

Chapter 2

Information Technology Challenges and Opportunities

2.1 Introduction

In the last decade, the world of data and digital enterprise has expanded, becoming greatly enriched but also more complex as research and development activity continues to introduce new opportunities and challenges across the spectrum of human educational endeavour. Usage of descriptive words and phrases including titles such as Big Data, Data Analytics, Data Science and Disruptive Technology are commonplace within the information, communications and technology (ICT) field. Some of these terms have existed for decades; the frequency of their appearance however, notably in online publications and social media content, denotes the catalytic coincidence of greater awareness of the potency of exponential strides in the advancement toward artificial intelligence and machine learning. Collectively the label Big Data or BDA is capturing attention in the commercial sphere, particularly in the context of companies that use technology and continuous machine-supported development to enhance efficiencies in financial services delivery. The term widely adopted in this process is ‘FinTech’ (Wikipedia [2016](#)).

In the build-up to this point, knowledge transfer (KT) defined by King ([2010](#)) as ‘any exchange of knowledge between or among individuals, teams, groups, or organizations, whether intended or unintended’ emphasizes both the vital capacity of the human brain to exchange, digest and analyse information and the feeding or conversion of that information into knowledge. King and He, in a separate book chapter to that referenced earlier, write about Knowledge Sharing (KS) as distinct from Knowledge Transfer, describing KS in the context of organisational assets intended to achieve commercially competitive advantage (King and Jun He [2010](#)). Avoiding the trap of entering into the distinctions and varied definitions offered about knowledge transfer and knowledge sharing we are concerned in this book to encourage collaboration across disciplines, supported through continuous development of machine-based data management and analytical capabilities. Pre-occupation with definitions can cause some distraction for research authors; and

the KT/KS example is accompanied with various terms used to describe cooperative activities across mixed research specialisms, i.e. Cross-disciplinary, Interdisciplinary, Multidisciplinary and Transdisciplinary. A common characteristic emerging from these similar terms is the intentional move away from the constraints of an often attributed silo mentality in academic research institutions.

2.2 Interdisciplinary Research

Without playing a game of favourites and contributing to an unnecessary debate, we choose to use the term ‘Interdisciplinary research’ (IR) which we deem for the purposes of this book as the integration and value-output delivery processes emerging from research into disparate domain concepts, the data and their relationships. There are innumerable permutations of such integrations. Pohl et al. (2015) have explored the challenges of publishing IR, looking at hindrance and support factors. Scholars finding it difficult to publish interdisciplinary research complain of the lack of journal reviewers who place value on IR. In Pohl et al. (2015), a sociologist who posed a question about how to collaborate with a biologist, stating “What should we write about? I don’t know”.

A specialist subject researcher such as in a healthcare-specific domain may need to translate technical data relationships and properties into lay-consumer language in order to support a mobile communications device application serving the particular patient community. Calling upon expert source material then amounts to cross-disciplinary research activity. But it does not necessarily contribute to a reciprocal exchange of information. It is KT and primarily a one-way process. Put simply we need information to help build the knowledge base. In a mutually symbiotic exchange, anticipating KS, interdisciplinary research represents a transition from the cross-disciplinary KT status, denoting joint enterprise and some form of shared return from the research investment, financial or non-financial. Again put simply, but in this new context, we need to share information to help build and enrich the knowledge base in which we enjoy a mutual research interest.

2.3 Semantic Web and Linked Data

2.3.1 *Semantic Web*

The Semantic Web is an extension of the World Wide Web in which the meaning or semantics of information and services is defined (Campbell and MacNeill 2010), making it possible for people as well as machines to “understand” the web content. In essence, it makes a shift for data modelling not only in human readable but also machine readable format. This means that machines are capable of semantic

processing and reasoning. Since the Semantic Web term appeared in the early 2000s, a large amount of research has been done resulting in a number of publications in the area.

The fundamental building block playing a significant role in the semantic web is the Resource Description Framework (RDF). The meaning is expressed by RDF encoded in the form of subject—predicate—object expressions also known as triples.

