Metrics for the Internet Age: Quality of Experience and Quality of Business

Aad van Moorsel
Software Technology Laboratory
HP Laboratories Palo Alto
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E-mail: aad@hpl.hp.com

Quality of Service, Quality of Experience, Quality of Business, performability

The primary topic of this report is 'metrics'. More specifically, we discuss quantitative metrics for evaluating Internet services: what should we quantify, monitor and analyze in order to characterize, evaluate and manage services offered over the Internet? We argue that the focus must be on quality-of-experience and, what we call, quality-of-business metrics. These QoE and QoBiz metrics quantify the user experience and the business return, respectively, and are increasingly important and tractable in the Internet age. We introduce a QoBiz evaluation framework, responding to the emergence of three types of services that impact quantitative evaluation: business to consumer services, business to business services, and service utility through service providers. The resulting framework opens avenues for systematic modeling and analysis methodology for evaluating Internet services, not unlike the advances made over the past two decades in the area of performability evaluation.

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Aad van Moorsel,
E-Services Software Research Department
Hewlett-Packard Laboratories
Palo Alto, California, USA
aad@hpl.hp.com

Contribution to the fifth performability workshop,
in honor of John F. Meyer, inventor of performability.

Abstract

The primary topic of this report is 'metrics.' More specifically, we discuss quantitative metrics for evaluating Internet services: what should we quantify, monitor and analyze in order to characterize, evaluate and manage services offered over the Internet? We argue that the focus must be on quality-of-experience and, what we call, quality-of-business metrics. These QoE and QoBiz metrics quantify the user experience and the business return, respectively, and are increasingly important and tractable in the Internet age. We introduce a QoBiz evaluation framework, responding to the emergence of three types of services that impact quantitative evaluation: business to consumer services, business to business services, and service utility through service providers. The resulting framework opens avenues for systematic modeling and analysis methodology for evaluating Internet services, not unlike the advances made over the past two decades in the area of performability evaluation.

Keywords: Quality of Service, Quality of Experience, Quality of Business, QoS, QoE, QoBiz, management, e-services, web services, performability, metrics, analysis

1. Quantitative Evaluation in the Internet Age: What is Different?

Who cares if your web shopping site has an availability of 'three nines'? 99.9% availability corresponds to a little over eight hours of total down time in a year, but most customers do not care, nor do line-of-business managers. The customer only cares if the site is up when she wants to shop. Moreover, if the site is down for a few seconds during a shopping session, she will only care if it makes any difference for the execution of her ongoing tasks. The business manager only cares if she loses business because of down time, and for how much money this could have been prevented.

From the above example, it follows that system metrics such as availability are not sufficient to evaluate an Internet service. Instead, user experience metrics and business metrics are necessary. Surely, this is not a new realization—at any point in computing system history, there have been implicit considerations about user and business requirements when evaluating systems and services. For instance, decisions about upgrading computer equipment routinely consider user needs and costs. However, the

problem has always been that the relationship between system quality, user experience, and business cost is hard to make concrete. QoS, QoE and QoBiz analysis has therefore never been done in systematic and integrated fashion.

In the Internet age this must change. The relation between QoS, QoE and QoBiz has become very apparent, and more easily to discern. In the web shopping scenario, the user experience directly influences how much shopping the customer does, and how much money the business makes as a consequence. Results are available that relate response times with user behavior [1] and business loss [12]. In the Internet age, not only are QoBiz metrics increasingly important, they are also more directly measurable and therefore better tractable.

Acronyms:

QoS:	Quality of Service
QoE:	Quality of Experience
QoBiz:	Quality of Business
B2C:	Business to Consumer
B2B:	Business to Business
xSP:	any Service Provider
ISP:	Internet Service Provider
ASP:	Application Service Provider
MSP:	Management Service Provider
CSP:	Communications Service Provider
HSP:	Hosting Service Provider
SLA:	Service Level Agreement

The crucial difference in the Internet age is that people, processes and institutions play roles that are closely integrated with the system (that is, the Internet) itself. They form ecosystems in which business is conducted through technological means (business-to-consumer as well as business-to-business). In addition, technology services are being provided and consumed in similar fashion as electricity and water (the service utility model). In particular, we identify the following trends as drivers for QoBiz management:

- Integration of the user in Internet ecosystems (B2C)
- Integration of enterprise business processes in web-service ecosystems (B2B)
- Emergence of the service utility model (service providers/xSPs)

In what follows we discuss the metrics that are suitable to evaluate the ecosystems that arise from these three trends. Intuitively, B2C naturally leads to QoE analysis, and B2B requires QoBiz analysis, as we discuss in Section 3. In Section 4, however, we introduce a more abstract notion of QoE and QoBiz, which allows us to construct a general framework in which every participant in an Internet ecosystem deals with QoS, QoE and QoBiz concerns at its own level of abstraction. That is useful for structured evaluation of service providers, which may have various participants interacting in a joined ecosystem (ISP, ASP, MSP, CSP, HSP, …). Eventually, we hope that the proposed framework is a useful steppingstone towards generic methodology and software support for QoBiz evaluation of Internet services.

Before discussing Internet metrics in detail, however, we consider in Section 2 how metrics like QoE and QoBiz relate to the performability metric for fault-tolerant systems.

2. A Performability Perspective

The introduction of the performability metric in 1978 was motivated by the growing acceptance of fault tolerant systems [6]. One characteristic that makes those systems

different from the preceding generation is that they are able to operate in degraded mode. This implies that it is no longer sufficient to know that the system is up or down—instead, one needs to know 'how much up' it is (at what mode of degradation), and what the level of performance is in this mode. In other words, one needs to evaluate not only what the system 'is,' but also what it 'does,' thus combining reliability with performance evaluation [4]. The introduction of performability has its roots in the need of evaluating a new class of systems in a more systematic and meaningful manner than previously done. It is no surprise that a disruptive technology like the Internet requires something similar.

Performability provides a bridge between mathematical modeling and domain-specific system engineering. That is a very important aspect: there is a system engineering need to systematically classify and identify appropriate domain-specific metrics, since it leads to more powerful quantitative modeling approaches for the considered class of systems. As an example, in earlier work, we identified so-called system metrics and task metrics, and we showed that the latter, though arguably more relevant, are systematically harder to analyze [8]. This has lead to the insight that conversion laws (like Little's law for queuing systems) are critical, and ultimately made us propose the 'action model' paradigm for task metrics [9]. The most convincing example demonstrating what can be achieved when tying mathematical modeling and system engineering is the performability evaluation approach based on reward models and (variations of) stochastic Petri nets [7]. This approach provides systematic modeling and software tool support for quantitative evaluation of fault-tolerant systems. It has taken quantitative modeling of fault-tolerant systems beyond solving case studies. This paper would serve its purpose well if it would instigate systematic approaches to QoE and QoBiz analysis for Internet services, comparable to those existing for performability evaluation of fault-tolerant systems.

3. QoS, QoE and QoBiz

To create an intuition for the various quality metrics, let us consider for a moment a grocery store, and identify what quality of service (QoS), quality of experience (QoE) and quality of business (QoBiz) means in that context.

Grocery store. QoS metrics of a grocery store are metrics that say something about the store itself, not taking the perspective of customer or business: is the store open or not, what is the average number of customers that pass through a counter every hour. These QoS metrics provide base info about the grocery store—however, they do not tell anything important for customer or owner. For this we need QoE and QoBiz metrics, respectively. QoE metrics relate to the customer experience: is the grocery store open if 'I' (the customer) want to visit. Another QoE metric is the actual time I spend at the register, and also if I consider the service 'slow' or 'fast.' Note that the mentioned QoE metrics have a counterpart in the QoS metrics mentioned above, but are different in that they take the customer angle (which may, indeed, be subjective in nature). QoBiz metrics, finally, relate very closely to 'dollars:' 'will my business make more money if I add counters?,' 'will my business make more money if I open my store between 10 pm and 5 am?' and 'is the layout of my store optimal in guiding customers to the most profitable items?'

