Management of Technology Activities

A Guide for Sustainable Entrepreneurs

SUSTAINABLE ENTREPRENEURSHIP PROJECT

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About the Project

The Sustainable Entrepreneurship Project (www.seproject.org) engages in and promotes research, education and training activities relating to entrepreneurial ventures launched with the aspiration to create sustainable enterprises that achieve significant growth in scale and value creation through the development of innovative products or services which form the basis for a successful international business. In furtherance of its mission the Project is involved in the preparation and distribution of Libraries of Resources for Sustainable Entrepreneurs covering Entrepreneurship, Leadership, Management, Organizational Design, Organizational Culture, Strategic Planning, Governance, Corporate Social Responsibility, Compliance and Risk Management, Finance, Human Resources, Product Development and Commercialization, Technology Management, Globalization, and Managing Growth and Change. Each of the Libraries include various Project publications such as handbooks, guides, briefings, articles, checklists, forms, forms, videos and audio works and other resources; management tools such as checklists and questionnaires, forms and training materials; books; chapters or articles in books; articles in journals, newspapers and magazines; theses and dissertations; papers; government and other public domain publications; online articles and databases; blogs; websites; and webinars and podcasts.

About the Author

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Management of Technology Activities

§1   Introduction

For most companies, management of "technology" involves both engineering/product development activities (i.e., incorporating technology into products and/or the processes used to manufacture products) and information technology ("IT") activities that include internal and external communications and other projects and support. In some instances, these companies will create separate management structures for each of these functions, although a single senior executive, generally referred to as either the "chief information officer" ("CIO") or the chief technology officer ("CTO") will still retain ultimately responsibility and the leaders of each function will report to that executive. For example, a company might have separate vice presidents or senior directors of engineering and IT. The engineering group might be a centralized source for standards and assume responsibility for support functions, technology initiatives and engineering career development. The day-to-day work of the engineers is often organized into decentralized project teams in various business areas. In contrast, the IT activities are typically fully centralized and organized by function (i.e., support, service, infrastructure etc.) that carry out their activities through project teams.[1]

Advances in technology have changed the ways that all companies and public agencies conduct their businesses and identifying and implementing the best organizational structure for managing technology activities has become a key issue for chief executive officers and members of organizational governing boards. Management activities not only include oversight of IT assets and managing the integration of technology into the design and manufacture of products, but now extend to developing an IT strategic planning process; integrating IT management operations and decisions with organizational planning, budget, financial management, human resources management, and program decisions; coordinating the technology strategies and activities of divisions and business units; and providing information and advice to the senior management group and other company managers regarding technology-related issues. This chapter covers key concepts and issues in the management of technology activities including the roles of the chief information and technology officers, and strategies for effectively deploying each of those positions in the organizational structure; ideas for improving appreciation of the role that the IT department plays within the company; guidelines for determining the CIO reporting structure; the responsibilities of chief innovation officers; and the management of technology in technology-based startups.

§2   Chief information officer

The term "chief information officer", or "CIO", was first used in the 1980s, a time in which the position was generally thought to be the ideal integration of an experienced

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[1] S. Hart, "Inside the Minds—The Role of the CTO in a Technology Company" in Achieving Success as a CTO: Leading CTOs on Building IT's Reputation, Capitalizing on Employee Strengths and Creating a Productive Environment (Boston MA: Thomson/Aspatore, 2008).

business manager with a knowledgeable information system ("IS") technician.[2] According to Synnott and Gruber, the CIO was the "senior executive responsible for establishing corporate information policy, standards, and management control over all corporate information resources".[3] Benjamin et al. described the CIO as the "corporate officer who truly understands the interconnection of the information flow to the business".[4] In a different study, Synott said that CIOs were a "new breed of information systems managers": businessman first, managers second and technologists third.[5] Sprague and McNurlin's list of CIO responsibilities included understanding the business; establishing credibility with the systems department; increasing the technical maturity of the firm; creating a vision of the future and selling it; and implementing IS architecture.[6] Each of these definitions and descriptions highlighted the challenges that CIOs faced in successfully balancing their technical and managerial job roles, a dilemma that eventually led to debate about the appropriate training and career path for a prospective CIO.

During the 1990s, the pressures on, and expectations of, the CIO position began to change as companies became more focused on leveraging their IS to support both operational and strategic goals of the firm. Research conducted about the period found that the CIO position had risen to the top levels of the organizational hierarchy and that CIOs were more involved in strategic decision making with the CEO and other members of the executive team. This meant that the job description of the CIO, which was already quite broad, got even bigger and that the high-level responsibilities or issues confronting the CIO included meeting the changing technical needs of the organization (i.e., the "architecture manager"); building a reputation as a knowledgeable business executive (i.e., being perceived as a "proven businessperson"); orchestrating the successful implementation of the IS strategy (i.e., an "operations supervisor"); and maintaining the proper IS staff (i.e., acting as a "personnel developer").[7]

According to Mullins and Klinowski, the CIO is responsible for ensuring that the company's IT investments are aligned with its strategic business objectives, which means that he or she is the key executive for information assets, operations, and policy.[8] In

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[2] The discussion in this section is adapted from R. Beatty, K. Arnett and C. Liu, "CIO/CTO Job Roles: An Emerging Organizational Model", Communications of the IIMA, 5(2) (2005), 1.

[3] W. Synnott and H. Gruber, Information Resource Management (New York: John Wiley & Sons, 1981).

[4] R. Benjamin, C. Dickinson and J. Rockart, "Changing Role of the Corporate Information Systems Officer", MIS Quarterly, (9) (1985), 177.

[5] W. Synnott, "The Emerging Chief Information Officer", Information Management Review, 3(1) (1987), 21.

[6] R. Sprague and B. McNurlin, Information Systems Management in Practice (Englewood Cliffs, NJ: Prentice Hall, 1993).

[7] R. Beatty, K. Arnett and C. Liu, "CIO/CTO Job Roles: An Emerging Organizational Model", Communications of the IIMA, 5(2) (2005), 1, 2 (citing B. Ives and M. Olson, "Manager or Technician?: The Nature of the Information Systems Manager's Job", MIS Quarterly, 5(4) (1981), 49; L. Applegate and J. Elam, New Information Systems Leaders: A Changing Role in a Changing World, MIS Quarterly, 16(4) (1992), 469; and C. Stephens, W. Ledbetter, A. Mitra and F. Ford, "Executive or Functional Manager? The Nature of the CIOs Job", MIS Quarterly, 16(4) (1992), 449).

[8] S. Mullins and J. Klinowski, Defining the complimentary job roles of the CTO and CIO (April 18, 2003), http://www.techrepublic.com/article/defining-the-complementary-job-roles-of-the-cto-and-cio/ [accessed September 12, 2016]

many cases, the CIO is also responsible for the oversight management of various office automation tasks including desktop architecture and support, network implementation, software development and information management. They noted that as technology has become more important for businesses, the duties of the CIO have expanded to include both strategic and tactical duties, a development which has made the CIO's role more stressful, more business-oriented, and less "hands-on". The desired skill set of a CIO has evolved and now includes both a core technical background and a strong business background. Mullins and Klinowski cautioned that the CIO should not be the lead engineer or programmer, but rather he or she must accept the role of, and be perceived as, the business executive who is responsible for synchronizing IT initiatives to the company's overall goals. Mullins and Klinowski noted that in order to be successful, the CIO must be a positive leader; an effective communicator, skilled in both listening and speaking; a persuasive negotiator; and a customer-orientated individual.

