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Emerging Requirements for Technology Management: A Sector-based Scenario Planning Approach

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Abstract

Identifying the emerging requirements for technology management will help organisations to prepare for the future and remain competitive. Indeed technology management as a discipline needs to develop and respond to societal and industrial needs as well as the corresponding technology challenges. Therefore, following a review of technology forecasting methodologies, a sector-based scenario planning approach has been used to derive the emerging requirements for technology management. This structured framework provided an analytical lens to focus on the requirements for managing technology in the healthcare, energy and higher education sectors over the next 5-10 years. These requirements include the need for new business models to support the adoption of technologies; integration of new technologies with existing delivery channels; management of technology options including R&D project management; technology standards, validation and interoperability; and decision-making tools to support technology investment.

Keywords: technology management; technology forecasting; scenario planning; healthcare; energy; higher education

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Introduction

Technology is a valuable resource for many organisations both in the industrial and non-for-profit sectors. Companies need to have access to leading technologies in order to remain competitive and especially in knowledge-intensive industries such as the pharmaceutical, oil & gas, aerospace and industrial engineering sectors. The adoption and implementation of technologies, whether through in-house development by the company or via acquisition from an external source, is not just related to the characteristics of the technology itself but can be equally associated with the effectiveness of the corresponding technology management practices used within the company. Similarly, in other sectors such as healthcare and higher education, the performance of both companies and not-for-profit organisations will be impacted by the availability of technology. Technology management provides the structures, processes and tools to allow this technological resource to be deployed in order for an organisation's strategic objectives to be delivered.

In the oil and gas sector, new technologies are allowing previously inaccessible reserves of crude oil to be extracted and areas such as microbial enhanced oil recovery are attracting significant levels of investment. Conversely, in the pharmaceutical industry there is a recognised pattern of major investment in the drug discovery and development process in areas such as oncology research and development, which is required in order to ensure 'big pharma' have sustainable portfolios of drug compounds to bring to market. In the aerospace industry, there is investment in new materials technologies, such as high performance composite materials that offer improved stiffness and reduced weight when compared to traditional metallic materials used for structural components.

Organisations need to be able to forecast new and emerging technologies for a number of different reasons. Companies are interested in identifying emerging technologies to contribute to new product development as well as the development of improved manufacturing processes. This is required to ensure companies remain competitive so they are able to benefit from emerging technologies, which can be integrated into the company's supply chain. These industrial drivers will benefit from an improved understanding of the relationships between different technologies as part of the innovation process and the factors that contribute to technology adoption, which extend to social, environmental, economic and legislative influences. For instance, within the oil and gas services sector, companies are developing improved technologies to ensure that carbon dioxide emissions can be reduced as part of the upstream operations of international oil companies. In this context changes in the environmental landscape and the introduction of more stringent national and international legislation to reduce carbon emissions have the potential to result in higher liabilities for companies involved in the fossil fuels exploration and production business and consequently this can drive the need for technology solutions that reduce such emissions.

In addition to contributing to new product development, technology forecasting can provide companies with the evidence to make strategic decisions in regard to the development of technical capabilities and this includes the prioritisation of internal R&D activities as well as external investments with research suppliers. Other organisations, such as governmental agencies, research foundations and charitable bodies may use technology forecasting to support research investments in areas that have societal benefits, for example, research on developing improved algorithms for cyber-security applications.

Literature review on technology forecasting

In order to identify the emerging requirements for technology management that lie ahead and principally over the next 5-10 years, it is useful to first consider the approaches that are currently used to forecast technologies themselves. This is because future technology management issues are likely to be related to the corresponding technologies under development in the future. In terms of the current practice for forecasting technologies, there are a number of different processes that are in use. Requirements capture (Cooper et al., 1998) and subsequent analysis can be undertaken for any given field of interest, for example, the capture of the industrial requirements for new or improved structural aerospace materials, such as metal-matrix composites. Requirements engineering through a scenario-based software tool has been previously reported and this method is based on the initial acquisition and modelling of a use case (Sutcliffe et al., 1998). Comparison of the use case with a collection of abstract models corresponding to different application classes is carried out, where the models are associated with different sets of generic requirements. Consequently, through focusing on the class(es) associated with a particular use case, the generic requirements can therefore be reused. There are a range of other structured methodologies also available to support technology forecasting and this includes using the Soviet-originated theory of inventive problem solving (TRIZ) methodology (Mann, 3003) based on assessing technology and business evolution trends.

