The Philosophy of Change and Adaptation of Radiology to the Information Age

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IN THE LATE nineteenth century and the early twentieth century, there was a series of new inventions—electricity, the telephone, the motorcar, and the airplane. Now, as the twenty-first century dawns, we have the invention of the computer, accompanied by the emergence of telecommunication modalities.

There is a common theme here. As a species, *Homo Sapiens sapiens* over the ages has toiled consistently at improving one fundamental aspect of its existence—*communication*. As a result, the world has shrunk progressively, and increased the ability to transmit data, develop information, acquire knowledge, and, finally, assimilate wisdom. The ultimate communication improvement is the “virtual environment,” where distances will become inconsequential, time will become immaterial, and knowledge and wisdom will no longer be the prerogative of the privileged few.

Throughout the history of civilization, from the invention of the printing press through the development of the automobile to the invention of the computer, we observe a cyclical phenomenon. There is an initial reluctance to accept the new technology, followed some time thereafter by a massive incursion of the new technology, penetration throughout the market, and an acceptance, which moves on to refinement of the technology. We have seen this paradigm replicate itself in every element of human endeavor.

This cycle in the marketplace occurs in three predictable stages: (1) the innovation wave—when new products and services make their way into niche markets; (2) the spending wave—when the economy booms and the race for leadership in emerging new industries heats up; and (3) the power wave—when organizational change and revolution in work secure the mainstream position of the new economy and create a productivity surge.

With every technology revolution a new age is ushered in making life more streamlined and allowing the human race to expend its considerable evolutionary momentum into further improving its environment.

“Immediacy is the driver of the digital economy—commerce is non-stop and real time: products obsolesce more quickly, the first to market

are rewarded. Agility and the capacity to shift to ever-changing conditions are basic.”—Bruce Harrel IBM strategist.

Medicine of all the branches of science has lagged behind the power curve in ages past and is doing so again in the era of information, frequently using the excuse that medicine is more of an art than a science.

In alarming contrast, the general population has come to expect immediacy in all aspects of life as well as death. They are clearly frustrated with our inability as purveyors of healthcare to answer their need for immediacy and resolution. This manifests itself in the increasing diatribe against health maintenance organizations (HMOs) and the growth in tort claims, the widening chiasm between the healthcare providers and their beneficiaries.

PART 1

There is no area of specialization in healthcare that lends itself better to adopting the efficiencies conferred on us by the information revolution than radiology. With the advent of the digital output from radiology acquisition devices, the laying down of rapid networks, vast storage capabilities, computer-aided design, etc, radiology has become the exemplar of medicine's entry into the Information Age.

While this is exciting, a quick survey of the landscape in radiology reveals that most radiology departments throughout the country have been extremely slow to embrace these changes. There is clear evidence of panic on the consumer side of the industry. The vendors are scrambling to get a foothold and rushing to invent a better mousetrap. A plethora of how-to pundits with seminars and

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workshops have sprouted up teaching radiologists and radiology departments how to enter the information-electronic age.

The practice of medicine, like most complex endeavors, can be dissected out into the highly customized, complex, intuitive and pleasurable right-brain tasks and the repetitive, mind numbing left-brain tasks. The relegation of left-brain tasks to machines will make medicine efficient and more accessible.

In order to embark on this journey and achieve this goal successfully, some fundamental principles have to be accepted: there is nothing magical or redemptive about hard work. Inefficiencies are avoidable. They do not add "character" to our milieu. We need to develop a manageable method of addressing and incorporating the imminent changes imposed on us by the Information Revolution.

Most organizational behavior can be characterized as one of two types or a mixture of the two in varying proportions¹: (1) make-and-sell organizations—predict what the market will demand, make products and then go out and sell them. This is, for the most part, an efficient left-brained endeavor. (2) Sense-and-respond organizations—help to identify the customer's needs and work to satisfy. This is clearly more right-brained and intuitive.

All businesses interact with their customers in at least two ways—the following two paradigms in the transaction of business/commerce—(1) it makes offers to them, and (2) it responds to requests from them. When we apply this to the practice of radiology, we find that there are both aspects to our conduct of business. The advantage in defining our business environment along these lines is that it allows us to streamline our jobs. We can then deliver what our customers clamor for: a customized product delivered efficiently.

