Foreword

"Empirical science may have to be considered, not merely as a scientific theory – that is, a system of asserted statements arranged according to certain rules – but rather as a complex consisting partly of such statements and partly of human activities." Alfred Tarski, Introduction to Logic xi-xii.

"We don't really have a health care delivery system in this country. We have an expensive plethora of uncoordinated, unlinked, economically segregated, operationally limited micro systems, each performing in ways that too often create suboptimal performance both for the overall health care infrastructure and for individual patients." George Halverson, Health Care Reform Now!: A Prescription for Change, 2007.

The development of the grid since the early 1990s has led from a system of methods for sharing computation and information resources, to a system of active virtual communities: from computation through sharing, to sharing through computation. Our ability to extend and exploit both perspectives is of extraordinary relevance to biology and medicine. It gives us the opportunity to organize increasingly sophisticated, flexible and powerful systems of logic, data, rules, computation and human activities within social networks in which time and space constraints are reduced to a minimum. In so doing, we may hope to create the infrastructure, methods, and (virtual) organizations needed to deliver the benefits of evidence-based and personalized medicine to the seven billion inhabitants of planet Earth.

What are we sharing and distributing when we apply the grid to healthcare and biomedical research? Computation, software, and information, certainly – but also to a great extent we are enabled to share computed results, which given an appropriate infrastructure can be passed from process to process (workflows), stored and retrieved, layered in mutual support, interpreted, counterposed and resolved. The Grid now enables us to construct a connected system of computational "collaboratories" within virtual organizations (VOs) that embrace different specialties and disciplines in biomedicine and healthcare, as well as engineering and software, and that must ultimately also extend to healthcare providers, payers, and of course patiens. In this way, we create *an ecosystem of actions, tools and information*. The Grid as VO is a system of radical enabling technologies for this scientific knowledge ecosystem.

Virtual cooperation and complex layering of technologies and results are now available on a global scale, allowing interpretations and conclusions to be extracted from masses of data obtained in ultra high-throughput experiments. The results of one group's experiment, or data from huge numbers of clinical observations, can now be data mined, consumed by workflow processes and used as input to further interpretations and conclusions, with great rapidity and agility. These results can then drive further experiments, inform the design of, and participation in, clinical trials, and ultimately ensure that better care is delivered to more patients, faster than before. At the core of this knowledge ecosystem are grid-enabled virtual organizations, made possible through organized and uniform service models around computational, communications and storage resources, with shared commitments to common semantics and models of component behavior.

In perhaps no other area of endeavor does the emergence of virtual organizations present such complex issues – and striking opportunities – as in biomedical research and healthcare. In the U.S. alone, health care costs surpassed $2 trillion in 2006[1] with approximately 6% of these expenditures going to biomedical research[2]. It is widely accepted that this "nonsystem," while outstanding in its technical capabilities, is far from effective in delivering the right care to the right people at the right time. Grids and VOs promise to contribute significantly to productive organization of service delivery, improvement of quality of care, and more rapid translation of basic medical research into advances in clinical care. Yet realizing this vision involves a host of challenges, technical and social.

Technical challenges include achieving the uniformity of infrastructures and services, and network, computational and communication resources, required to make sharing feasible; balancing local versus global policies and requirements (access, security, trust, load, service provisioning); and developing computable semantic representations of data, metadata, policies and services. Social challenges include adequate funding of the research required to build out the grids and VOs that will support a healthcare revolution; balancing research with product development, and the quest for the perfect with the deployment of the good; the agile capture, mapping and translation of user requirements into working systems features with adequate fidelity; overcoming the substantial disincentives that currently hinder sharing across the healthcare nonsystem; and building methods and systems that can scale not only to many patients and providers, but also to many countries, societies, and economies.

This book provides a comprehensive and focused view of the state of research in the application of grids and virtual organizations to these and other challenges. Reporting in particular on the results of the European Union's substantial HealthGrid program, the book includes descriptions of both cutting-edge research and substantial deployments. We believe it will make a significant contribution to meeting the challenges that currently face healthcare, and will be of great importance in broadening the application of an extremely powerful system of technology and social organization in biomedicine.

ENDNOTES

1 U.S. Centers for Medicare and Medicaid Services, Office of the Actuary, National Health Statistics Group, 2006 National Health Care Expenditures Data, January 2008. Retrieved from http://www.cms.hhs.gov/nationalhealthcareexpenddata/01_overview.asp?

2 Moses, H. 3rd,, Dorsey, E.R., Matheson, D.H., Their, S.O.,(2005, September 21). Financial anatomy of biomedical research. *JAMA 294*(11), 1333-42.

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