Technology roadmapping has been used widely (Phaal et al., 2004) to support the development of new products and services through identifying technology alternatives, which are then be mapped and in some cases with resource plans to underpin the strategic planning process. The roadmapping exercise is process-driven but the effectiveness of the ap-

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proach can also be highly contingent on the people dimensions associated with the culture of the organisation as well as the roles and responsibilities of those involved with the process implementation (Gerdsri et al., 2009). Although the resulting roadmaps can be useful visual outputs of the roadmapping process, the real value associated with this technique is often the planning that is carried out in order to generate the roadmaps and such planning will be dependent on both the quality of the available information as well as the participation of those involved.

The Delphi method has been used for many years as a structured forecasting tool (Okoli and Pawlowski, 2004), which involves capturing the views of a group of experts through an iterative process that seeks to converge on a common view. Although the method has been used widely it does have weaknesses due to the dependence on the quality of the expert's knowledge and also creative or disruptive thinking can be inhibited by the process. There are a range of other related techniques that can be viewed in the broader context of forecasting and planning and these include a number of statistical methods, such as bibliometrics, demographic modelling, techno-economic analysis and trend analysis.

Scenario planning has been used widely to forecast not just technologies but also on a more strategic level to help identify business strategies and organisational direction (Amer et al., 2013). The process benefits from being systemic in nature thereby encompassing a broad view of the area under consideration. The methodology was deployed extensively within the international oil company Royal Dutch Shell (Wack, 1985), where it was used to help the company set long-term plans across the various business areas (such as exploration & production; petrochemicals; oil trading; marketing; etc.) and the method has even been reported as helping the company to mitigate the effects of the global oil price shock in the 1970's. The original planning approach involved the development of simulation models that incorporated data across areas such as industrial development, materials usage and demographics along with different scenarios in regard to economic, social, environmental or technical trends. Although the methodology has been criticized as involving an overly subjective element, it does nevertheless provide a powerful lens to consider different future states (or scenarios), which can be effectively moderated or tweaked to accommodate the impact of changes within a particular area.

Methodology

The methodology selected was based on the scenario planning approach, which allowed findings to be generated based on established perspectives and practice as well as emerging viewpoints on technology development and adoption. In order to develop an improved understanding of the emerging requirements for technology management, three sectors were identified as being leading indicators for a broad range of technological advances and these were healthcare, energy and higher education. This methodology provides the context for technology management issues thereby enabling both practitioners and researchers to apply the findings from the research. A schematic view of the methodology used is provided in Figure 1.

Stage 1 involved the collection of data and information on the three sectors. A comprehensive literature review was undertaken on emerging technologies in the three sectors, which allowed secondary data to be gathered according to a systematic approach. This was accompanied by the collection of data from a series of other activities, such as attendance by the author at lectures, workshops and conferences

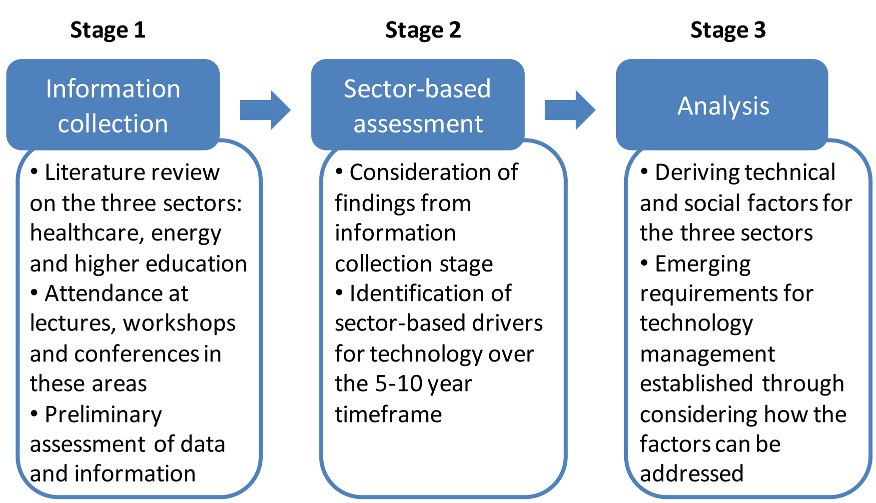

Figure 1. Overall methodology for establishing emerging requirements for technology management.