A good reference point for the roles and responsibilities of the CIO in the public sector is the Clinger-Cohen Act of 1996, which was designed to improve the way that the federal government acquires, uses and disposes of IT.[9] Among other things, the Act created a CIO position and assigned it responsibility for providing advice and assistance to senior managers on IT acquisition and management; developing, maintaining and facilitating implementation of a sound and integrated IT architecture; and promoting effective and efficient design and operation of all major information rights management processes, including improvements to work processes. In addition, the CIO is expected to be involved in overall strategic planning for the organization including assessing requirements for personnel regarding the knowledge and skills needed to achieve performance goals that have been established by the organization; assessing the extent to which all managers within the organization meet those requirements; developing strategies and specific plans for hiring and training; and reporting on progress made in improving information rights management capabilities. Another resource is the following list of ten competency areas for the CIO developed by the Federal CIO Council: policy, strategic planning, performance and results-based management, process improvement, capital planning and investment, leadership management, technology assessment, security, architectures and acquisition.

Strickland and Theodoulidis conducted an extensive analysis of the evolution of the role of the CIO in relation to the responsibilities of the position and to the role of technology in the internal and external environment of organizations.[10] Based on this work, they compiled the following list of the key themes and challenge of the position:

- *Managerial responsibilities:* As the role of the CIO transformed over the years from a technician to a manager and then to an executive his or her responsibilities have shifted away from functional activities to strategic ones.

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[9] Adapted from http://balancedscorecard.org/Resources/Articles-White-Papers/CIO-Responsibilities [accessed September 12, 2016]

[10] S. Strickland and B. Theodoulidis, Chief Information Officer: A Journey through Time, http://www.citi.columbia.edu/B8210/read17/CIO.pdf [accessed September 15, 2016]

- *Two-way alignment:* The continuously increasing role of the CIO in organization strategy has led to greater emphasis on the CIO responsibility to align the business operations and the IT function.
- *Internal communication:* It has become increasingly important for the CIO to build relationships within the organization and this means developing internal communications skills to communicate and in some cases educate their colleagues on the IT function. In addition, effective internal communication should be at the forefront of the CIO's efforts to design, develop and maintain an IT-enabled communication and collaboration environment within the organization.
- *External environment:* As the IT function expands in importance, the CIO must pay more attention to the external environment and monitor IT activities of competitors, best practices in business processes and other ideas that can be implemented to increase the support provided by technology for the business of the company.
- *Competitive advantage:* The CIO has been asked to assume responsibility for identify ways in which technology can be turned into a competitive advantage of the company, which can happen when the technology itself becomes the basis for innovative products or services and/or when the internal design and use of technology (i.e., IT architecture and infrastructure) improves the efficiency of business processes.
- *Innovation:* The CIO has been asked to take on a number of different roles with respect to innovation including assisting in developing new products and services and reducing costs and enhancing efficiencies in business processes.
- *Information management:* The CIO is expected to take the lead in making information a strategic resource for the company, a process that includes collection, manipulation and distribution of information throughout the company.

The key roles of the CIO position identified by Maes & De Vries included information strategist, co-creator/advisor business strategy, IT portfolio manager, enterprise architect, business advisor and trend watcher.[11] A global Chief Information Officer study by IBM was conducted during 2009 that included more than 2,500 CIOs from 78 countries and 19 industries and found three twofold aspects of CIO roles referred to as "innovation", "return on investment" and "business impact".[12] The researchers used the term "twofold" for the aspects because they were spread between two opposed sub-roles as follows:

- *Innovation:* CIOs were expected to be insightful visionaries and creating thinkers about cutting-edge technology; however, at the same time they were asked to be capable pragmatists and work to advance the productivity of current IT solutions and build a foundation for innovation.
- *Return on Investment:* CIOs were expected to create value through better customer services and understanding the needs of customers; however, they also were being asked to reduce costs through automation, centralization and standardization.
- *Business Impact:* CIOs had obligations to make an impact both horizontally and downward with colleagues throughout the organization. With other executives, the

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[11] R. Maes and E. De Vries, "Information Leadership: The CIO as Orchestrator and Equilibrist", Paper presented at the 29th International Conference on Information Systems, Paris (2008).
[12] International Business Machines ("IBM"), The new voice of the CIO Insights from the global Chief Information Officer study (2009).

CIOs job is to be a "collaborator" who builds partnerships and provides support for better business models and shift organizational culture. At the same time, the CIO must inspire and motivate the IT managers and subordinates to create and maintain excellent IT centers and develop IT expertise.

When the CIO position was first created and popularized the role typically focused on leading the data processing and IS departments. However, as time went by and technology became an increasingly important element of the business environment for all companies, the CIO position drifted away from purely operational responsibilities to encompass creating business value through technology, strategic planning of business growth objectives and ensuring that the company's IT systems and procedures are aligned with the business goals of the company. Other key activities added to the job responsibilities for the CIO included development of customer service platforms; IT and development team personnel management; vendor negotiations and IT architecture; supplier management; information risk management ("IRM"); IS policies, strategies, and standards; and technology futures and budgets.[13] New skills that were needed in order to be successful in the CIO position included strategic planning, software development management, leadership, project management, network and relationship building, change management and overall business and financial acumen.[14]

The actual and potential roles and responsibilities of the CIO grew to be quite extensive and easily went beyond what any one person could realistically handle. As such, in order for the CIO to be effective he or she needed to have the resources to put together a staff of people with the requisite competencies and, of course, it was the responsibility of the CIO to make sure that his or her group was motivated and that staff members collaborated effectively. Management skills became essential since the areas of interest for the CIO were so broad, spanning managing the existing IT infrastructure, scanning the environment to identify new technological trends and participating in decision making and planning as part of the executive team (including making sure that other executives understand the technology-related issues upon which they are asked to decide). Not surprisingly, the pressures of the position led to high turnover rates among CIO's, a situation that made it difficult for companies to maintain stability in an area that was indisputably crucial to their success. The new pressures on the CIO led to a call for reconsideration of the traditional model and creation of a new "chief technology officer" ("CTO") position that could assume some of the growing responsibilities of the CIO.

§3   Chief technology officer

The growing importance of technology, as well as the pressures on the CIO position described above, have led to the emergence of a new "chief technology officer" ("CTO") position, sometime referred as the Vice President of Technology, created to assume

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[13] L. Schneider and L. Bradford, Business or IT: What's the Main Job of a CIO? (March 28, 2016), https://www.thebalance.com/business-or-it-what-s-the-main-job-of-a-cio-2071252 [accessed September 13, 2016]

[14] Id.

responsibility for the development and management of an overall technology strategy for the company. The role of the CTO goes beyond managing specific R&D and product development projects to include overall planning and coordination of the company's R&D activities; coordinating the technology strategies and activities of divisions and business units; acting as the functional manager of the activities of the technology managers for each of the company's divisions and business units; overseeing technology sales, purchase and licensing activities; providing information and advice to the senior management group and other company managers regarding technology-related issues; and supporting new technology-based business initiatives launched by the company.

Tietze et al. gathered and analyzed information on typical responsibilities, key skills, necessary qualifications and organizational integration into the corporate structure with respect to the CTO position through a survey conducted among German executive recruiting consultants that was complemented by an analysis of international CTO job offers.[15] In general, they found that both large companies and small- and medium-sized enterprises ("SMEs") associated equal importance to similar responsibilities, skills, qualifications and organizational integration (i.e. central, local, staff) with a CTO, while the hierarchical integration of CTOs being a major difference. Tietze et al. also found that while the typical job responsibilities of a CTO were similar to those of a senior director or manager of R&D the CTO generally had a more external focus that included the broader business environment and those professional networks that most corresponded to the innovation requirements of the firm.