2.3.2 *Linked Data*

Linked Data refers to a collection of interrelated data (Campbell and MacNeill 2010). It lies at the heart of the semantic web. This concept has gained traction after the publication of large Semantic Web resources such as DBPedia, Bio2RDF, etc., and by the announcement by some Governments of their decision to make public data public, in a set of Open Government initiatives e.g., data.gov, data.gov.uk (Heath and Bizer 2011). DBPedia makes the Wikipedia data and other datasets e.g. Geonames, available in RDF. By providing those links within and between the datasets, it allows applications to exploit knowledge from datasets (Campbell and MacNeill 2010).

Linked data provides a way to publish data on the semantic web that encourages reuse, reduced redundancy, maximises its interconnectedness, and enables network effects in order to add value to data (Heath and Bizer 2011). Berners-Lee (2009) states that in principle, linked data uses Uniform Resource Identifiers (URIs) as names for things and uses HTTP URIs so that people can look up those names. When a URI is found through SPARQL (a recursive acronym for SPARQL Protocol and RDF Query Language), it provides useful RDF information and includes RDF statements that link to other URIs so that they can discover more things.

2.3.3 *Challenges and Opportunities*

The semantic web makes search processes easier for finding, sharing, reusing and integrating information; effectively helping to interpret and convert information so that it takes on a knowledge status value. The quality of data found in the semantic web is not however self-evident when considered at the datum level, i.e. as a singular piece of information. Correlations of data drawing upon different semantic web search sources present the opportunity to move toward acceptance that data outputs are reliable; but for significantly sophisticated exercise, size and density limit the productivity of the collation process and its intended benefits.

The vast, inestimable volume of data and its constant rapid growth dominated through the worldwide web ‘super-library’, and by accessibility to extensive data

base resources, defy any human solo or team opportunity to cognitively capture all of the pertinent datasets for acquiring sufficient knowledge to successfully address a specific-topic problem. The additional barrier to such knowledge acquisition or ‘capture’, is the complexity of the data and the relationships that exist or may potentially exist, in them. Identification of relationships within and developmentally possible for data therefore demands a cross-disciplinary exchange capability. Education in its fundamental form is a knowledge transfer activity. Purposeful interactions between individuals and entities increasingly demand the sharing of knowledge between two or more, and more frequently today, multiple, subject matter domains.

Taxonomies, nomenclature, and contextual interpretation for the most part unique to subject matter domain ecosystems, present educational obstacles and knowledge transfer opportunities. The processes for and productive outcomes from, cross-disciplinary research and collaboration are at the human cognition level burdened with labour intensive, time consuming and cultural compatibility challenges.

2.4 Ontologies as Building Blocks for the Semantic Web

The key foundations of the Semantic Web are ontologies. Ontologies, which are normally represented in the RDF Schema or Ontology Web Language (OWL), describe formally shared conceptualizations of a domain of interest (Gruber 1993).

Solodovnik (2010) described the concept of Ontology from its philosophical origins to its adoption within the ICT field as follow:

Philosophically, Ontology is a systematic explanation of being that describes the features of Reality. Nowadays Ontology is proliferating in organizing Knowledge of different domains managed by advanced computer tools. Ontology qualifies and relates semantic categories, dragging, however, the idea of what, since the seventeenth century, was a way to organize and classify objects in the world. Ontology maximizes the reusability and interoperability of concepts, capturing new Knowledge within the most granular levels of information representation. Ontology is subjected to a continuous process of exploration, formation of hypothesis, testing and review. Ontological thesis proposed today as true, tomorrow may be rejected in light of further discoveries and new and better arguments.

The growth of ontologies has tended to be based upon specification of concepts with dedicated topics with limited work directed toward cross-pollination of knowledge and know-how. As this book brings together two seemingly discordant domains, we perceive this as an opportunity to prompt researchers and ontologists to seek new models for machine learning systems.

We consider how societal need-based probabilities will emerge from interactive domain data possibilities. While at first sight EDI and ACT in Cross-Cultural Healthcare Communications (CCHC) occupy distinctly different domains comprised of disparate data, ontology supported knowledge development and management for societal progress present considerable KS enrichment opportunities. In

the interdisciplinary research mode and with good cause such as commercial market opportunities, the ontologies representing these two ostensibly unconnected domains represent potentially rewarding exploitation prospects. Bridging the functionality and resultant KS gap between these two ontologies (for example) offers enhancement of the intellectual capabilities in a third, combined, domain, i.e. cross-cultural recruitment communications processes for the healthcare sector. Australia depends on healthy net immigration flows to continue to build and sustain its intellectual and economic future.