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held in the three sector areas (carried out over a 12-month period). This approach allowed the literature findings to be supplemented by additional insights and viewpoints acquired from the expert presentations at these events. Stage 2 was based on consideration of the information gathered allowing identification of the sector-based drivers for technology. Finally stage 3 involved deriving the technical and social factors underpinning the requirements for new and improved technologies within each of the sectors followed by a process of deductive reasoning to ascertain the emerging requirements for technology management.

Results

The results on the emerging requirements for technology management obtained from the scenario planning approach are provided according to the three sectors (healthcare, energy and higher education) investigated within this research study.

(a). Healthcare sector

There are a range of key drivers in the healthcare sector that have the capacity to influence emerging technology management requirements. The sector has for a number of years been generally subject to rising costs (Orszag and Ellis, 2007) driven by the complexity of healthcare provision and the availability of technologies, for example, the use of PET-CT imaging to support the therapeutic treatment for oncology patients (Boellaard, 2010). Therefore, rising costs are driving the need for more affordable approaches to the provision of healthcare, which includes diagnostic systems (Yager, 2006), medicines (Bjerrum, 2002) and other therapeutics, and this is an area where technology developments can play a significant role. The development of new drug compounds continues to be a scientifically and technologically challenging area. Whilst the biotechnology business model has yielded some major innovations in the way drug compounds are developed and drug discovery processes, such as high-throughput screening (Casalino, 2012), have also helped in this regard. Nevertheless, pharmaceutical companies continue to make major levels of investment in scientific research and increasingly this is with external research suppliers. For example, the open innovation approach to research development being pursued by Pfizer as part of its CTI (Centers for Therapeutic Innovation) partnership model with university clusters, which are focused on a particular therapeutic area (Ratner, 2011). Furthermore, the commercialisation of full genomic sequencing (Bashir, 2013) will provide massive levels of genetic data on individuals and there are likely to be major implications in regard to the provision of new and improved preventative therapies, i.e. in terms of personalised approaches to medicine. This 'Big Data' challenge will require both scientific and technology solutions and this part of the healthcare arena will need to benefit from the participation of established companies, start-up enterprises as well as universities and other research institutions.

There are also major challenges in regard to harnessing ICT (information and communications technology) in the healthcare sector and so called e-health technologies (Morrison, 2012) offer significant promise to improve the provision of healthcare through, for example, improving the quality of information provision to the patient. Other benefits can be associated with potentially improving the efficiency of