The above scenario can easily be transposed to Internet services. QoS metrics are metrics such as availability and performance; QoE metrics are response times and availability of a service as experienced by a customer [13] [14]; finally, the QoBiz metric is expressed in terms of money, such as the average amount of money received per executed transaction. Figure 1 shows some of the typical metrics. Note that QoS metrics are further divided in two: system metrics and task metrics [8]. QoS task metrics are very close to QoE metrics, with two exceptions: (1) QoE metrics may have a subjective element to it while QoS task measure do not, and (2) QoE metrics may be influenced by any system between the service provider and the customer, while task measure relate to the quality of the considered system and service only. An example of the latter is the QoE of a web site, which heavily depends on the ISP's network conditions, the speed of the modem, etc [3] [5]. In that case the QoS task metric for the web service would only consider the web site, while the QoE metric must take into account all the other elements as well.

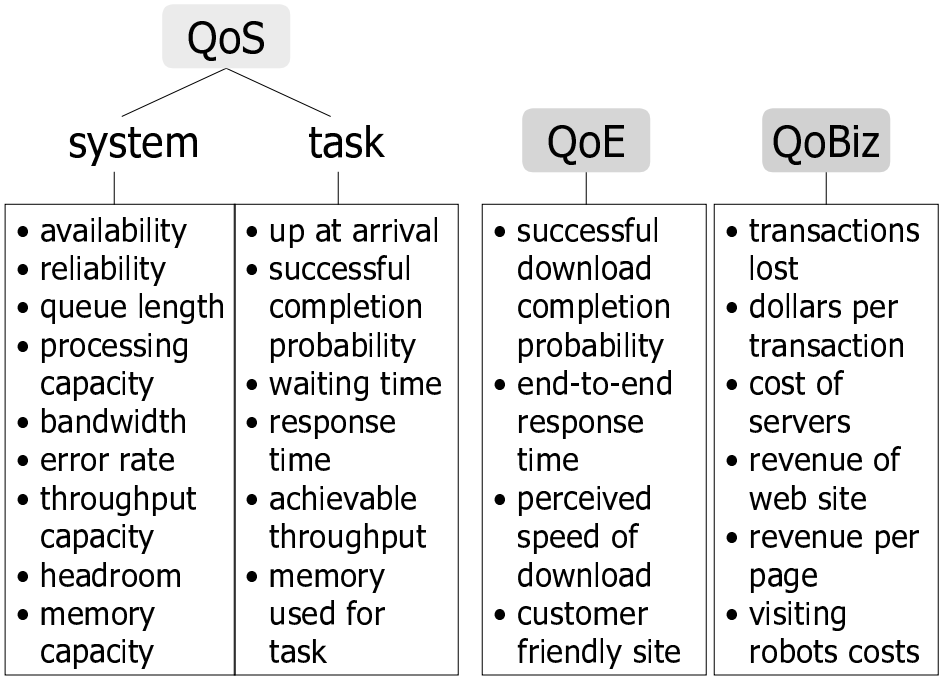

Figure 1 Examples of QoS (system and task), QoE and QoBiz metrics

4. QoBiz Evaluation Framework

In Section 1, we identified various roles played by people, processes and institutions participating in Internet business. Together, conglomerates of these players create an ecosystem, consisting of customers, suppliers, partners, etc. Each player in such an ecosystem has QoS, QoE and QoBiz concerns, and the quality metrics of different parties depend on each other [10] [11]. By abstracting away the intuitive notions of customer and business used in Section 3, we now construct a framework for systematic quantitative evaluation of Internet services.

