICIENCY

SOLUTION BRIEF

MAY 2013

HIGHLIGHTS

The eBay™ Digitial Service Efficiency (DSE) methodology connects technical infrastructure effectiveness to top-level business metrics because it:

- MEASURES the key variables of revenue, cost, performance, and environmental impact based on user consumption of services provided
- TUNES the infrastructure engine by identifying the knobs that can be adjusted at all levels
- OPTIMIZES effectiveness by striking a balance between the interconnected variables

Although DSE results are company-specific, the methodology of measuring, tuning, and aligning infrastructure with corporate priorities can be used by any company delivering services over the network.

Digital Service Efficiency (DSE) helps eBay to see the full cost, performance and environmental impact of customer *buy* and *sell* transactions, giving eBay a holistic way to balance and tune its technical infrastructure.

DRIVING FORCE OF THE ECONOMY

Data centers are the driving force behind today's economy. The servers, storage, and network equipment they contain support everything from traditional enterprise systems to global commerce engines such as those run by eBay.

If the technical infrastructure behind a presence such as ebay.com could be viewed as an automobile, customers would be in the driver's seat because they choose how they consume the services that eBay has to offer. eBay optimizes its technical infrastructure to perform best for the workload its customers impose, helping to accelerate business and boost the economy—all while helping to reduce its environmental impact.

MPG FOR TECHNICAL INFRASTRUCTURE

Until now, companies have been unable to make direct connections between what their customers do on their web sites and the total cost of providing services to them. DSE is essentially a "miles per gallon" measurement for technical infrastructure that makes an end-to-end connection between what customers do and the fundamental business metrics they influence— including cost, performance, environmental impact, and revenue.

Using DSE, eBay can make more informed decisions on how to optimize every aspect of its technical infrastructure, including the sourcing of electrical power, data center infrastructure, IT infrastructure, and the software that delivers services to users.

While the actual services and variables are specific to eBay, the methodology can be used by any company to make better business decisions. Just as "your mileage will vary" from any MPG rating, DSE provides an introspective view of how well a company has optimized its technical infrastructure. Comparisons between companies are important only in that users of DSE are making a commitment to greater transparency and reduced environmental impact. The actual services measured will normally be specific to the company using the methodology.

Through sharing the methodology and its results, eBay hopes to stimulate a larger conversation on how measurement can drive the tuning of technical infrastructure for improved business value. As the concept develops, companies can use DSE to improve transparency and provide insight into trends in energy consumption that

companies can use in their decision-making processes. This brief provides an overview of DSE concepts with more detailed information available in the future.

TUNING THE ENGINE OF THE ECONOMY

Global data center power use has been increasing at an alarming rate. *As of 2010, data centers used as much as 2.2 percent of global power output, up 56 percent over 2005*.

Data center operators are responding to these alarming statistics by increasing their focus on efficiency, using metrics-driven approaches to bring down overhead costs. Simply unplugging data centers is not an option because nearly every business enterprise depends on them to conduct everyday business. The imperative is to better tune the infrastructure to deliver optimal business value for the economic and environmental costs

Until recently, energy efficiency choices were made in a piecemeal, isolated, component-by-component manner that missed the larger context of the decision.

For example, selecting a more efficient uninterruptible power supply (UPS) is irrelevant if the business function that it supports does not require it. In eBay's case, right-sizing the application to have the appropriate data center redundancy, fault-tolerance, and maintainability characteristics removed a substantial amount of redundant equipment, cutting costs in half, and significantly improving efficiencies.

MEASURING DATA CENTER EFFICIENCY

The industry has now achieved meaningful insight into the larger impact of past and future energy efficiency improvements, through The Green Grid's Power Usage Effectiveness (PUE™) metric.

PUE measures how effectively the data center infrastructure powers and cools the servers, networks, and storage systems that deliver IT services. When PUE was introduced, it was common for data centers to have PUE measures greater than 2, meaning that for every watt of energy consumed by IT equipment, another watt would be lost in the electrical distribution system or used to cool the data center. Bottom line: more than 50 percent of the power delivered to the data center was not used by the IT equipment.

INDUSTRY COMPETITION

The emergence of a standard measure sparked competition in the industry to achieve the lowest PUE. For example, a case study *Breaking New Ground on Data Center Efficiency* published by The Green Grid detailed the ways in which eBay has achieved partial PUE measurements as low as 1.018 in its Project Mercury data center in Phoenix, AZ. The paper showed how eBay tuned the infrastructure so that more than 98 percent of the power was used by the IT hardware to do real work.

Similarly, Google has been publishing *trailing twelve-month PUE results* since 2008, achieving an impressive 1.12 average for one of the largest data center portfolios in the world.