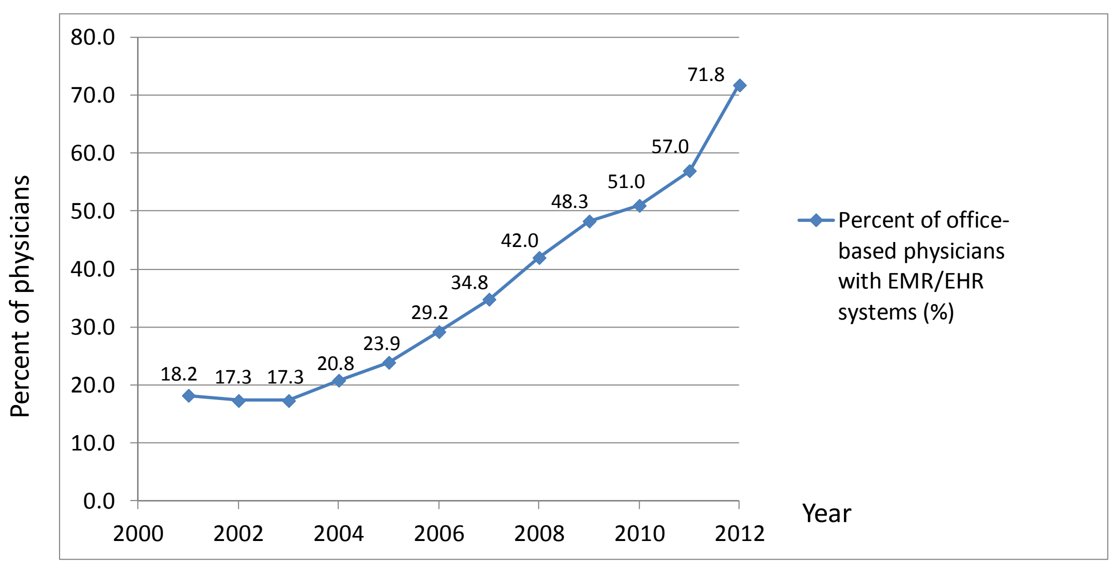

Figure 2. Level of office-based physicians with EMR/EHR systems in United States from 2000 to 2012 (Source: Hsiao and Hing, 2012).

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primary healthcare since medical practitioners would, for instance, be able to replace some follow-up visits with electronically enabled consultations (i.e. through an appropriate online portal) thereby freeing up physician time to consult with more patients as well as providing higher quality care to existing patients. Although these benefits are still to be proven through adoption of supporting business models, there do appear to be significant opportunities for technology to make a major impact in the delivery of healthcare.

In regard to primary healthcare, the adoption of electronic medical/health records (EMRs/EHRs) is likely to be a major factor over the next 5-10 years that drives innovation in healthcare IT and systems enabled to utilise increasingly complex medical data and information. Such records could potentially contain all the information related to a particular patient, including pathology, radiology and clinical data and information in a suitable digital format. Data storage, analysis and interpretation, transfer and communication as well as data security are just some of the technology challenges associated with implementation of these records. In this context Figure 2 highlights the increasing level of EMR/EHR usage by office-based physicians in the United States. It should be noted that the data from 2001-2009 is based on the US National Ambulatory Medical Care Survey interviews and mail survey sources, whereas data from 2010-2012 is preliminary and based on mail survey only sources. Nevertheless, this data clearly shows the rapidly increasing level of EMR/EHR usage in the United States (from 18% in 2001 to 72% in 2012) and as this technology becomes embedded into the fabric of healthcare delivery, the scope and provision of services is likely to be significantly changed. In this scenario there are a range of associated technology management requirements, such as the need for new business models to support online medical provision as well as the need for recognised IT systems standards to govern the technology implementation pathways.

Through consideration of these sector-based drivers for technology and the emerging requirements that may arise over the next 5-10 years, it is possible to identify both the technical and social considerations, which in turn contribute to specific technology management requirements for the healthcare sector. This analysis is provided in Table 1.

(b). Energy sector

The key drivers for technologies related to the energy sector can potentially be viewed in the context of an increasing level of global demand for energy across industrial and domestic markets (and especially from Asia and other developing regions) along with pressure on the supply of both conventional and alternative energy sources. Although the global oil supply may have already reached or be approaching peak supply level (Lutz, 2012), there are still vast supplies of other forms of oil, e.g. heavy oil, tar sands and oil shale (in addition to natural gas and coal). However, the impact of carbon emissions on the environment and the spectre of global warming are leading to a position where such energy-rich resources will be increasingly subject to regulatory frameworks in order to limit environmental exposure. This will drive the need for new technologies, for example, in the area of carbon capture and storage (Anderson and Newell, 2004). Carbon capture and storage (CCS) technologies are targeted on the removal of carbon dioxide from either fossil fuel exploration or production sources through injection of the gas into either deep underground aquifers or other geological formation under the seabed. However, such ap-