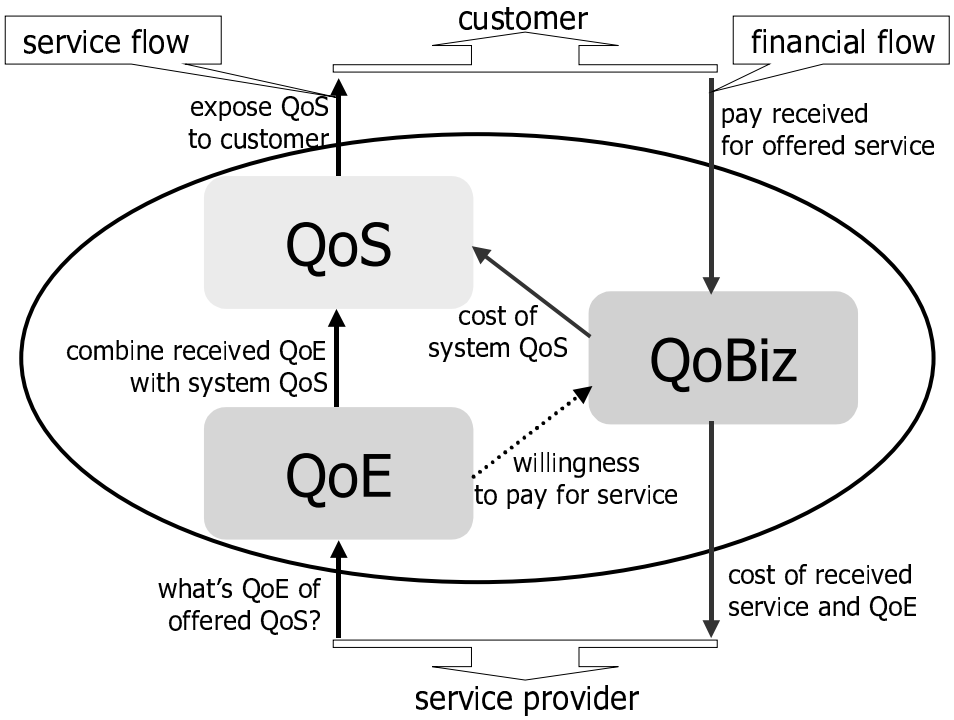

Figure 2 QoS, QoE and QoBiz for a single participant in an Internet ecosystem.

Figure 2 depicts the quality concerns of any player or participant in an Internet ecosystem. The player has connections with service providers and with customers (bottom and top of Figure 2, respectively). A service is received from the service provider, and a service is offered to the customer. This service flow is depicted on the left-hand side of the figure. Each player has its own metrics of interest: an Internet service provider is interested in bandwidth, an application service provider is interested in number of customers supportable, and an end customer is interested in perceived response time. Using the participant's own metrics of interest, it receives a certain QoE level from the service provider (the QoE box in Figure 2). In addition, it exposes a service to the customer, possibly using some additional resources of its own—these resources together with the received service have a certain QoS (the QoS box). This service will then be exposed to the customers.

The right-hand side of Figure 2 gives the financial flow, which directly relates to quality of business metrics. QoBiz is influenced by cost and revenue considerations. To achieve a certain QoS level, resources must be paid for ('cost of system QoS' arc). In addition, each service provider must be paid for its delivered QoE (arc down to service provider). If the service provider delivers high QoE, the participant's willingness to pay for the service increases (as depicted by the dashed arc between the QoE and QoBiz box). These are all cost items for the considered participant. In addition to cost, there is revenue from the customers, which is depicted by the arc from the customer to the QoBiz box. Evaluation of QoBiz must take into account all these cost and revenue aspects.

We now relate the building block for the QoBiz evaluation framework in Figure 2 with the three important trends for QoBiz evaluation identified in Section 1, in the following order: xSPs, B2C and B2B.