The use of machine support systems increases the potential of the value factor through greater resource efficiencies. This is attractive to serious researchers for several reasons. Speed and accuracy for the collection and management of complex data will facilitate justifiable confidence to ameliorate the research delivery model. The research constraints touched upon in the previous section can be mitigated through task devolution techniques which employ ontology construct principles. Ontology development offers the benefit of emulation of human collaboration by capturing and employing interdisciplinary research precepts (Wang et al. 2016).

In a human conversation, the two domains in simpler terms (employer recruitment healthcare communication) can be easily assimilated. They are very common facets of contemporary life and social discourse in the developed world.

Why and how might we bring about the coalescence of diverse domain knowledge as a machine learning and intelligent machine reasoning capability? The term ‘Artificial Intelligence’ (AI) emerges from this thought process. AI however may not reliably convey the objectives or the ‘ultimate goal’ of advancing ontology constructs. A 2004 paper on computational ontologies and information systems lists ‘artificial intelligence, knowledge representation, information science, library science, and database management’ as matters ‘of inquiry, development and application’ (Kishore et al. 2004).

Indicative of the ontology and machine learning fields of research, we find reason these several years on, to refine our thinking and intentions about AI in particular. We nevertheless advocate for the continual evolution of intelligent machine systems for which ontologies will play a significant productive role as the building blocks for machine learning and for machine-independent simulation of human brain power and ensuing capabilities. In this closer examination of the goal of intelligent machines, we commonly find mischaracterizations, largely arising from fascination in the form of speculative media articles about robotics, threats to human labour from automation and science fiction entertainment depictions of AI. Kelly (2015) provided some informative relief from the ‘AI fiction’ obsession. Kelly (2015) asserts that the future of intelligent systems technology will be ‘cognitive’ as opposed to ‘artificial’. They generate not only answers to numerical problems but also hypotheses, reasoned arguments and recommendations about more complex and meaningful bodies of data. Cognitive systems can make sense of the 80% of the world’s unstructured data. This enables them to keep pace with the volume, complexity and unpredictability of information and systems in the modern world.

2.5 Agent-Based Technology

Agent-based technology has attracted substantial attention and has become an active research area in recent years. In addition, the advent of the Semantic Web technology has provided the underlying infrastructure that allows software agents to process data and perform sophisticated tasks on behalf of users. A definition of term ‘agent’ that has been widely accepted is given by Wooldridge (2009):

An agent is a computer system that is situated in some environment and that is capable of autonomous action in this environment in order to meet its delegated objectives.

According to Wooldridge and Jennings (1995), Jennings (2000), the key properties of an agent are as follows.

- **Autonomy:** agents encapsulate some state and make decisions on what to do based on this state without the direct intervention of humans or others.
- **Reactivity:** agents are situated in an environment and are able to perceive this environment through their sensors. Then, through effectors, they respond in a timely fashion to changes that occur in their environment.
- **Pro-activeness:** agents do not simply act in response to their environment. They are able to exhibit goal-directed behaviour by taking the initiative.
- **Social ability:** agents are able to cooperate with humans and other agents in order to achieve their design objectives.

Software agents can be differentiated from traditional software applications in terms of certain characteristics. The differences between traditional software applications and software agents are presented in Table 2.1.

Table 2.1 Differences between traditional software applications and software agents, adapted from Turban et al. (2010)

Characteristics	Traditional software applications	Software agents
Nature	Static	Dynamic
Autonomy	Follow instructions	Be able to perform tasks without direct control, or at least with the minimum of human intervention
Manipulation	User initiates every action	Sense the environment and react autonomously
Interactivity	Non-interactivity	Can interact with other agents, humans, or software programs
Temporal continuity	Terminate when process is complete	Continue to run over time (persistent)
Concurrency	Generate process in one dedicated server with limited processing power	Dispatch simultaneously to accomplish several parts of a task in parallel
Mobility	Stay in one place	Be able to travel from one machine to another

From Table 2.1, it is clear that the software agents are different from traditional software applications. Moreover, compared with the object-oriented paradigm, the agent technology can be considered as a descendant that improves the nature of passive objects with the notion of autonomous actors (Braubach et al. 2005). In contrast to simple objects with methods that can be invoked by other objects, an agent communicates with other agents by means of message-passing. In addition, it can act proactively to accomplish its individual goal. Agents can work as stand-alone entities to perform particular tasks on behalf of a user. However, many agent applications are based on environments that contain multiple agents collaboratively working together as a group. This is also known as a multi-agent system.