Several other interesting observations were made by the researchers based on the results of their survey. First, while it was fairly common for the CTO to be admitted as a member of the senior management team at large companies this was not the case at the SMEs. The researcher speculated that this was due to the fact that SMEs had a smaller number of executives and tended to follow what was called the "all the way up principle" under which promotions were made only after a person, such as the CTO or equivalent, demonstrated value to the firm. Second, the researchers noted that CTOs were still very rare in German companies at the time the data was collected in 2005 in comparison to the situation in the US. Third, the researchers included references to the work of the others on the roles and skills of CTOs such as a study done by Adler and Ferdows that indicated that the main area of responsibilities for CTOs among Fortune 100 companies in the US included coordination among business units' technological efforts to ensure synergy and economies of scale; representation of technology within the top management team; supervision of new technology development; assessment of technological aspects of major strategic initiatives; and management of the external technology environment.[16] Finally, they pointed out that the level of involvement of the CEO in various aspects of technology management—technology strategy development, overall R&D budgeting,

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[15] F. Tietze, P. Lorenzen and C. Herstatt, The Role of the Chief Technology Officer: Responsibilities, Skills, Qualifications and Organizational Integration (2007). They noted that their study was conducted as a pre-study to a larger survey prepared by the European Institute for Technology and Innovation Management (www.eitim.org) regarding the role of the CTO in Europe, Japan and the US.

[16] P. Adler and K. Ferdows, "The Chief Technology Officer", California Management Review, 32(3) (1990), 55.

project selection and prioritization, internal technology resource allocation and selection of outside technology investments—would likely have an influence on the responsibilities of scope of authority of the CTO.[17]

§4   --CTO roles and activities

The activities and responsibilities of the CTO will vary depending on the size and business focus of the company and the skills, experience and job descriptions of the other members of the senior management group. That said, however, a strong CTO will generally be actively involved in the development and implementation of a technology strategy for the company; planning and coordinating R&D activities to support the company's technology strategy; coordinating the technology strategies and activities of divisions and business units; acting as the functional manager of the activities of the technology managers for each of the company's divisions and business units; overseeing technology sales, purchase and licensing activities; providing information and advice to the senior management group and other company managers regarding technology-related issues; supporting new technology-based business initiatives launched by the company; conducting technology audits and benchmarking the company's technology portfolio in relation to competitors; establishing and maintaining processes for technology forecasting and defining the strategic technology requirements of the company; and establishing procedures and practices for keeping informed of new developments and acquiring and protecting those technologies that are crucial to the business strategies of the company.

With regard to responsibilities of the CTO, the results from the survey conducted by Tietze et al. indicated that observation of the technical surroundings to search for important innovative technologies for the company was the most important. The importance of other responsibilities fell into the following order: observation of development activities and technology portfolios of competitors; consulting the CEO and other members of the executive board in strategic topics; strategic, cross-sectional management of the technology portfolio (including technology acquisition, technology utilization and development co-operations); coordination of R&D projects; building and maintaining networks to experts, universities and other CTOs; coordination and realization of due diligence during acquisitions; communicational and representational tasks (e.g., presentation of new products in the media; and development of the firm's IT infrastructure. The average score for the last three items was below the median of 3.0 on the 1.0-to-5.0 scale used in the survey.

With regard to the responsibilities of CTOs mentioned in published job advertisements the most emphasis was placed on observation/interpretation/analysis of new applications and products and strategic planning. Less commonly mentioned, yet still important, were strategic planning; development of strategic relationships; ensuring IT security/licensing/upgrading/integrity; communications with providers, distributors and customers; development, evaluation, coordination of IT technologies; and providing leadership in tech-related infrastructure. A relatively small number of advertisements

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[17] See E. Roberts, "Benchmarking Global Strategic Management of Technology", Research Technology Management, 44(2) (2001), 25.

also mentioned establishing technical standards, representing the company in the business and managing disaster plans.

Another list of the multiple roles associated with the CTO position focused on specific responsibilities to collaborate with other members of the executive team and provide support to each of the key functional areas including production, sales and marketing[18]:

- *Technical Vision:* The CTO must work with the CEO and other executives to develop a technical strategy for the company which is aligned with the company's overall business objectives. In this role, the CTO must demonstrate both technical and business skills and must be comfortable with identifying and analyzing various options, assessing risks and defining goals.
- *Production:* The CTO should be proactively involved in maximizing the efficiency of production efforts by working with the leaders of the engineering and production groups to aid recruitment and retention efforts and streamline production operations. The CTO should be able to identify and champion innovative ideas and provide suggestions on coordinating the various teams and operations involved in the production process.
- *Business Development:* The CTO is responsible for identifying new technological developments that can improve the company's efficiency and customer satisfaction. In this role, the CTO works with business partners on acquisition of new technologies and with customers to understand their requirements with respect to the technical aspects of the company's products and services. Information gathered from these communications and relationships can be shared with other executives to provide a clearer picture of competitive trends for everyone in the C-suite.
- *End-User Responsibility:* The information that the CTO collects while meeting with customers should be shared with the sales organization so that it has a better idea of the issues that customers are looking to solve and the ways in which the company's technology can provide appropriate solutions. Customer interaction is also a good way for the CTO to explain the company's technology to customers and otherwise assist in meeting the needs of end users.
- *Marketing:* The CTO can play a valuable role from a marketing perspective by acting as the public face for the company's technology vision and participating in various media activities including speaking engagements, conferences, interviews, articles and social media presence. The CTO should also engage with the marketing team to develop messages and create and implement strategies for engaging with customers and the general community.

§5   --CTO skills and competencies

As for the skills that were required of potential CTOs, the job advertisements reviewed by Tietze et al. revealed that the most important were broad-based technical background and knowledge in the business area, strong verbal/written communication skills and

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[18] 5 Chief Technology Officer Responsibilities (March 6, 2015), http://yscouts.com/executive/5-chief-technology-officer-responsibilities/ [accessed September 12, 2016]

team/people leadership skills. Other skills mentioned less frequently included language skills, project management skills, ability to be the top technical role for engineers, visionary skills and problem-solving/analytical skills. As for qualifications, almost all of the advertisements limited consideration to candidates with specific long-time experience in the business area. Other important qualifications, in descending order of importance, included experience as a CTO or senior project manager, long-term experience in team management, experience in negotiations with suppliers and other third parties, a record of achievement and international experience.

§6   --Berray's study of the role of the CTO

Berray observed that the CTO role, while arguably the least important of the C-suite positions at the time that it was first recognized, was destined to become more important as companies realized the importance of technology to their competitive strategies and that the CTO operated at the elusive nexus of technology and leadership.[19] Berray and a colleague conducted an extensive study over a three year period at the end of the 1990s and early 2000s that involved discussions with hundreds of CTOs and CIOs and a written survey of approximately 30 CTOs. The results of this survey allowed him to propose answers to two fundamental questions: What were the then-current models in companies for the role of the CTO and which model would be most appropriate for particular companies based on its specific business activities, requirements and processes?

§7   ----The four CTO role models

Berray found that there were many variations on the specific roles of the CTO across the industries and companies that he surveyed and that it was not possible to develop a profile of a "typical" CTO and his or her responsibilities. He noted that this finding did not mean that the CTO lacked power or influence in relation to other members of the executive team (i.e., the CEO, COO and CFO), but rather that it highlighted the challenges that companies are having in incorporating technology into their competitive strategies and determining the best way to relate technology to optimal decision-making at the top of the organizational structure. He argued that the information collected during his survey pointed to the existence of four general CTO models: the "infrastructure manager", the "big thinker", the "technology visionary and operations manager" and the "external facing technologist".

