

A Review of the Article:
The World Wide Web: Opportunities for Operations Research
and Management Science

by

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This paper was a review of the recent journal article, *The World Wide Web: Opportunities for Operations Research and Management Science*, by Hemant Bhargava and Ramayya Krishnan. In the following pages, this report addressed six issues as they related to the article. Those issues were the problem addressed, prior research, significance, methodology, contributions, and further research.

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Chapter 1

Introduction and Problem Addressed

This paper is a review of the recent journal article *The World Wide Web: Opportunities for Operations Research and Management Science* (Bhargava & Krishnan, 1998, Fall-b). In the following pages, this report addresses six issues as they relate to the article. Those issues are the problem addressed, prior research, significance, methodology, contributions, and further research.

Problem Addressed

In response to the phenomenal growth of the World Wide Web (WWW or Web) and its accompanying effects on Operations Research/Management Science (OR/MS), Bhargava and Krishnan wrote the article to address the problem of understanding the opportunities presented to the field by the Web. The article addressed three questions and had three main goals. The questions were:

- What is it about the Web that caused its widespread use?
- How does the Web relate to OR/MS, and will OR/MS ever be the same again?
- What OR/MS activities will benefit from Web technologies, and what will the benefits be?

In addition to answering the above questions, the article had the following objectives:

- Provide a concise technical and capabilities overview of the Web.
- Illustrate and explain the potential positive impact that Web technologies are able to make on the OR/MS profession.

- Describe the Web-based technologies currently available for OR/MS workers to Web-enable their applications in the new distributed environment.

The article began with a short overview of the history of the World Wide Web and its beginnings at the European Laboratory for Particle Physics (CERN). This was followed by a discussion divided into six sections. The first section presented four vignettes that illustrated ways that Web technologies could benefit OR/MS work. Section two provided an introduction to the architecture of the Web and the fundamental technologies that support it. Sections three, four, and five described the tools employed in sections one and two. The sixth section discussed emerging technologies that Bhargava and Krishnan felt would be instrumental in the use of Web-based tools for OR/MS applications.

Chapter 2

Prior Research

The first section of this chapter is a brief review of the body of literature that motivated Bhargava's and Krishnan's research. This is followed by a discussion of other articles that are also relevant to the problem of understanding the opportunities presented to OR/MS by the Web.

Review of Referenced Articles

In the article, Bhargava and Krishnan did not identify any shortcomings in the prior literature. The following is a discussion of key journal articles referenced in the paper.

The World Wide Web

The *World Wide Web* (W3) provided an overview of the history of the Web along with descriptions of the underlying technologies it employs (Berners-Lee, Cailliau, Luotonen, Nielsen, & Secret, 1994, August). Topics covered were hypertext transfer protocol (HTTP), hypertext markup language (HTML), and universal resource identifiers (URIs). Bhargava and Krishnan referenced the article in the introductory sections of their paper to provide the reader with the background required in later sections.

Optimization on the Internet

Optimization on the Internet described NEOS (Network-Enabled Optimization System) (Czyzyk, Owen, & Wright, 1997, October). NEOS gives remote users the ability to run specialized computational methods on high performance servers over the Internet. Bhargava and Krishnan referenced this article in the first section of their paper to provide

a concrete example of how the Web could be leveraged to solve complex engineering design problems.

MIME: A Portable and Robust Multimedia Format for the Internet

In section three of the paper, Bhargava and Krishnan described the various Web tools required to present OR/MS content over the Internet. One important tool for the effective display and transport of multimedia content is MIME formatting. The article, *MIME: A Portable and Robust Multimedia Format for the Internet*, provided background into the role of MIME in extending mail standards to support multimedia (Borenstein, 1993). MIME formats are currently being used by the OR/MS community to deliver OR/MS content.