While this competition ensues, The Green Grid has introduced metrics that further elaborate on data center environmental impact including Water Usage Effectiveness (WUE™), and Carbon Usage Effectiveness (CUE™).

Organizations have begun to track and report on these measurements not just to compete with each other, but to actually demonstrate greater data center efficiency. This ultimately means lower long-term costs for business and the environment.

TAKING THE NEXT STEP

Standardizing on PUE for data center efficiency has brought immeasurable benefit to the industry, however it is only one piece of a larger puzzle. Data center efficiency measures alone, for example, do not account for the effectiveness of the IT load itself. By design, PUE only measures the energy used to power and cool a data center, it does not consider whether software burns excessive energy using inefficient algorithms, or whether the services are delivered by ten year-old servers consuming twice the power that newer hardware would. In essence, an organization could put toasters instead of servers in the data center and its PUE results would improve.

FOCUSING ON BUSINESS VALUE

Business organizations need to optimize their IT operations for best business value, and that is achieved through a deliberate balance of the value of services delivered (revenue), the cost of delivering the services,

their performance characteristics, and the environmental impact. Tuning these variables in tandem is like solving a Rubik's Cube. Imagine each color as representing an independent variable (for example cost, performance, environment and revenue), yet each is dependent on the others. It's easy to solve the same color on one side of the cube independently, but solving all sides at the same time is difficult.

Focusing too much on performance could increase costs and environmental impact. Focusing too much on cost reduction could decrease performance, negatively impact revenue, and increase carbon emissions. DSE allows everyone to see the impact of infrastructure optimizations by directly connecting the customer's consumption of delivered services to the cost, performance, and environmental impact of the services.

MEASURING INFRASTRUCTURE EFFECTIVENESS

Technology infrastructure can be compared to a car. It may be designed to achieve 50 miles per gallon, but real-world results depend on how it is driven. DSE provides a direct link between the business value produced and the cost, performance, and environmental impact that combine to produce that value. It incorporates the layers of the stack above and below the data center and IT infrastructure to include data center siting and power sourcing decisions as well as the layers of software that use the IT infrastructure to deliver business value (Figure 1).

DSE can help businesses create a balanced infrastructure ecosystem by supporting continuous improvement through measurement and trend analysis. If data centers are the engine of the new economy, then DSE provides the feedback on how the engine is performing to support current business conditions.

LINKING BUSINESS WITH ENERGY USE

DSE measures how many business transactions are completed per kilowatt-hour (kWh) of energy consumed. For eBay, this was the link that was missing from previous measurements. Understanding what