The 'infrastructure manager': Responding to the what Berray referred to as the "escalating complexity of information technology ("IT")"[20], many of the companies opted for an "infrastructure manager" role for the CTO in which the CTO took on the "line" responsibilities formerly associated with the CIO and oversaw the infrastructure and operations of IT: data center operations, network operations, applications development & maintenance, security, and other line functions. The primary job of the CTO for these companies was to keep the IT organizational operating efficiently. At the

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[19] The discussion in these sections is adapted from T. Berray, The Role of the CTO: Four Models for Success (April 2002).
[20] Id. at 2.

same time, the CIO continued to perform the "staff" role with respect to IT, which included overseeing technology strategy, executive-level relationships, budgeting, and the fusion of IT and business processes. While operational efficiency of the IT organization was important to the CIO, his or her key mandate was to continuously work to improve the effectiveness of the IT organization and determine how technology would be used to support the company and its pursuit and achievement of its overall strategic goals.

Not surprisingly, the "infrastructure manager" CTO typically reported directly to the CIO, who was a member of the executive team who reported directly to the CEO or the president of the company. While the role often came with an "officer" title, he or she was generally not considered to be an officer of the company or a member of the executive team. To be effective as an "infrastructure manager", the CTO needed to have good operational skills, a keen sense of managing technology and the ability to lead a large and diverse organization. Noting that this model separated the "executive" and "enabler" functions relative to technology, Berray cautioned about the repercussions for organizational behavior, design and integration for the company and seemed to question whether or not using the model adversely impact the company's ability to perform at a maximal level.

The 'big thinker": The "big thinker" CTO plays a more strategic and visionary role and focuses on how technology can be used internally by the company to enable new business models and business lines, increase revenues and preempt attempts by competitors to use technology to disrupt or dislodge the company's market position. Consistent with the strategic emphasis, the CTO is actively engaged with identifying and understanding advanced technology, competitive analysis, technology assessment, lab prototyping, partnering relationships, planning and developing architecture standards. A "big thinker" often works with a small, elite staff and reports directly to either the CIO or the CEO; however, he or she generally does not have direct control in the same way as a line manager and his or her effectiveness depends in large part on the ability to influence the decisions of others. Given this, a "big thinker" role works best for someone who has been with the company for a long period of time and who has developed a strong and trusted relationship with the CEO, CIO and other members of the executive team. In limited cases, a "big thinker" is brought in from outside the organization, but this only works if he or she brings along a tremendous public reputation. The main advantage of this model is having someone who can think independently and concentrate on long-term innovation; however, without direct input into decision making a "big thinker" must be able to influence senior executives to consider new information or different paths to accomplish key goals and must be patient about progress as it will typically take a long time for his or her ideas to catch on.

The 'technology visionary and operations manager": The "technology visionary and operations manager" CTO was common among the "dot.com" and other technology-oriented companies included in the survey and combined determination of how technology can be used to implement business strategy with actual responsibility for integrating and running the technology. Berray noted that this type of CTO needed to

have a strong combination of business and technical skills and must be recognized as a member of the senior executive team. A "technology visionary and operations manager" CTO was often a co-founder of a technology-oriented startup or brought into the business very early in the development of the company when it was crucial to get the business up and running and establish a core competence with respect to technology. At the start up stage, this type of CTO reports directly to the CEO and may even partner with the CEO as a co-chairman of the organization. The CTO must be prepared for expansion of the company and must be able to manage larger organizations while still being able to devote time to designing, building and running the technology. Over time, a CIO may be brought in to report to the CTO and take on some of the day-to-day duties and responsibilities of the "infrastructure manager" side of the CTO position.

Berray observed that it takes a special person—someone with both strong technology vision and the practical ability and experience to design, build, and run the technology while managing an increasingly larger organization—to pull off the "technology visionary and operations manager" role. While many CTO candidates demonstrate a capacity for vision and technology innovation, the reality is that the organization cannot change as fast as the CTO would like and it takes time for companies to put the IT management and infrastructure in place that is needed in order to implement new ideas and technologies. A consultant interviewed by Berray cautioned that visionary technologies must also have the skill to be successful managers, which meant that they must be able to understand how technological instruments functioned in complex contexts that included relationships among other assets (i.e., human, social, knowledge, and financial capital, communications, marketing, branding, customer relations, etc.).[21]

The 'external-facing technologist": According to Berray, an "external facing technologist" CTO "focuses his/her efforts on using technology to provide better products and services to external customers or clients" and his or her "main role is to develop the strategic technology plan for the organization by identifying, tracking, and experimenting with new and potentially disruptive technologies ... [and] … project and assess [their] impact on the corporation and its customers".[22] Berray noted that this type of CTO role is commonplace in IT consulting companies and in those companies the CTO is typically at least an equal peer of the CIO, whose role is focused on identifying and implementing the technologies that companies need to support their internal systems and management operations. The "external-facing technologist" is generally supported by a separate group that allows him or her to engage in a range of activities including technology research and development, technology transfer and change management, intellectual property, knowledge management and/or best practice management, and advanced specialized technology centers. In addition to his or her strategic role, this type of CTO is also expected to share best practices for exploiting key technologies across the company's front line to its customers.

The "external-facing technologist" CTO typically reports directly to the CEO, President or COO and is appointed to the position based on his or her reputation among the other

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[21] Id. at 3.
[22] Id. at 4-5.

executives or the public as being someone with both a broad knowledge of the potential value in emerging technologies and a keen understanding of how these technologies can affect the company's business and business processes. The impact of the "external-facing technologist" CTO will depend largely on his or her influence as a key advisor to the members of the executive team and, as such, he or she must have strong communication and interpersonal skills in order to be an effective influencer. While this type of CTO is often directly involved in decision making, it is also not uncommon for him or her to serve mainly in a broad, advisory function that includes helping senior executives to evaluate different paths to achieving the company's business goals. The "external-facing technologist" CTO may be tapped to act as an external spokesman for the company.

§8   ----Matching the role of the CTO to organizational needs

Having made his arguments about categorizing CTO into one of the four models described above, Berray turned to the more practical question of how companies can align the role, characteristics and strengths of their CTO to their specific organizational needs. The first approach that he suggested involved mapping the different CTO models against two forces that play an important part in driving organizational needs: the amount of business change affecting the company from either internal or external pressures and the percentage that "information", as opposed to physical assets, represents in the company's portfolio of products and services. The second approach was based on identifying the company's most important business requirements and processes and then comparing the relative capabilities of each CTO model with respect to each of the key requirements and processes.

Using the two driving forces mentioned above, Berray identified four different prototypes of organizations: (1) low pressure for business change and low dependence on information as an element of the product/service portfolio; (2) high pressure for business change but low dependence on information as an element of the product/service portfolio; (3) low pressure for business change but high dependence on information as an element of the product/service portfolio; and (4) both high pressure for business change and high dependence on information as an element of the product/service portfolio. He then argued that the best model for these situations was as follows: (1) the "big thinker"; (2) the "infrastructure manager"; (3) the "external-facing" technologist"; and (4) "the visionary and operations manager". The following paragraphs discuss the reasoning behind his recommendations.[23]

The first prototype organization—low business change pressures and low dependence on information as an element of its products and services—is likely operating in a relatively stable industry where change occurs slowly and typically takes the form of mergers and acquisitions that expand current business capabilities as opposed to bringing in new products, services or technologies. For these companies, information is not a critical element of the products and services that they offer; however, information is important for building and supporting those products and services. Berray argued that companies

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[23] Id. at 6-8.

operating in the food services, chemical and raw materials industries fell into this organizational prototype. A "big thinker" CTO made sense for these companies since he or she could provide valuable support in evaluating how information and technology could be used internally to enable new business models and business lines, increase revenues and preempt a competitor's attempts to use information or technology to disrupt of dislodge the company's market position.