Technical issues	Social issues	Technology management requirements
• Role of technologies for e-health provision. • Electronic Health Records (EHRs) allowing data and information to be more accessible. • Ease of use of healthcare IT systems in addition to levels of standardisation across the industry. • Personalised medicine approaches for disease control and wellness. • Requirements for 'Big Data', e.g. from genomic sequencing.	• Patient motivations to adopt technologies. • The need for lifestyle changes for patients, arising from greater levels of information provision and informed judgement. • Availability of technology according to socio-economic position and geographical location. • Need for health advocacy by primary care practitioners.	• Management of 'Big Data' and 'Big Analytics', including integration of different data streams to provide practical benefits for healthcare. • Development of business models to support new forms of technology adoption – answering the question, who pays for the technology? • Addressing the social implications of the increasing use of technology within healthcare. • Continuing need for technology standards, e.g. to support adoption of electronic health records. • Need for inter-operability and integration between different IT systems adopted across healthcare.

Table 1: Results from healthcare sector scenario planning.

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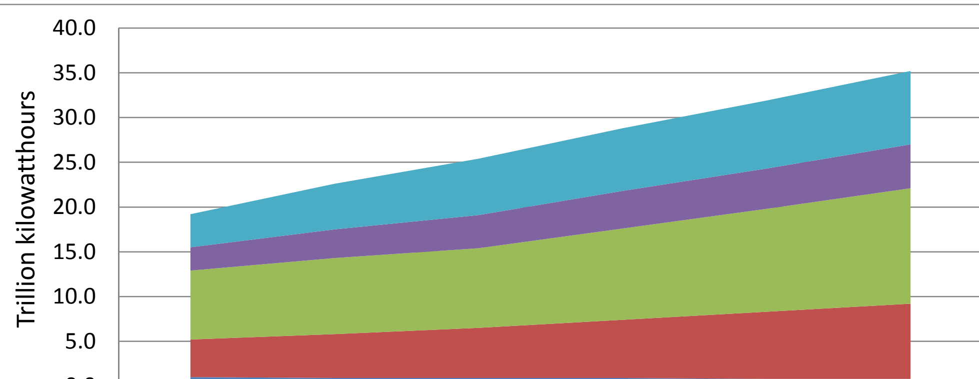
proaches are not without controversy and environmental, social, political and technical barriers all need to be overcome in order for CCS technologies to be implemented on, for example, coal or gas burning power stations.

In regard to transport applications, petroleum and diesel are likely to remain in the short/medium term as major energy sources but science and technology offer the prospect to lower carbon emissions and also provide access to a larger section of available fossil fuels, e.g. heavy tar sands and oil shales. Gas to liquids (liquefied natural gas, or LNG) can potentially provide cleaner solutions than oil or coal but combustion still results in carbon dioxide emissions. Other benefits for LNG include the vast supplies and ease of transportation as well as the discovery of new sources of deep gas seams. Furthermore, coal gasification (Irfan et al., 2011), which involves oxidation of coal to produce syngas, a mixture of carbon monoxide and hydrogen, can be undertaken to enable the resulting syngas to be converted to petroleum via the catalytic Fischer-Tropsch process. These areas all require new technologies to be developed along with the corresponding management processes.

Renewable approaches to energy supply and production offer environmentally sustainable solutions to meet the growing energy needs, however, there are many technology challenges that remain with renewable energy sources (Trainer, 2012), such as the variability of wind energy as well as the need for massive capital investment. There are also policy-related challenges (Peidong, 2009) and in China, for example, these include a need for more coordination and consistency of policy frameworks as well further substantial capital investment being required to support development of the sector. Solar power (Zweibel, 1990) through photovoltaics (PVs) offers a readily available solution in certain countries as well as very low environmental impact. However, again there are expected to be high capital outlay costs and the investment costs may not be covered by the lifespan savings unless a preferential feed-in tariff is offered by the local grid network. Other technological issues include a limited power density and since the energy is not available at night and is less available in cloudy weather conditions there can be a need for an electrical power storage system. Moreover, nuclear power (through nuclear fission processes) continues to be a major source of power in many countries although there are obvious environmental issues associated with this energy supply. In the future, nuclear fusion offers significant promise in regard to vast levels of energy potentially available although the technological obstacles here, such as those regarding materials and engineering considerations, are immense (Zinkle, 2005).