PART 2

We need to look at the following aspects of our business:

Who are our customers and what are our products/services?:

- Patients—who require our diagnostic expertise, our intervention and our therapy
- Clinicians—who request our diagnostic expertise to help them chart their course of action
- Student bodies, which include ourselves, our peers, our subordinates, our superiors, and the vendors from whom we purchase

equipment or services—these entities assimilate our diagnostic expertise, store it with their fund of information, and refine their own body of knowledge to use for future scenarios

- The organizations we work for—ie, our department, our hospitals, our HMOs. These entities use our contribution to develop and deliver their charter-healthcare and health maintenance.

How do we interact with our customers?:

Patients

- data entry for demographic and disease/health history
- perusal of relevant historical information pertaining to the problem in question
- delivery of service—ie, performance of the diagnostic or therapeutic procedure

Clinicians

- consultation
- reports
- direction to consideration different avenues of diagnosis or therapy

Students

- didactic
- Socratic

The Organization

- analysis of trends
- prediction of demands
- recommendation on future direction, expenditure
- input to organizational strategy

Most of our inefficiencies lie in the repetitive mind-numbing tasks that are performed mostly by the front-line workers in our establishments. Front-line workers themselves find these tasks uninspiring and fatiguing. Midlevel supervisors encounter a great deal of frustrations themselves from having to deal with variations in the quality of performance of left-brain tasks, lack of dependability of the personnel involved, and lack of consistent reproducibility of the task.

In a completely filmless department with seamless interface of the radiology information system with the hospital information system, several of these efficiencies are realized readily. The implementation of a completely digital department also adds considerable value by providing additional tools that are not available in an analog and labor-intensive department. The most important advantage conferred by the computer, information

technology and the improvement in communication, is the gift of time—time for the patient, time for the clinician, and time for the student.

Every product and its component tasks can be categorized into whether they are operational, tactical, or strategic. Table 1 is an adaptation of a table by Schultheis and M. Sumner on the issue of management. It can be adapted to every product and its production within a radiology department.

To take advantage of this strategy for preparation for radiology’s entry into the information age, we propose the following steps:

- Analyze each product and separate it into the component tasks that go into the production and delivery of the product.
- Reanalyze these components to ascertain which are best performed by a consistent and/or repetitive process.
- Insert automation into the conduct of daily business and replace the repetitive processes by computer assistance
- Expend the resources of the department in those areas that are best served by a sentient entity.
- Readdress this cycle until it is refined to the point of no further improvement.

For instance, one of the most important products in a diagnostic radiology department is the diagnostic radiology report. Let us analyze the cycle of production according to the plan proposed above. ✓ marks have been placed against tasks which are repetitive and could be automated. One will discover that majority of the operational tasks can be automated.

- data entry ✓
- scheduling ✓
- retrieval of historical data and information ✓
- performing the imaging procedure
- displaying of information obtained from the patient ✓
- comparison with previously obtained information

- generation of reports
 - normal reports
 - standard abnormal reports ✓
 - customized abnormal reports
- dissemination of reports to the requesting clinician ✓
- storage of information, image and report ✓
- assimilation of data for quality assurance ✓
- keeping track of department/equipment/radiologist/technologist/ancillary worker performance ✓
- Assessing sensitivity, specificity, accuracy of diagnosis
 - obtaining information from other sources such as pathology for comparison ✓
 - Comparing the provisional/radiologic diagnosis with the final diagnosis
- making recommendations to improve efficiencies, improve knowledge base for all student entities
- providing access to libraries, current literature, etc ✓
- displaying trends ✓
- making forecasts based on trends
- making recommendations based on forecasts

Operational and strategic tasks are intuitive and unstructured. Several of these tasks can be pre-staged using models. However, it is critical to refine and fine-tune the answers gleaned from the model by personal attention and practice.