The second prototype organization—low dependence on information as an element of its products and services but high business change pressures—is often extensively engaged in mergers and acquisitions activities and in searching for new products and services that can help maintain competitive advantage. Even though information is a relatively small element of the products and services of these companies, it is still important for them to have an effective IT organization that is capable of leveraging the existing structure across existing and new business units. The "infrastructure manager" CTO is the most appropriate model for this situation and he or she can take "line" responsibility for managing and enhancing IT infrastructure and operations and ensuring that the company's IT systems support better communications and collaborations across an organizational structure that is continuously growing geographically and in terms of the number of business units.

Examples of the third prototype organization—high dependence on information as an element of its products and services but low business change pressures—include established research, information technology consulting, software and hardware companies. For these types of companies, the best choice among the CTO models is the "external-facing technologist" focused on how the company can use technology to provide better products and services to its external customers and clients. The CTO can and should also provide value by acting as a reputable and experienced spokesperson for the company in communications with customers, clients, industry organizations and the general media.

The fourth prototype organization—both high dependence on information as an element of its products and services and high business change pressures—presents a challenging and dynamic situation for the CTO role that calls out for someone able to serve as both "visionary and operations manager". The CTO will be continuously involved in supporting the information and technology elements of a rapidly growing portfolio of products and services beginning with the design phase and moving forward through implementation (i.e., making the technology work in terms of reliability and availability and planning for seamless scalability of the technology). The "visionary and operations manager" CTO of this type of organization will also be actively involved in identifying and entering new markets and forging strategic technology-based alliances.

In addition to, or in tandem with, matching the CTO model to the company's external environment as defined by the two "driving forces" discussed above, companies should make sure that the capabilities and responsibilities of the CTO are aligned with their key

business requirements and processes. Berray proposed the following list of ten key business requirements and processes[24]:

- Identifying new technologies
- Exploiting new technologies
- Integrating new technologies
- Leveraging technology across business units
- Driving the business strategy
- Driving revenues
- Reducing costs
- Enhancing client relationships
- Enhancing communications and collaboration
- Building out or leveraging existing IT infrastructure

He then ranked the relative capabilities of all of the CTO models for each of the business requirements and processes using a continuum of "high", "medium" and "low". For example, when it came to integrating new technologies, the "visionary and operations manager" CTO was the only model ranked "high" while the "infrastructure manager" and "external facing technologist" CTO models ranked "medium" and the "big thinker" CTO model ranked "low". All this would indicate that companies placing a high strategic priority on integrating new technologies should strongly consider recruiting someone who can fulfill the responsibilities and provide the skills associated with the "visionary and operations manager" CTO model.

The rankings could be used to develop ideas on what types of strategic and operational situations, in terms of current or desired business requirements and processes, might be best suited for each of the four CTO models. For example, the "infrastructure manager" CTO model would presumably be a good fit when the key business requirements and processes for the company aligned with those that the capabilities of this model were scored as "high": leveraging technology across business units, reducing costs and building out or leveraging existing IT infrastructure. In the same way, the strengths of the three other CTO models were as follows: "big thinker": identifying new technologies and driving the business strategy; "visionary and operations manager": exploiting new technologies, integrating new technologies, leveraging technology across business units, driving the business strategy and building out or leveraging existing IT infrastructure; and "external-facing technologist": identifying new technologies, exploiting new technologies, driving the business strategy, enhancing client relationships and enhancing communications and collaboration.

In general, "visionary and operations manager" and "external-facing technologist" CTO models were stronger (i.e., ranked "high") in more areas, a sign that these models could provide companies with more flexibility in selecting and pursuing business requirements and processes and a deeper range of capabilities. In contrast, the "infrastructure manager" CTO model, while well suited for building and leveraging existing IT

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[24] Id. at 8.

infrastructure and technology across business units and reducing costs, was not a good choice when a company was looking to identify and exploit new technologies to drive its business strategy and increase revenues. Companies looking to use the rankings for help in designing their CTO positions and identifying appropriate candidates could select the business requirements and processes that were most important for execution of their strategies and then see which of the CTO models had the most relevant capabilities. For example, when a company is looking to drive its business strategy through identification, exploitation and integration of new technologies, the "visionary and operations manager" and "external-facing technologist" CTOs are probably the best fits and the "infrastructure manager" CTO would be the weakest choice, although someone with the skills of that model might be brought in to report to the CTO and oversee the build out and leveraging of the new technology that will be required in the future.

§9   ----Thinking strategically about technology leadership

Berray emphasized that the goal of the entire process is to think strategically about technology leadership and create a CTO position that will best enhance the company's specific business opportunities, maximize its resources, strengthen its brand and leverage internal and external relationships.[25] Key steps that need to be taken include understanding the entire array of internal- and external-focused roles and functions that can be provided by a person in the CTO position, identifying and assessing the IT functions that the company currently has in place and identifying the additional IT functions that the company will need in order to cope with driving forces in its business environment and manage the anticipated key business requirements and processes. Berray's contribution was to identify several different perspectives that companies can use to determine the role and position of their CTO in the organizational structure and the issues and activities on which the CTO should be expected to concentrate his or her efforts.

§10   --Smith's "patterns of the CTO"

Smith argued that it was possible to identify and describe five distinct "patterns" of a CTO based on the skills and responsibilities assumed by the person holding that office and the manner in which the person addresses the unique issues confronting a CTO.[26] Smith believed that the patterns facilitated greater understanding of the diversity within the position and could be used as a means for selecting a CTO who was the best match for the particular business situation and issues confronting a specific firm. He noted that the CTO position was relatively new and many of the tasks now being assigned to the CTO had traditionally been performed by others in the organization including persons who took on activities such as technology forecasting in a somewhat informal fashion outside of their regular job descriptions. Smith pointed out that the CTO position can be found in a wide range of industries and that given the diversity of business models among those industries it is unlikely that a universal definition of what a CTO does can be

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[25] Id. at 9.

[26] The discussion in the following paragraphs is adapted from R. Smith, "5 Patterns of the Chief Technology Officer", Research Technology Management (2006).

established. Nonetheless, Smith was surprised at what he perceived to be the dearth of research on the CTO position and set about the task of studying the backgrounds, responsibilities and missions of a number of persons acting as CTO. The result was the following patterns, each of which were driven in large part by the evolutionary stage of the business conducted by the firm and the technological and competitive environment of the industries and markets in which the firm is operating:

- *Genius:* The Genius CTO is the seemingly larger-than-life legend who conceives and champions an idea that fuels a technological revolution. Persons in this category are few and far between and would include Thomas Edison, Steve Wozniak of Apple and Sergey Brin of Google. While the Genius CTO is usually skilled at creating something new, possessing vision and confidence and exploiting a unique opportunity, all invaluable traits for an emerging company, he or she often encounters difficulties in managing teams, creating and administering organization-wide processes and working with other executives on long-term business and technology strategy. The Genius CTO is invaluable at crucial, generally early stages, of the firm's evolution; however, this pattern may not be appropriate once the firm has moved beyond the initial technological breakthrough to tackling the problems associated with building and maintaining a larger and more formal set of practices and procedures.

- *Administrator:* The Administrator CTO is someone with a keen understanding of both technology and the financial impact of technological issues that the firm must resolve as it grows. Smith noted that the CTO is not only involved in identifying and developing new technologies he or she must also assume responsibility for defending the budgets established by the firm for technology products, services and project labor. The Administrator CTO is someone who understands the technical needs of the firm's research team and is able to negotiate with outside vendors and service providers to ensure that the firm has access to the resources that it needs on terms that are fair and reasonable from a financial perspective.