Waste Disposal and Recycling Decision Support Systems

Bhargava and Krishnan discussed the use of server-side computation in the fourth section of the paper. One method of enabling server-side OR/MS computation is the use of CGI (Common Gateway Interface) scripts. The article, *Waste Disposal and Recycling Decision Support Systems*, described how the server-side OR/MS computational model could provide a Web-based optimization system for solving waste disposal and recycling problems (Bhargava & Tettelbach, 1998, August 28).

Bridging Boundaries: CORBA in Perspective

The article, *Bridging Boundaries: CORBA in Perspective*, discussed the role of CORBA (Common Object Request Broker Architecture) as a bridging technology (Baker, Cahill, & Nixon, 1997, September/October). The article also included a comparison of CORBA to other alternatives such as the Java and CGI approach. Bhargava and Krishnan referenced this article in section five of the paper, which provided guidance to OR/MS

practitioners on choosing the appropriate technology to implement OR/MS techniques on the WWW.

Architecture for a Web-Accessible Simulation Environment

In section five of the paper, Bhargava and Krishnan also discussed the application of applets as the user interface when the OR/MS algorithm resided on the server. The article, *Architecture for a Web-Accessible Simulation Environment*, provided an example of this architecture (Chatterjee, Paramasivam, & Yakowenko, 1997, June). The article described CSLab, a dynamic, Web-accessible simulation environment. CSLab provided a framework within which OR/MS researchers were able to create, configure, and execute experiments.

Using Java Applets and CORBA for Distributed Application Development

In the article *Using Java Applets and CORBA for Distributed Application Development*, Evans and Rogers discussed the use of Java applets to build a user interface that interacts with remote server software (Evans & Rogers, 1997). Bhargava and Krishnan referenced the article in section five to provide readers with a comprehensive list of the technologies available to build distributed applications on the Web.

XML: A Door to Automated Web Applications

In section six of the paper, Bhargava and Krishnan discussed emerging technologies and trends. These included XML (Extensible Markup Language) and specialized OR/MS markup languages such as AMPL and SIF/ML. The article, *XML: A Door to Automated Web Applications*, provided the insight into XML's role in automating Web-based OR/MS applications in the future (Khare & Rifkin, 1997, August).

On Using Web Technologies to Architect DSS

The article, *On Using Web Technologies to Architect DSS*, discussed the future use of Web technologies to solve military logistics planning problems (Krishnan & Padman, 1997). Bhargava and Krishnan referenced the article in section seven of the paper to provide an example of how the integration of real-time data feeds would result in the development of new types of planning and control systems.

The Emergence of Distributed Component Platforms

In the article *The Emergence of Distributed Component Platforms*, Krieger and Adler examined the concepts that underlie distributed component platforms (DCPs) (Krieger & Adler, 1998, March). These included Microsoft's DCOM (Distributed Component Object Model), Sun's JavaBeans, and the emerging Internet and OMG (Object Management Group) standards. In the future, Bhargava and Krishnan envisioned that smaller (distributed) components would be combined by users to create tools for their own use or for use as services.

Decision Support on Demand: Emerging Electronic Markets for Decision Technologies

In section seven of the paper, Bhargava and Krishnan referenced the article *Decision Support on Demand: Emerging Electronic Markets for Decision Technologies* to provide another example of the future of the OR/MS software economy (Bhargava, Krishnan, & Muller, 1997). The article described DecisionNet, a Web-based marketplace for decision technologies. The DecisionNet system offered interoperable OR/MS software components as services for specialized tasks or problems.

Relevant Articles

In addition to those referenced by Bhargava and Krishnan, the following articles are also relevant to the problem of understanding the opportunities presented to OR/MS by the Web.

A New Horizon for OR/MS

In the article *A New Horizon for OR/MS*, Geoffrion discussed the opportunities presented by electronic commerce (E-commerce) for OR/MS applications (Geoffrion, 1998, Fall). In addition to the traditional sources of demand for OR/MS applications (i.e. decision makers, managers, and policy makers), the article described a new class of potential beneficiaries - the general Web-using public. OR/MS applications embedded in business-to-consumer Web sites would benefit both the site and the visitor. One example given was the use of a personalized Monte Carlo simulation of the performance of a homeowner's insurance policy.