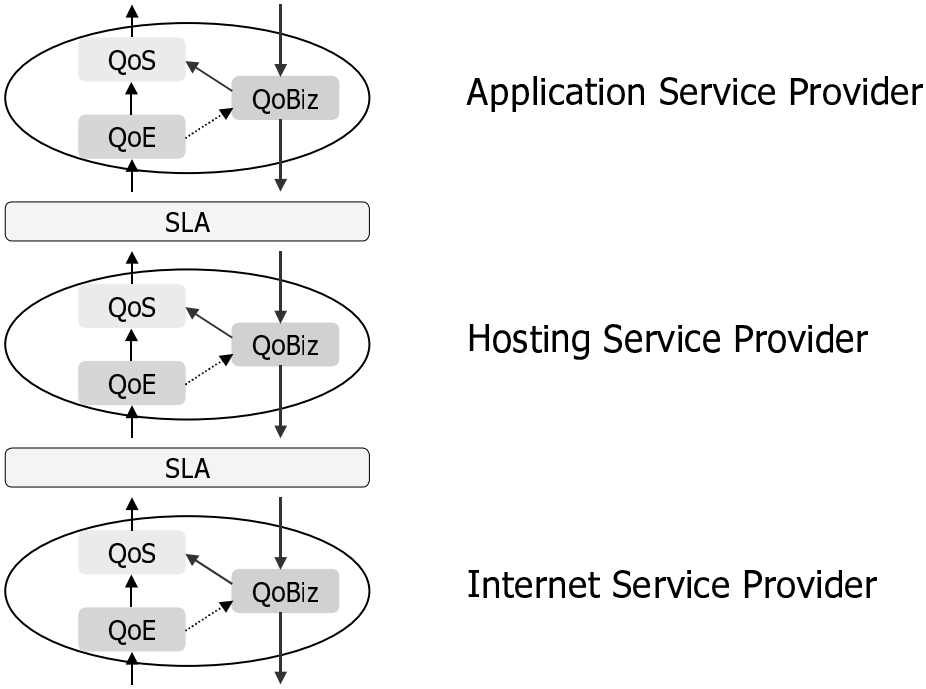

Figure 3 XSPs: Service Level Agreements between service providers

Service Providers (xSPs). In Figure 3 a chain of service providers all face QoS, QoE and QoBiz concerns. SLAs specify the delivered service levels. An ISP delivers bandwidth to an HSP, who delivers CPU and storage to an ASP, who delivers applications to a customer. For each service receiver, the SLAs are most useful if they are expressed in terms of its QoE metrics, while for the providers visibility may not go beyond the offered QoS. As we noted in Section 3, the offered QoS does not necessarily directly translate to the perceived QoE, since other network and communication players may play a role in how the service is delivers.

With respect to quality of business, the SLAs also play an important role. Often, SLAs specify costs and penalties depending on the delivered quality of service. Hence, QoBiz evaluation has a lot to do with a cost-benefit analysis and prediction for SLAs. In addition, the service utility model has direct impact on QoBiz evaluation as well. In the service utility model, resources are not bought by the customer but paid for when used. This opens up new charging models for providers and requires new strategy and planning for resource reservation by customers. All together, it is clear that interesting opportunities exist to create systematic analysis methodology and tools for QoBiz evaluation of (chains of) xSPs.

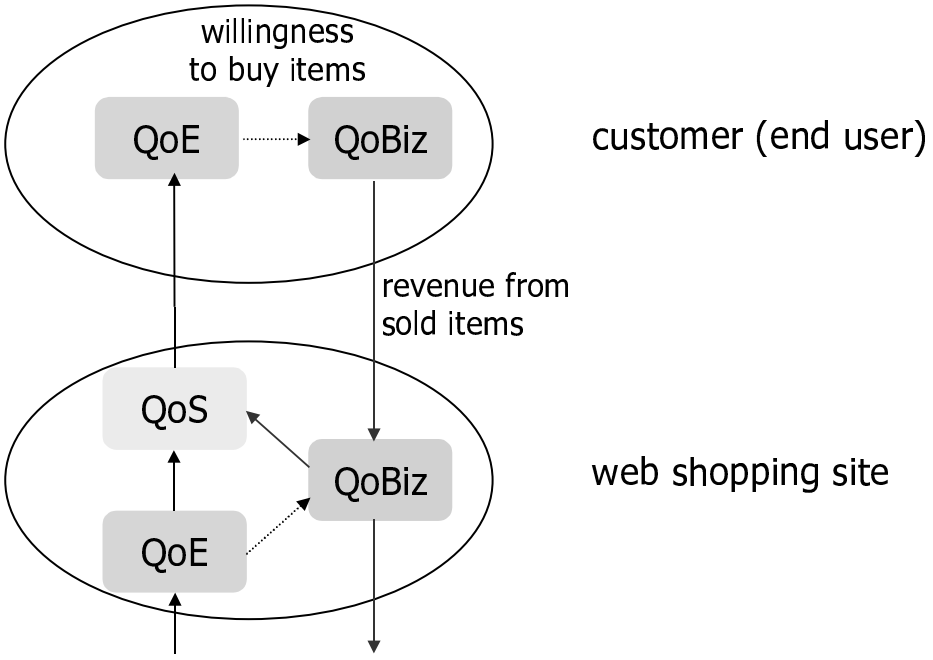

Figure 4 Business to Consumer scenario: QoBiz influenced by executed transactions