Optimization models such as those using linear programming can be used for a variety of projects such as developing budgets, selecting least-cost mix of personnel and equipment ingredients for running a diagnostic radiology department, optimal manpower allocation, workload leveling, cost and workload shifting, etc. Decision analysis models, project planning models, and management models can be used to coordinate large projects and to uncover flaws in the original plans. A variety of

Table 1. Categorization of Component Tasks^{3,4}

Characteristic	Operational	Tactical	Strategic
Frequency	Regular/repetitive	Mostly regular	Often ad hoc
Dependability of results	Expected results	Some surprises	Results often contain surprises
Time period covered	Past	Comparative	Future
Level of data	Very detailed	Summaries of data	Summaries of data
Source of data	Internal	Internal & external	Internal & external
Nature of data	Highly structured	Some unstructured data	Highly unstructured data
Accuracy	Highly objective data	Some subjective data	Highly subjective data
Typical user	First-line supervisors	Middle managers	Top management
Level of decision	Task-oriented	Control & resource allocation-oriented	Goal-oriented

Adapted from Schultheis and Sumner.³

these models are available; however, they have to be customized to fit each individual situation.

Three steps have to be taken in order to progress from an analog department to becoming a virtual enterprise. The first step is to deploy individual free-standing picture archiving and communications systems (PACs) in each of the hospitals in a given geographic location or within an enterprise. The second step is to link these free-standing enterprises together. These are interconnections are based on the communications networks available—commercial or private. The third step is to set up a meta-manager, which would manage the vast amounts of data generated at and by each site

The meta-manager we are developing will mine data and information at every location. The information will include the following:

- Patient Information
 - Prior clinical history
 - Prior images at any of the locations in the network
 - Pertinent clinical data such as allergies
 - Other data such as military profile, needs of the military, eg, deployment
 - Urgency
- Physician Information
 - Availability of worker (radiologist)
 - Additional expertise
 - Workload at the time of sampling
 - Credentialing information
 - Current licensing status
 - Continuing health/medical education status of each radiologist
 - Dictating preferences
- Site Information
 - Workload generated at any given time (present/past)
 - Equipment available
 - Preventive maintenance data
 - Performance history
 - Availability of other equipment
- Study-Specific Information
 - CPT coding
 - Time taken to generate study & other additional features such as contrast administration
 - World Health Organization coding for teaching file cases
 - Fetching of other pertinent data, eg, definitive/working diagnosis
- Other Databases/Libraries
 - Teaching files

- Testing/continuing medical education (CME) modules
- Radiology library
- Referring Physician Data
 - Phone numbers
 - Reporting preferences
- Weblink availability—for transmission of report or clinical image.

At this point one has to consider what possible benefits could be conferred by networking the enterprise.

The efficiencies that can be achieved are mainly the following: (1) timeliness of delivery of the product, ie, the report/the consultation; (2) the customization of the product to the customer; (3) cost savings by providing expertise virtually; (4) time savings by providing expertise on-time; (5) added value by providing second opinions/reading or subspecialized expertise; (6) improved ability to look at trends, plan equipment purchases and resource allocation

The changes are imminent and the journey is exciting and often scary. However, this is a necessary journey and the sooner we take it the better off we are. As always, half a journey does not get one to the expected goal.

Donald Tapscott, Chairman of Alliance Technologies, an international think tank, in his seminal book *Blueprint to the Digital Economy*² describes the trepidation we feel very aptly:

"We are all wondering how digital media is changing business. How big will electronic commerce be? When will it take off? What will the new enterprise look like? ... It's as if we're sitting on a beach wondering what the weather will be today. But we haven't noticed that just beyond the horizon is a 100-foot high tsunami, which will not only affect the weather today, but will sweep us all away if we don't get ready. There is a tsunami approaching which few have noticed. This tidal wave results from the intersection of the technology revolution and the Net Generation (n-Gen, children aged 2-22 in 1999)."

REFERENCES

1. Haeckel SH: Adaptive Enterprise Design: The Sense- and -Response Model. Planning Review. Chicago, IL, Planning Forum, May/June 1995, 12
2. Tapscott D: Alliance for Converging Technologies: Blueprint to the Digital Economy. New York, NY, McGraw Hill, 1998, 1-2
3. Schultheis R, Sumner R: Management Information Systems: The Manager's View. (ed 2). Homewood, IL, Irwin, 1992, p 329
4. Shim JK. Vest Pocket Guide to Information Technology. Prentice Hall, 1997, pp 18-19