Even though an individual agent can perform a task on behalf of a single user, its capacity is limited by its knowledge and resources. Thus, agents are usually implemented in a multi-agent context. A multi-agent system (MAS) consists of multiple agents acting in an environment to achieve a common goal or their individual goals (Ye et al. 2016). There is an increasing interest in MAS research because of its significant advantages including its ability to solve problems that may be too large for a single agent. MAS allows a complex task to be decomposed into subtasks, each of which is then assigned to an individual agent to undertake independently, but which can be supported by a knowledge base. They have distributed architectures which control distribution by utilising the mechanisms of cooperation and coordination.

MAS have various advantages over a single agent, such as reliability and robustness, modularity, scalability, adaptability, concurrency, parallelism, and dynamism (Elamy 2005). When a system is implemented based on MAS architecture, it is easy to add a new functionality or to modify an existing functionality. Within MAS, the functionality is created by calling the service that a particular agent offers. Therefore, in order to add a new functionality, a new agent responsible for a new service can be added into a system. In order to modify or improve the functionality of the system, the existing agent can be modified or substituted with a new one. In this case, a system is loosely coupled which means that it is easy to extend, remove, and modify without breaking down the system. In addition, MAS can make the system more fault-tolerant by replacing an agent that has crashed with a new agent that can be launched on the fly as a substitute for a failing agent (Terje and Marius 2015).

MAS are suitable for applications that require distributed and concurrent processing capabilities. They are employed in the applications in several domains such as supply chain management (Rady 2011; Zimmermann 2006; Ngan and Kanagasabai 2013), web-services (Mohamed and Makhlof 2014; García-Sánchez et al. 2009), healthcare (Dolgui et al. 2015; Shakshuki and Reid 2015; Isern et al. 2010), e-learning (Terje and Marius 2015), etc. When a group of individual agents constitutes MAS, it is crucial to have a mechanism that can control such a group. Communication is a key for MAS to exhibit social behaviour (e.g., share information, coordinate their tasks). Individual agents in MAS interact with one another by exchanging messages using a specific Agent Communication Language (ACL). The purpose of ACL is to enable agents to convey messages to one another

with meaningful statements (Vaniya et. al. 2011). Most ACLs are based on the speech-act theory. Speech acts are expressed by means of standard key words also known as communicative acts or performatives (e.g., request, inform, confirm, and propose). They are used to inform the intention of the communication from the sender to the receiver. The agent's message consists of various parameters such as sender, receiver, content language, ontology, and the actual content. Examples of well-known ACL languages are KQML (Knowledge Query and Manipulation Language) and FIPAACL (Foundations for Intelligent Physical Agents-Agents Communication Language) proposed by FIPA (The Foundation for Intelligent Physical Agents 2015). FIPA is the relevant standardisation body that promotes agent-based technology and the interoperability of its standards with other technologies.

2.6 Conclusion

Information systems research is by its nature a process of developmental enquiry, an effort to plot pathways into the future, using the tools of today and of yesterday to trawl through, mine and analyse data while ever hopeful of creating new knowledge through intellectual discovery and a process of deductive reasoning. All research is constrained by availability of resources, including time, data access and validation disciplines, and circumstances governing funding, ethics compliance and completion deadlines. Accordingly, and as much as 'completion' may be regarded as the research goal, this is never true in the context of research output value. Knowledge acquisition is a limitless endeavour.

In this book, we aim to outline the development of assistive cross-cultural communications in healthcare and employer demand intelligence systems. The former aspire to improve Australian Aboriginal type 2 diabetes healthcare communications; and the latter examines recruitment practices.

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