- *Director:* The Director CTO, often referred to as the Director of Research and Development, is typically a scientist or researcher with a strong individual understanding of the relevant technology who also demonstrates a talent for organization and leading exceptional people and is willing to reduce the time that he or she spends on direct, hands-on research in order to oversee the activities of the entire R&D team. The role of the Director CTO certainly includes budgetary oversight in the same way as the Administrator CTO; however, the Director CTO demonstrates a specific understanding of the need to be well versed in the technical aspects of the firm's products and processes and ensure that the firm's R&D activities are aligned with the firm's overall strategies and focused on generating results that lead to profitable products for the firm. This last point is particularly interesting and important: the Director CTO will almost certainly have the technical skills to understand, and be curious about, a wide range of ideas and potential projects but must be able to pass on those projects that may be challenging and exciting yet hold

little hope for resulting in products that will be profitable and contribute to the execution of the firm's then-current business strategies.[27]

- *Executive:* The Executive CTO pattern is seen most often among larger firms and features integration of the CTO position into the senior executive team with particular responsibility for guiding strategic decisions involving technology and managing the firm's overall innovation process. Smith succinctly described the Executive CTO as "a businessperson who measures innovation, research, and experimentation by the contribution it makes the company's revenues and future competitive advantage". The Executive CTO may have a scientific or research background; however, he or she has clearly made a shift into a number of different areas of strategic important including responsibility for the firm's research projects, technology forecasting and collecting and disseminating knowledge that can be used for improving research activities.

- *Advocate:* The Advocate CTO pattern finds the CTO focusing on the experience that customers have when using the firm's product and services and how the firm interfaces with its customers. Smith noted that the Advocate CTO is most commonly found in retail and service firms and typical areas of interest would be identifying and implementing technology-based solutions for improving customer service (e.g., improving the firm's e-commerce tools to facilitate easier online ordering by customers). The Advocate CTO is focused on selecting and combining the best products and solutions for meeting customer needs and generally assigns implementation of new technologies and upgrades to information technology systems to other specialists within the firm, many of whom are often directly accountable to a Chief Information Officer with whom the Advocate CTO works closely.[28]

Smith also noted that many firms make a conscious decision not to create a CTO position, a situation that Smith referred to as "void". Smith observed that this appears to be a common approach for businesses that are generally stable and believe that technology plays a relatively minor role in their operations and/or that new technology will only become important once a stable solution has been defined by the entire industry. However, he argued that even "non-technical" businesses can benefit from designating someone who can act in one or more of the ways described above such as vetting, recommending and overseeing implementation of new computing systems to track inventory, thereby reducing costs, or collecting and analyze data about customers, thereby creating opportunities to improve customer service increase customer satisfaction. Relatively stable businesses, such as grocery stores, must now understand

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[27] While the Director CTO spends a good deal of time evaluating project ideas and, as such, accumulates a good deal of knowledge about how a particular project is intended to evolve to the point where it can generate a profitable product or process the Director CTO relies on R&D managers, often directed by a Director of R&D who reports to the CTO, for execution and sponsorship of important R&D projects.

[28] Smith noted that firms needing the skills and interests of someone suited to the Advocate CTO pattern may assign the responsibilities of the CTO to a Chief Information Officer ("CIO") given that many of the initiatives are grounded in improvements to information technology systems; however, it should be noted that the traditional role of the CIO is focused on the internal needs of the firm and that a CTO (or a CIO taking a broader view that incorporates customer requirements and interfaces) is still needed in order to ensure that the firm uses technology effectively with respect to its products, services and customer relationships.

new technologies such as the ability to deliver advertisements and coupons to their customers through their smart phones while they are onsite.

§11 Organizational assumptions about the role of the CIO and the IT function

Noting that even though IT had become increasingly important for all businesses the CIO position was still not widely accepted as member of the executive team, Kaarst-Brown undertook a study of organizational assumptions regarding the CIO that might have an impact on the internal status of IT executives and their IT function.[29] Her research led to identification of five categories of "underlying assumptions"[30]:

- *Control Assumptions:* Who controls IT direction? Assumptions about which organizational level or functional group should control decisions about IT direction.
- *Centrality Assumptions:* How central is IT to business strategy? Assumptions about the significance of IT to business strategy.
- *IT Skills Value Assumptions:* What is the value of IT skills and knowledge? Assumptions about the value or lack of value placed on IT skills and knowledge among different groups or levels.
- *Justification Assumptions:* What justifies further IT investment? Assumptions about the purposes for which IT should be used that justify further IT investment.
- *Beneficiaries of IT Assumptions:* Who benefits or loses when IT is used? Assumptions about who wins or loses as a result of IT development or adoption, with potential winners and losers broadly defined to cover the full range of stakeholder groups from employees to customers.

In order to have a better understanding of each of the assumptions it is instructive to note the spectrum of possible assumptions within each category[31]:

- *Who should control IT direction?:* IT professionals (IT) should control IT direction; corporate business executives should control IT direction; business units should each control their own IT direction; control should be shared between IT and users groups; and "let's not control it, let's avoid it because IT is out of control".
- *How central is IT to business strategy?:* Embraced as imperative to corporate success: significance depends on whether a business leader is sponsoring the IT project; high level of centrality to operational and tactical goals at the business unit level; selective centrality, depending on nature of strategic business problems; and not significant at all unless required by external forces (industry standard; survival issue).
- *What is the value of IT skills and knowledge?:* IT skills are highly valued and rewarded and may give one status regardless of position or gender; IT skills are not as important as insurance skills, but people with IT skills can be useful if directed by business leaders; IT skills and knowledge are necessary for certain business unit managers and staff; IT professionals or skill holders are valuable when partnered with

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[29] M. Kaarst-Brown, "Understanding an Organization's View of the CIO: The Role of Assumptions about IT", MIS Quarterly Executive, 4(2) (June 2005), 287.
[30] Id. at 290.
[31] Id. at 290-292.

holders of business skills but neutral on their own; and IT skills are not valued and may be threatening.

- *What justifies further IT investment?:* Experimentation and research and development in IT provide opportunities for finding new or improved services ("innovation"); justified when IT will help reduce staff or operating costs ("same output with less staff"); justified when IT can support unit-level strategy or improve personal and unit productivity (i.e., more output of better quality with same people); justification varies depending on business problem or strategy and IT opportunity (cost, quantity, quality, variety, or innovation); and investment in new IT is justified when there are competitive or survival pressures (i.e., when there is no choice but to invest in IT to survive or stay current with industry standards).
- *Who wins and who loses with IT adoption?:* Everyone wins–IT, the IT professionals, the organization, shareholders, and customers; the organization and shareholders win; IT and other staff may lose: specific business units may win; no one loses, except maybe IT); the organization, shareholders, and customers win, but selective losses may be unavoidable; and no one wins; or non-technology staff lose.

Kaarst-Brown then studied various organizations to identify the dominant assumptions of departments and groups for each category and found that they could be clustered into discernable patterns of behavior toward IT, the senior IT executive and the IT function as a whole. The five distinct clusters of assumptions that were identified, and there attitudes regarding each of the five assumptions described above, were as follows[32]:

"A Necessary Evil"

- Control: Let's not control it, let's avoid it because IT is out of control
- Centrality: Not assumed to be central to business strategy
- IT Skills Value: Not valued; potentially a threat
- Justification: No choice but to adopt IT solution as a survival measure
- Beneficiaries: Non-IT staff will lose; no one wins

"IT is Support, Not a Partner"

- Control: Corporate business executives should control IT direction
- Centrality: Must have senior business champion or sponsor
- IT Skills Value: Business knowledge superior; IT second class but used when needed
- Justification: To reduce costs and/or staff (or at executive decree of benefits)
- Beneficiaries: Staff may lose; organization wins; IT staff may suffer demands

"IT Rules!"

- Control: IT professionals should control IT direction
- Centrality: Crucial at corporate (strategic) level
- IT Skills Value: IT skills highly valued and rewarded

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[32] Id. at 293.