OR/MS, Electronic Commerce, and the Virtual INFORMS Community

The article, *OR/MS, Electronic Commerce, and the Virtual INFORMS Community*, also discussed the opportunities presented by E-commerce for OR/MS applications (Bhargava & Krishnan, 1998, Fall-a). The use of embedded OR/MS applications in consumer Web sites was described. One example provided was the use of a Web-based decision support system to help consumers with health insurance planning. Choosing a health insurance plan is a difficult problem for most people, and most would benefit from the application of OR/MS methods.

The World Wide Web: It's the Customers

In the article *The World Wide Web: It's the Customers*, Trick focused on the impact of the Web on the users of OR/MS instead of the producers (Trick, 1998, Fall).

The main point of the article was that the Web exposed the benefits of OR/MS applications to a large group of potential customers.

Chapter 3

Significance

Bhargava and Krishnan made a significant contribution to the field of OR/MS by investigating the problem of understanding the opportunities presented by the Web. Their article provided a concise overview of the technical capabilities of the Web. In addition, it explained the potential impact that Web technologies would be able to make on the OR/MS profession. Finally, the article described the Web-based technologies available for OR/MS workers to Web-enable their applications.

Geoffrion, in another recent article, recognized the significance of Bhargava's and Krishnan's paper (Geoffrion, 1998, Fall). Geoffrion stated that the paper did an outstanding job of sketching the important OR/MS opportunities presented by the Web. In addition, he wrote that the article did a thorough job of explaining the technicalities of how the Web could be used in the service of OR/MS.

Trick also recognized the paper's significance (Trick, 1998, Fall). In his article, Trick acknowledged Bhargava and Krishnan for providing a comprehensive snapshot of the state of the art and its implication on OR/MS.

Chapter 4

Methodology

The research methodology employed by Bhargava and Krishnan is that of a qualitative/descriptive case study (Tellis, 1997, July). In the investigation by Bhargava and Krishnan, the background, development, current conditions, and interactions of current Web-based technologies and the OR/MS community were observed, recorded, and analyzed. As discussed by Mauch and Birch in another recent work, the qualitative/descriptive case study methodology is well suited to this type of investigation (Mauch & Birch, 1998).

Chapter 5

Contributions

The following is a summary of the significant results and contributions made by Bhargava and Krishnan through their research. Most significant were the authors' ability to address (in a thorough, concise, and organized manner) the problem of understanding the opportunities presented to the OR/MS field by the World Wide Web.

In short, Web technologies are relevant to the OR/MS field in a couple of ways (Bhargava & Krishnan, 1998, Fall-b). First, the Web is a multimedia communication system that will become more effective to the OR/MS field as the use of information push technology increases. Second, the Web is a large distributed environment in which interactive computational OR/MS applications can be made available and interacted with on a global scale.

In addition, the authors made a thorough analysis of present and future technologies for enabling Web-based execution of OR/MS applications. Methods for combining multiple client-side and server-side execution were also reported. Finally, the authors contributed to the field by detailing how the effective exploitation of Web technology will require changes and greater involvement by the OR/MS community.

Chapter 6

Further Research

In conclusion, Bhargava and Krishnan asked three questions to stimulate discussion in areas that would extend their research. Those questions were:

- Besides technology, what else is required to realize the potential of the Web?
- Can certain structures or generic systems serve as catalysts in realizing this potential?
- Can OR/MS software be developed at a community level rather than be developed multiple times by individuals?

In addition to those suggested by the authors, the application of OR/MS applications to E-commerce is another area in which to extend the research.

As pointed out in an article by Geoffrion, Bhargava's and Krishnan's research should be extended by investigating the possible integration of OR/MS applications into business-to-consumer E-commerce Web sites (Geoffrion, 1998, Fall). In addition, Geoffrion proposed that the importance of the Web to the OR/MS community is that it empowers dispersed practitioners in addition to enabling embedded applications.

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