As can be observed, there continue to be many sources of energy each with their own set of technology challenges, which will need to be addressed if the growth in demand and shortage in supply are to be met whilst mitigating the effects of climate change. Indeed the total (world) net electricity generation for both OECD and non-OECD countries is expected to approximately double from the 2008 figure (19.1 trillion kilowatts) to the expected level in 2035 (35.2 trillion kilowatts) (U.S. Energy Information Administration, 2011). Moreover, this data indicates that coal, natural gas



	2008	2015	2020	2025	2030	2035
Renewables	3.7	5.1	6.3	7.0	7.6	8.2
Nuclear	2.6	3.2	3.7	4.2	4.5	4.9
Coal	7.7	8.5	8.9	10.2	11.5	12.9
Natural gas	4.2	4.9	5.6	6.5	7.5	8.4
Liquids	1.0	0.9	0.9	0.9	0.8	0.8

Figure 3. Total (OECD and non-OECD) net electricity generation by energy source from 2008 to 2035 (projected) in trillion kilowatthours (Source: U.S. Energy Information Administration, 2011).

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and liquid fossil fuels (such as petroleum and kerosene) will continue to be in significant usage over this timeframe, with expected large increases in the use of both coal and natural gas (68% and 100% increases respectively from 2008 to 2035). In this period renewables are expected to increase by 122% representing the largest proportional increase in usage, although by 2035, renewables will still only represent 23% of global net electricity generation with nuclear being 14% and the remaining 63% from fossil fuels (coal, natural gas and liquids). Consequently, there will be a significant need to manage the prioritisation of technologies to support the growth of renewables and the implementation of technologies to mitigate climate change, e.g. through designing and introducing carbon capture facilities on existing coal fired power stations and also on new gas fired stations. Innovation in new business models will be required alongside development of financial instruments that support the introduction of these technologies as there could be the need for significant capital expenditure as well as uncertainty over rates of return and the long-term profitability of new technologies.

Through consideration of these sector-based drivers for technology and the emerging requirements that may arise over the next 5-10 years, it is possible to identify both the technical and social considerations, which in turn contribute to specific technology management requirements for the energy sector. This analysis is provided in Table 2.

(c). Higher education sector

The key drivers related to technology development in the higher education sector span a broad range of areas. The increasing costs of higher education has been report-

Technical issues	Social issues	Technology management requirements
• Fossil fuels continuing to dominate but with an increased need for technology, e.g. for enhanced oil recovery; carbon capture, storage and use; cleaner use of natural gas. • Renewable energies expected to grow gradually but this will depend on technology availability and commercial factors. • Biofuels expected to be a niche energy vector. • Nuclear (fission, and eventually fusion) continuing to be a feature.	• The need for sustainable development and addressing environmental concerns especially reducing carbon emissions. • Demographic trends and the economic rise of the 'BRIC nations' resulting in massive increases in energy demand. • Energy dependence of Western nations. • How to tackle society's need for energy efficiency in regard to transport, housing, heating and lighting.	• Business model innovation to support emerging technologies in the energy sector. • Project management of R&D activities to provide technology options, including role of universities and companies in research provision. • Decision-support tools needed to help support the selection and development of energy related technologies. • Strategic management of technologies to support societal concerns (e.g. reducing carbon emissions) and responding to demographic changes.

Table 2: Results from energy sector scenario planning.