- Justification: R&D; innovation; to improve or create new services
- Beneficiaries: IT staff win; organization and clients win

"Business Can Do IT Better"

- Control: Each business unit should control its own IT direction
- Centrality: Important at operational or tactical levels
- IT Skills Value: IT knowledge and/or skills REQUIRED at mid-managerial and staff business levels
- Justification: Improved services; personal productivity and unit level services
- Beneficiaries: Business units win so organization wins; IT may lose if shut out of projects

"Equal Partners"

- Control: Control should be shared by IT professionals and business units
- Centrality: Balanced importance depending on issues
- IT Skills Value: IT skills valued as partnered with business skills
- Justification: Customer oriented; problem-specific
- Beneficiaries: Selective losses; organization and customers win

Kaarst-Brown noted that there were functional and dysfunctional impacts to each of the clusters and argued that by understanding the dominant assumptions of each of the important groups within his or her organization a CIO could anticipate potential relationship issues and proactively address them in order to be more effective and elevate the status of the CIO position and the IT function. Specific recommendations for CIOs operating in each of the clusters included the following[33]:

"A Necessary Evil"

- CIO may have to budget scarce resources (time and money) for education and training of key business management or users before moving forward on plans.
- CIO will need to provide lots of reassurance, including business plans that include risk assessments and contingency plans.
- CIO should encourage participation throughout various stages of R&D, pilot tests, systems development, and testing of products before deployment.
- Third-party endorsements from respected business leaders may be helpful. Internal success stories are also helpful, but not from those branded as "techies."

"IT Is Support, Not a Partner"

- Make sure the CIO office is on the same floor as the other business executives.
- Be where you can participate in discussions.

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[33] Id. at 298-300.

- Recruit business-savvy IT staff or educate IT staff on business issues. Get them out in the business interacting with business staff.
- Educate the executive group on existing and emerging technologies, but be realistic about criteria for fit, risks and rewards.
- Market internally by promoting project successes and IT's contributions to the business.
- Cultivate a senior business-unit mentor who can speak for IT when the CIO is not invited.
- Require business plan justification that links IT and business, with a clear focus on how IT supports business goals.

"IT Rules!"

- CIO must keep the focus on cost/benefit and IT business value.
- With power and status comes responsibility, creating a high pressure position. Management of expectations is critical.
- Communicate, communicate, communicate.
- Keep the IT function's focus on business processes and adding business value, not just on the joys of the technology.
- Since the buck stops in IT, the CIO needs to gain educated business supporters and business sponsorship for projects so that the business executives and other management are equally committed and accountable.

"Business Can Do IT Better"

- CIO must work with various business units to educate and negotiate support for standards and internal controls.
- CIO should support training of business personnel on IT and IT development methodologies.
- Communicate and internally promote joint successes of IT projects.
- CIO and IT function should negotiate to play support roles in business-driven projects.
- Manage data as an organizational, not just a departmental, resource

"Partners All the Way"

- While seeming the ideal, having an equal role at the table puts the CIO on the same level as other executives, so good relations continue to be important.
- The CIO will want to allocate resources to keep the business folks up-to-date on IT and also to make sure IT staff are current on key business issues.
- There may be opportunities IT staff to move laterally into the business and create cross-functional teams.

Kaarst-Brown pointed out that it more likely than not that the CIO will be called upon to manage multiple clusters within his or her organization. In other words, one group may

see the CIO and the IT function as a valuable partner while another group thinks of IT as little more than a "necessary evil".[34]   In that situation, the CIO must be sensitive to the differences and potential reasons therefor.   In many cases, problems can be traced to strongly held views of a single decision maker within the group and the CIO will need to spend time understanding why these individuals feel the way they do and figuring out the best way to possibly change opinions.   In fact, Kaarst-Brown was optimistic that a CIO's ability to build and sustain strong relationships can have a positive influence on organizational culture and assumptions about the IT function.

§12   Effective CIO/CTO collaboration in the organizational hierarchy

As discussed above, the escalating duties of the CIO created pressures for incorporating a new CTO position that could assume some of the growing responsibilities of the CIO. Beatty et al. noted that the key question was just how to introduce the CTO position into the hierarchy described above in a way that benefitted the organization while avoiding unnecessary and inefficient disruption to established operating dynamics.   One conceptualization of the "typical" organizational hierarchy for management of the various IS functions in the 1990s was suggested by Parker and Cash and included the following positions, reporting relationships and levels[35]:

- The CIO was at the top of the hierarchy, responsible for all aspects of IS, and oversaw two main groups—telecommunications and data administration—each of which had a director on the second level of the hierarchy who reported directly to the CIO and who were formally expected to collaborate with one another.
- Another director, for data processing, was on the third level of the hierarchy and reported directly to the CIO.   The data processing director had three functional managers on the fourth level of the hierarchy reporting directly to him or her and overseeing systems development, programming and operations, respectively.
- Two other functional managers on the fourth level of the hierarchy also reported directly to the CIO and oversaw the information center and office automation, respectively.

While this structure had worked well for a number of years, it was becoming clear that it was simply unreasonable to expect that one person could effectively carry out both the traditional responsibilities of the CIO and deal with the rapidly escalating changes in technology and the organizational IS requirements.   Beatty et al. suggested that it would be useful to compare and contrast three possible approaches to a "CIO/CTO Organizational Hierarchy": placing the CTO in a direct line under the CIO; placing the CTO on a parallel footing with the CIO; and eliminating the traditional CIO position and allocating all of the executive leadership responsibilities of the IT function to the CTO.[36]

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[34] Id. at 300.

[35] C. Parker and T. Case, Case Management Information Systems: Strategy and Action (Watsonville CA: McGraw-Hill Publishing, 1993).

[36] R. Beatty, K. Arnett and C. Liu, "CIO/CTO Job Roles: An Emerging Organizational Model", Communications of the IIMA, 5(2) (2005), 1, 3.

Beatty et al. explained that the somewhat radical proposal to eliminate the traditional CIO position was based on the assumption that information was already being managed with different structures in all organizations, thereby reducing the need for any executive-level involvement in that area, and that the real issue that organizations needed to confront was managing "technology", a task that required a dedicated C-level technology executive.[37] Beatty et al. expressed concern that this move might be seen as little more than a change of title and that the CTO would need to work to re-establish the status and acceptance that had taken such a long time for the CIO position to achieve in the eyes of the other executives and the rank-and-file of the company.[38]

The CTO would serve as the single person responsible for all of the traditional technically-related responsibilities that were previously overseen by the CIO including the information center, office automation, operations, networking and telecommunications. The CTO would also be responsible for several of the newer technological functions such as technology assessment and workgroup environment. All of the senior managers of the functions mentioned above would report to the CTO. The CIO would retain responsibility over the remaining functions such as systems development, programming and data administration, and the senior managers of those functions would report to the CIO.[39]

It is conceivable, however, that the CIO and CTO would both have C-suite status and serve as members of the executive team of the company. Beatty et al. cautioned that this approach will likely be meant by opposition from other executives who will be worried about the disruption to the balance of interests at the top of the hierarchy. In addition, senior management coordination may become more unwieldy—the CEO's span of control would be broadened--and clear guidelines will need to be established with respect to who reports to whom. Beatty et al. concluded that the benefits of this approach would be outweighed by the challenges and recommended that just one of the C-level positions, the CIO in their view, be included on the executive team. As to concerns about having a C-level position that did not come with executive team status, Beatty et al. responded that this approach was consistent with the then-emerging popularity of similar positions in other areas such as chief privacy officers and chief security officers.[40]

Mullins and Klinowski saw the CTO position as being a natural progression given the evolution of the CIO's role away from hands-on technical involvement and explained that the CTO provided support to the CIO, serving as his or her "right hand", by assuming responsibility for designing and recommending the appropriate technology solutions to support the policies and directives issued by the CIO.[41] In this role, the CTO is the company's senior "technology specialist", a role that requires skills similar to those of the CIO but which is skewed more toward a strong technology background in fields such as

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[37] Id.