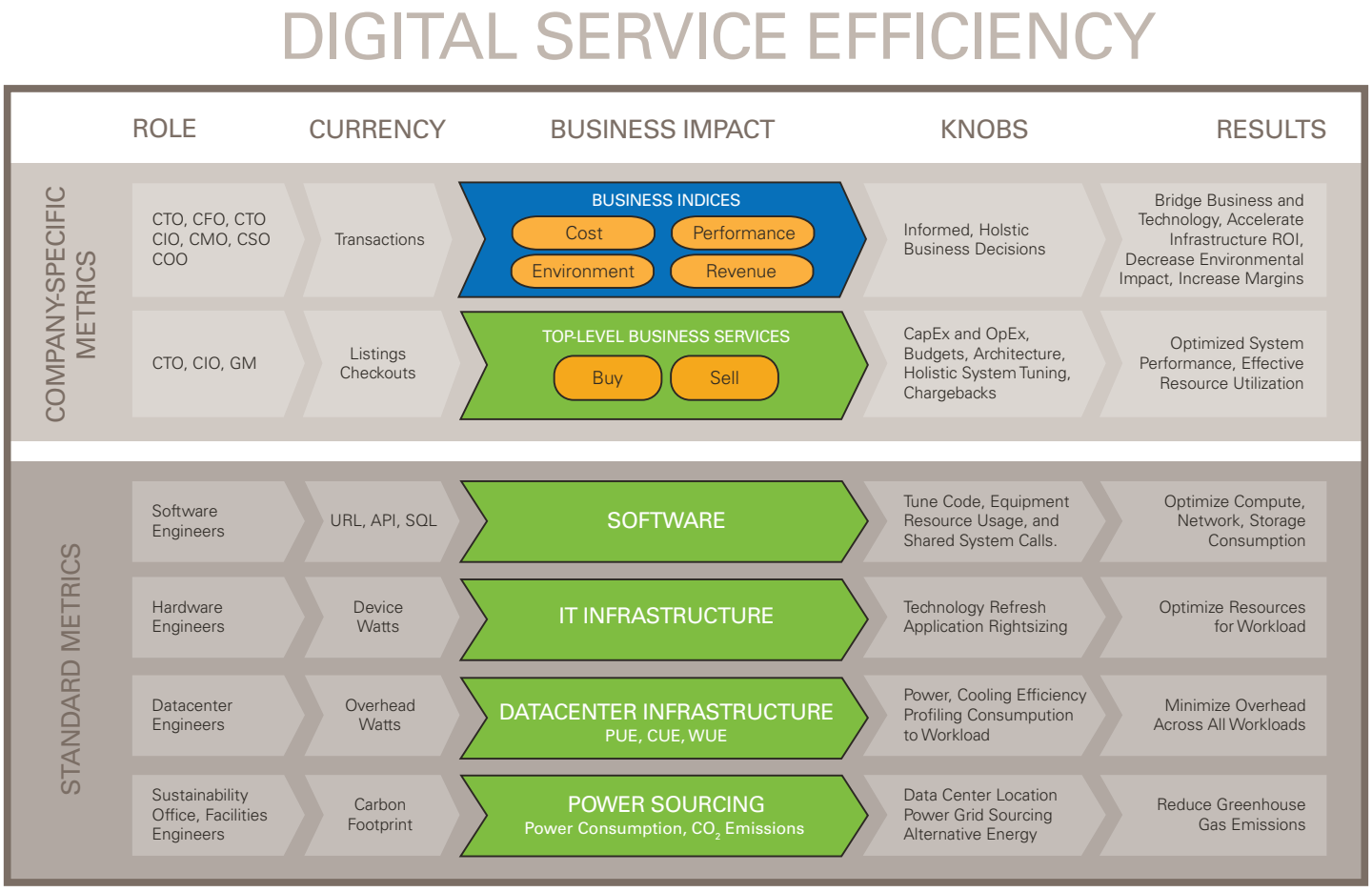

Figure 1. DSE directly links business value delivered with all layers of the technology stack that is engaged to produce the value.

services users were consuming and how much energy was required to deliver them connected the work done with the infrastructure delivering it. To establish a specific transaction measurement, eBay had to establish what services were being consumed and how many transactions were completed in delivering each service.

In the case of ebay.com, customers initiate two types of services: *buy* and *sell*. These user-level actions begin a series of requests that ripple through the entire software and hardware stack, consuming power throughout the infrastructure illustrated in Figure 1. These two user requests constitute the demand on the eBay technical infrastructure.

Once these two services were established, a common transactional measurement was identified. For eBay, a transaction is the same as a uniform resource locater (URL). Each buy or sell request progresses through a specific number of URLs to deliver the service. Now that the nature of a transaction is established, a family of interconnected metrics can be applied to provide further insight for optimizations:

- PERFORMANCE: transactions per megawatt hour (MWh), transactions per user, transactions per server
- COST: dollars per MWh, dollars per transaction, dollars per user, dollars per server
- ENVIRONMENTAL IMPACT: metric tonnes of carbon dioxide (CO_2) per MWh, tonnes of CO_2 per transaction
- REVENUE: revenue per transaction, revenue per MWh, revenue per user

ENGAGING THE ENTIRE BUSINESS

Connecting the key business variables with delivered services empowers an entire business to increase the effectiveness of its technical infrastructure. DSE enables eBay to dynamically tune its infrastructure engine by systematically exposing the multi-dimensional, interconnected knobs that developers, engineers and operators can turn to optimize all layers of the infrastructure stack. While the services defined are very specific to the company's product, the same methodology can be applied to any company delivering services over the network. PayPal, for example, has two high-level services, *payments* and *transfers*. While these are different services, the methodology to measure their technical infrastructure effectiveness is the same. The PayPal payment and transfer services have transactional URLs that are traversed for each service requests.

The methodology for deriving DSE is:

1. DETERMINE THE TOP-LEVEL SERVICES DELIVERED TO CUSTOMERS. When visiting eBay, customers use two primary services: buy and sell. The exercise of identifying these services forces the logical consolidation of dependent services under the top-level services, creating a hierarchical tree of interconnected components that can be measured.
2. QUANTIFY THE ENERGY CONSUMED FOR EACH TOP-LEVEL SERVICE. This includes direct and indirect (shared) consumption in kilowatt-hours. The sum should add up to the total power consumed by infrastructure, including both IT and non-IT load.
3. ESTABLISH APPROPRIATE CURRENCIES. Following the flow of software through its multiple layers exposes how each service is provided, identifying internal currencies that then translate to each layer in the data center. In the case of eBay, the top-level services (buy and sell) use URLs as their common currency. Subsystems supporting the top-level services such as search engines, databases, data warehouses and other shared infrastructure use APIs and SQL queries as currencies. The IT currency is watts consumed by IT equipment. The data center currency is watts, adding to the non-IT data center infrastructure cost. Finally, all kilowatt-hours consumed are converted into tonnes of CO2 emitted by the source of the electricity used.
4. DISCOVER THE KNOBS. These are the variables that can be turned to balance the cost, performance, and carbon footprint of delivering services. Below are examples of knobs that were turned at each layer to optimize the infrastructure supporting ebay.com.
   a) SOFTWARE ENGINEERS can optimize platforms and applications by more closely examining how many resources are consumed by activities such as responding to a request for a URL, the resulting API calls to an application server, and the resulting SQL queries to a database tier. Each of these activities involves the consumption of network bandwidth, CPU cycles, memory, and I/O operations, each of which can be optimized. Engineers at eBay found that by slightly decreasing the memory allocated for an