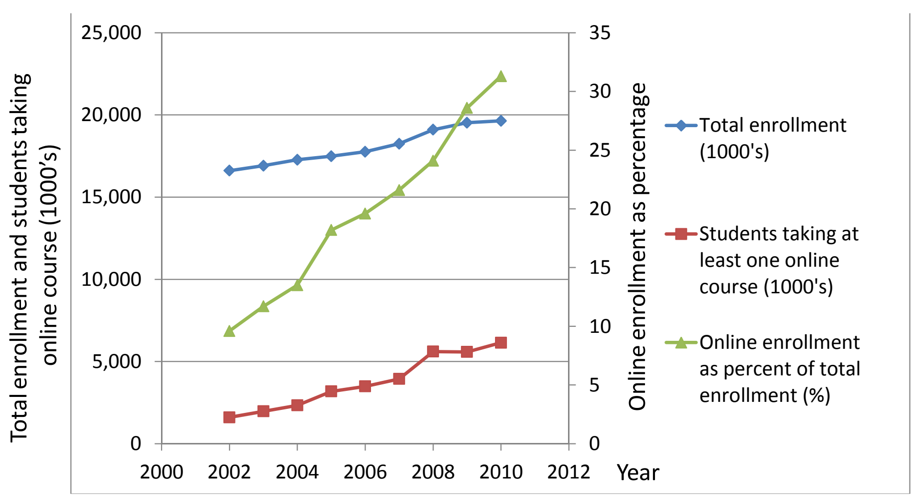

Figure 4. Total and online enrolment in degree-granting postsecondary education institutions from 2002 to 2010 (Source: Allen and Seaman, 2011).

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ed for many years (Johnstone et al., 1998) as driving the need for greater efficiency and higher levels of quality at universities and tertiary education institutions. In order to improve the level of quality there needs to be robust quality assurance and supporting qualification systems introduced to ensure degree programmes provide students with the necessary knowledge, skills and competencies required for today's society. There also needs to be accountability for change at higher education institutions and this requires effective governance and leadership, which will be contingent on the quality and performance of university leaders and their staff. These matters will likely be under increased pressure as the university sector expands, due to the growth of developing countries and also from the globalisation of the university sector (Maringe and Foskett, 2010). These changes will provide opportunities for some universities to grow and prosper and yet others may struggle to meet the increased levels of competition in terms of securing funding, remaining attractive to increasingly mobile students and also being able to attract high-calibre academic faculty in a free labour market.

The impact of ICT and digital technologies has the capability to significantly enhance the way in which education is delivered at universities although the provision of technology can also potentially disrupt conventional delivery methods (i.e. lectures, tutorial, etc.) and so greater attention is required on the complexities of introducing digital technologies at universities (Lea and Jones, 2011). Although university campuses are unlikely to disappear, there will be greater opportunities for technology-driven innovation in teaching practice, for example, the use of tablet computers and mobile applications ('apps') as well as activities such as podcasting and webinars. The effectiveness of e-learning practice will likely be dependent on the input of teachers, students and university administrators, and adoption of e-learning technologies will also be related to the demographic characteristics of the university (Nawaz and Kundi, 2011).

The rise of online provision of courses at universities has been continuing to increase in recent years and data from the United States (see Figure 4) shows that participation by students at degree-granting postsecondary institutions in online courses as a percentage of total enrolment has increased from 10% in 2002 to 31% in 2010 (Allen and Seaman, 2011). An increasing level of online provision leads to a distributed approach to education and so called massive open online courses (MOOCs) have also been launched by often prestigious universities (such as Stanford University, USA), which provide entire courses online and free of charge (Cooper and Sahami, 2013). However, such innovative methods present a number of challenges in terms of whether certification will be provided and how assessment is carried out as well as validation and plagiarism issues to be addressed. Furthermore, there needs to be further development of the supporting business models to allow universities to better understand how such teaching provision can be integrated into the operations of universities, for instance, will such activities be viewed as revenue generating in their own right, or will they be more of a profile-raising initiative to effectively advertise the university more widely to students that may then wish to apply to study at the university? Nevertheless, MOOCs represent a highly innovative extension to education, which will further contribute to the globalisation of higher education through enabling students from developing nations to access high-quality teaching resources from developed countries.

As the competition between universities increases, there will also be competitive pressure on research activities and not just education. Universities have been able to attract funding from industrial companies for many years but such translation activities need to be fully aligned with the company's requirements for research if the technical outputs are to contribute to improved products, services or manufacturing processes. This will require improvements in the way such university-industry research collaborations are structured and managed, including the development of process models that allow both parties to secure the required benefits (Philbin, 2008). Consequently, there may be further polarisation of higher education, with greater levels of research funding (industrial, governmental and charitable) being concentrating at fewer research-intensive universities with other academic institutions having to concentrate on teaching and translation being restricted to technology transfer through consultancy.