Business to Consumer (B2C). We argued in earlier sections that QoBiz becomes more important and better tractable for Internet applications. Figure 4 and Figure 5 show why this is the case. Figure 4 depicts a B2C scenario, such as for amazon.com. Figure 5 depicts a B2B scenario, corresponding to for instance a travel agent web service that conducts business with a hotel booking service. In both cases, the important aspect is that transactions executed between players directly correspond to the business revenue created. In the B2C case, transactions that correspond to orders create business revenue for the service provider. Moreover, QoS and QoE directly influence the QoBiz results, albeit in intricate ways. Nevertheless, the relationships between QoS/QoE and QoBiz is much more direct than for old-style computing systems that support administrative activities. It is also more dynamic and natural than for SLA agreements.

Figure 4 shows that the end customer makes decisions about purchasing based on the perceived QoE (and many other elements). The QoS concern of the end customer is a non-issue, since there is no service delivery that must be done, and we therefore removed the QoS box from the end user. QoBiz between customer and web service now includes the revenue generated at the web service from the interactions with the customer (see the label in Figure 4).

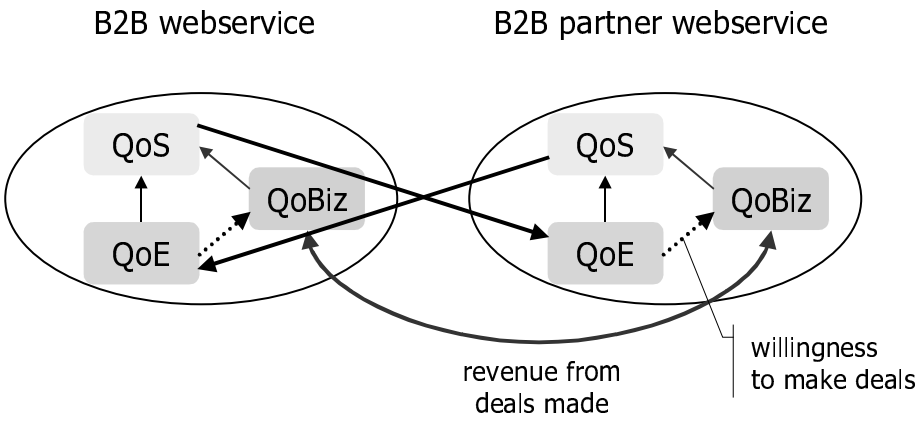

Figure 5 Business to Business partner scenario: QoBiz influenced by executed transactions

Business to Business (B2B). Figure 5 depicts two partners executing B2B transactions. In this case, the term 'partners' better describes the mode of interaction than the term 'service providers.' Their mutual willingness to do business with each other depends on the perceived QoE. Better QoE increases the willingness to make deals. QoBiz, then, depends on how much business is executed between the partners.

Having identified QoS, QoE and QoBiz relationships for Internet ecosystems is only a first step in establishing quantitative evaluation methodology for Internet services. In [2], Jim Grant argues for QoE/QoBiz management throughout the system life cycle, an aspect we have not considered in this manuscript. However, the real challenge is in identifying mathematical modeling techniques, efficient solution algorithms, and software tool support that systematically deal with QoBiz evaluation.

5. Conclusion

This paper introduces the concept of QoBiz (quality of business) metrics and evaluation. It builds up an evaluation framework for Internet services, relating QoS (quality of service), QoE (quality of experience) and QoBiz. The need to consider QoBiz metrics when evaluating Internet services has become increasingly apparent because of the emergence of three types of service models: business to consumer services, business to business services, and the service utility model using service providers. In all three cases, business and system considerations must be considered in unison. The developed evaluation framework is a steppingstone towards systematic support for QoBiz evaluation of Internet services. In the future, we may hope to see generic modeling methodology, solution algorithms and software tools to support such evaluation.

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