Figure 2. A dashboard can display a company's specific DSE measures over a set of user-selected time periods.

application in a pool of servers, they were able to remove 400 servers from the pool, decreasing nearly a megawatt of power consumption and avoiding over US $2 million in capital to refresh the servers. Performance increased; costs and carbon emissions decreased.

b) HARDWARE ENGINEERS can more closely match software requirements with server capabilities during technology refresh cycles. eBay replaces servers every three years, usually doubling performance for the same wattage consumed. At eBay, hardware engineers have determined the optimum processor and memory configurations for software applications in both virtualized and non-virtualized environments. Inserting these requirements into technology refresh cycles has allowed doubling capacity while keeping operational budgets flat. Performance increased; cost and carbon emissions decreased.

c) DATA CENTER ENGINEERS can build and operate highly efficient data centers that are matched to the availability requirements of software. For example, eBay has found that nearly 80 percent of its applications do not require highly redundant and fault tolerant data centers. They also aligned with the hardware engineers to consolidate the top 15 hardware configurations into two standard configurations, optimizing packaging and cost. The result was a doubling of data center power capacity, a four-fold increase in rack density, and a 53 percent reduction in cost per megawatt delivered over the last four years. Performance increased; costs and carbon emissions decreased.

d) FACILITIES ENGINEERS can evaluate the impact of data center site decisions by identifying the cost/benefit of choosing a site with access to renewable power sources, or optimizing a current site by investing in renewable power generation. For its next-generation data center in Utah, eBay has invested in on-site fuel cells as its primary power source. When the center opens in August of 2013, the fuel cells will not only increase the reliability of the site; they will directly reduce the data center carbon footprint by 13 percent. Performance stays constant; costs increased slightly; but carbon emissions decreased dramatically—all in a state in which 94 percent of current delivered power is generated by coal.

ITERATIVE PROCESS

Optimizing the many variables that are involved in making IT investments more effective is a continuous process. In ongoing use, eBay iterates through its internal currencies and turns the knobs that impact the cost, performance, and carbon footprint of delivering services.

Figure 2 illustrates how eBay presents its quarterly DSE results. Viewers can observe that in the first quarter of 2013 ebay.com averaged 32,228 transactions per kilowatt hour, an 18.5 percent improvement over the 27,193 transactions per kWh measured in 2012. The left side the dashboard indicates infrastructure consumption statistics, including the:

- Owned clean energy
- Data center power efficiency
- Carbon avoidance
- Total IT power consumed
- Total servers used
- Active users

This infrastructure consumption was based on the demand for buy and sell services.

On the right side of the dashboard, eBay connects the business key performance indicators, specifically revenue, cost, and carbon impact. This quarterly reporting allows anyone to see how effectively the ebay.com engine ran based on user consumption.

By applying the methodology described in this brief, other organizations can make informed, holistic decisions on how to optimize their infrastructure based on their own services and currencies. Choices on where to make capital investments, how to optimize performance and when to implement energy savings measures are no longer made in isolation. Instead they are tied to the very metrics that fundamentally matter to the business—in eBay's case, the business impact of delivering a buy or sell action online.

CONCLUSION

DSE from eBay represents the first measurement methodology to give high-level executives and technical professionals the tools they need to evaluate, tune, and balance their technical infrastructure investments. It is a measure of business efficiency that transcends simple energy efficiency.

As the pressure to reduce the environmental impact of global technical infrastructure continues unabated, the choices that reduce carbon footprint won't be made simply to achieve a badge of honor. They will fundamentally be business decisions.

By illuminating the complex relationship between revenue, cost, performance, and environmental impact, DSE gives chief executives and technical professionals unprecedented insight into the impact of their decisions and better tools with which to make them. DSE exposes the path to improve infrastructure effectiveness and reduce carbon emissions simultaneously reaching the audience that can make real change happen. ■

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To join the conversation about Digital Service Efficiency, please visit dse.ebay.com or email dse@ebay.com.