Through consideration of these sector-based drivers for technology and the emerging requirements that may arise over the next 5-10 years, it is possible to identify both the technical and social considerations, which in turn contribute to specific technology management requirements for the higher education sector. This analysis is provided in Table 3.

Discussion

The adoption of existing and emerging technologies is an important source of value for all organisations and especially industrial companies, which require access to leading technologies in order to remain competitive. Technology management provides the vehicle to allow the development, acquisition and deployment of technology to take place and it is therefore useful to consider the emerging requirements for technology management so that organisations are prepared for the future. There are a range of methodologies available to forecast technologies themselves, ranging from roadmapping and requirements capture through to trend analysis and scenario planning. This paper has described the results from the use of a sector-based approach to scenario

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planning in order to generate a view on the emerging requirements for technology management that will potentially need to be addressed over the next 5-10 year timeframe. Through a structured approach to information gathering based on literature reviews augmented by attendance at sector specific events, it has been possible to establish a qualified perspective on the drivers for technology across the healthcare, energy and higher education sectors. This has been extended through socio-techno analysis to enable identification of the emerging requirements for technology management for each of these three sectors.

The healthcare, energy and higher education sectors all represent knowledge intensive parts of the global economy and they are being impacted by an increasingly dense and more diverse data and information landscape. The rapid development of ICT along with the pace of digitisation is driving new practices along with the challenges associated with 'Big Data', i.e. understanding how organisations can leverage massive levels of data that are now becoming available. Therefore, technology management needs to provide the tools to support technology implementation and improved decision-making to meet societal needs, e.g. development of carbon capture technologies for clean power generation, or development of personalised medicine approaches through genomic technologies. The development of decision support tools that integrate technology availability factors with market analysis data will be useful in this regard and such systems need to be made available to industry practitioners allowing implementation and subsequent benchmarking to take place. There is also a need to integrate technologies alongside existing delivery channels, e.g. adoption of communications and mobile technologies in healthcare and education. Understanding the process, structural and cultural implications of such integration will need to be undertaken alongside a deeper awareness of the barriers to technology adoption in all three of the sectors. The need to understand the emerging requirements for technology management is not restricted solely to industrial companies, as this research has outlined, not-for-profit organisations, such as universities, also face challenges if they are to benefit from technology opportunities and avoid the corresponding risks. Therefore, technology management as a discipline needs to develop and respond to the arising technology issues as well as societal and industrial needs. There should be a greater awareness of the future requirements for the management of technology and this paper has provided insights into the emerging requirements for technology management for three important sectors.

The limitations of this paper lie with the research methodology employed. However, the findings have been established through a structured approach that draws on a comprehensive literature review supplemented by other data and information gathering activities. The use of a sector-based approach to scenario planning has provided a systematic and focused method to allow qualitative information and supporting quantitative data on sector trends to be analysed.

Future work is suggested on refinement of the sector-based scenario planning approach through capturing additional technical inputs in order to improve the richness of the material provided, for example, the use of a survey instrument with a group of experts from the sector areas. The use of systems dynamics, such as cause and effect modelling, is also recommended in order to provide further mechanistic insights into the emerging requirements for technology management.

Technical issues	Social issues	Technology management requirements
• Digital technologies and web-based platforms. • Role of mobile communications technology in education. • Technology allowing a wider delivery of education through multiple channels and across a global basis. • Universities increasingly networked and the continued focus on collaboration with industry and commercialisation of research. • Development of blended learning systems.	• Social mobility means greater sections of society can benefit from higher education. • Online delivery of education available globally, which includes open access delivery models. • Increasing mobility of students and staff at universities. • Universities continuing to deliver research to meet societal needs, e.g. healthcare, energy, environment and security.	• Increased role of mobile communications technology can lead to innovation in education provision. • Integration of web-based services with conventional modalities. • Need for accreditation and validation standards for online teaching. • Expansion of higher education sector in developing countries, leading to greater levels of technology and innovation management activity. • Continued need for innovation in how universities collaborate and partner with industrial companies, e.g. new intellectual property (IP) frameworks.

Table 3: Results from higher education sector scenario planning.

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