[38] Id. at, 4, 7.

[39] Id. at 4.

[40] Id. at 5, 8.

[41] S. Mullins and J. Klinowski, Defining the complimentary job roles of the CTO and CIO (April 18, 2003), http://www.techrepublic.com/article/defining-the-complementary-job-roles-of-the-cto-and-cio/ [accessed September 12, 2016]

IT, electrical engineering or computer science and less on business education. While other members of the executive team may balk at creating a second C-suite position focusing on some aspect of technology, Mullins and Klinowski argued that the CTO provides companies with invaluable executive-level subject matter expertise on the critical issues surrounding the technologies that the CIO must employ in order to achieve the company's strategic objectives.

Potential benefits from implementing a CIO/CTO structure included reduction in CIO turnover, concentration of CIO job responsibilities and continuity of strategy vision. At the same time, companies need to cope with several new challenges such as the creation of a new management level, the need to ensure that there is effective coordination between the two positions and potential reporting level confusion.[42] Assuming that the new organizational structure calls for placing the CTO in a direct line under the CIO, the final step is to determine and allocate the responsibilities of the CIO and CTO so that the organizational model can operate effectively and not be bogged down by conflict that delays decisions and confuses IS personnel and managers and employees in the functional departments. Suggestions from Beatty et al. followed the CIO responsibilities suggested by Sprague and McNurlin[43]:

- *Understand the Business:* Beatty et al. argued that it was the responsibility of the CIO to clearly understand the business objectives of the company and the markets in which the company sells its products and services so that CIO is able to discharge his or her responsibility for ensuring that IS projects and initiatives to the company. This understanding should be gained by attending industry meetings with line executives, becoming a partner with line management and holding informal informational listening sessions. Once the business objectives and strategies of the company have been approved by the executive team, with input from the CIO, the CIO must communicate those objectives and strategies to the CTO so that he or she can develop the appropriate supporting technological infrastructure.
- *Establish Credibility with the Systems Department:* Beatty et al. felt that it was the responsibility of the CIO to work with the various functional departments to establish standards and service levels for the key IS functions that ensure that they are perceived as successful and reliable by the functional departments. This process includes building confidence among the functional departments that IS development projects will be delivered on-time and within budget, IS will respond promptly to inquiries from functional departments and key information technologies (e.g., networks, operations, telecommunications) will be readily available to IS system users. Once these standards and services levels have been set, the CIO must communicate user expectations to the CTO for technical functions that are controlled by the CTO and it is the responsibility of the CTO to make sure that those standards and service levels are met and exceeded by those technical functions that he or she oversees.

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[42] R. Beatty, K. Arnett and C. Liu, "CIO/CTO Job Roles: An Emerging Organizational Model", Communications of the IIMA, 5(2) (2005), 1, 6-7.

[43] Id. at 5-6 (citing R. Sprague and B. McNurlin, Information Systems Management in Practice (Englewood Cliffs, NJ: Prentice Hall, 1993)).

- ***Increase the Technical Maturity of the Firm.*** Beatty et al. assigned the CTO with responsibility for both assessing and acquiring new technologies, and also ensuring the proper initiatives (e.g., Help Desk) are launched to support the successful integration of the technology into the company's business processes.
- ***Create a Vision of the Future and Sell It:*** Beatty et al. argued that it fell to the CIO to be the single person in the organization with responsibility for establishing the company's vision for the IS technology and selling that vision to the other members of the executive team. Input from the CTO in the form of technical guidance during the implementation of the projects that are part of the vision will be essential; however, the visionary role must remain with the CIO and he or she must ensure that the vision aligns tightly with the overall business goals of the company.
- ***Implement Information Systems Architecture:*** Beatty et al. recommended that the CIO and CTO share responsibilities with respect to the creation and maintenance of the company's IS architecture (e.g., hardware, software, networks, databases etc.) and ensuring that it supports established business practices and processes. The CTO should be responsible for the technical implications of the IS architecture; however, the CIO should be actively involved in assisting the CTO in resolving any organizational issues that may arise from integrating new technologies into the established organizational IS architecture.

§13   Optimal CIO reporting structure

Banker et al. conducted extensive research on the optimal CIO reporting structure, specifically the factors that should be taken into account in deciding whether the CIO should report to the CEO or the CFO.[44] Based on analysis of longitudinal data from two periods (1990-1993 and 2006) they found support for their hypothesis that a company's "IT orientation" determined its CIO reporting structure. Specifically, companies that used sales over assets as a success measure, an indication that they used IT primarily for strategic differentiation, and had superior results on that measure tended to have their CIO report directly to their CEO. On the other hand, companies that used average operating income over sales as a success measure, an indication that they leveraged IT for operational excellence, and had higher results on that measure generally had their CIO reporting to the CFO. Banker et al. also confirmed that companies that correctly aligned their IT orientation with their CIO reporting structured enjoyed superior performance over time. Specifically, companies with a strategic differentiation IT orientation (i.e., high sales over assets) that had their CIO report to the CEO had superior performance over time as compared to companies with the same IT orientation that used a CIO-CFO reporting structure, a result that was also achieved by companies that opted for an operational IT orientation (i.e., operating income over sales) and a CIO-CFO reporting structure as compared to companies with the same IT orientation that selected a CIO-CEO reporting structure. They argued that the results supported both Chandler's

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[44] See R. Banker, N. Hu, P. Pavlou, IT Orientation, CIO Reporting Structure, and Firm Performance: To Whom Should the CIO Report?, http://opim.wharton.upenn.edu/wise2004/sun112.pdf [accessed September 15, 2016] and R. Banker, N. Hu, J. Luftman and P. Paylou, CIO Reporting Structure, Strategic Positioning, and Firm Performance: To Whom Should the CIO Report? (February 23, 2010), http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1557874 [accessed September 15, 2016].

strategy-structure paradigm and Galbraith's strategy-structure alignment perspective it is not a question of which CIO reporting structure was superior but rather whether or not companies did the right job in aligning their structures with their strategic positioning.

§14   Chief innovation officers

In addition to the CIO and CTO positions, there has been increasing interest in the creation of a position of "chief innovation officer". The primary job a chief innovation officer had been described as leading their companies' efforts to find and develop ideas for new products and ensuring that other executive officers recognize and support initiatives to encourage innovation.[45] While a chief innovation officer often comes up with ideas, he or she is not expected to be the only one working on idea generation and, in fact, his or her focus should be on establishing processes that empower others, both inside and outside the company, to contribute. For example, the chief innovation officer should set up an internal website that can be used by employees to submit suggestions for improving existing products or developing new ones. Ideas from outside the company may come from customers, either directly or through product review sites, and relationships with universities and organizations that conduct research in areas of interest to the company.   The chief innovation officer might even set up an incubator for technology-focused startups that provides them with resources and other support to work on ideas that might eventually be picked up and used by the company.

Once the ideas have been identified, the chief innovation officer ensures that they are all evaluated and that the most promising ones are passed on for further development and testing and eventual release into the marketplace. The chief innovation officer should oversee the incubation of new ideas, making sure that a business case is developed when appropriate, driving collaboration among different business units when necessary, championing new products and services among other members of the executive team to be sure they receive adequate funding and other resources, and working with product and marketing managers to bring new products and services to market as quickly as possible in order to realize a return on the investment associated with the development efforts. Once new innovative products and services have been released, the chief innovation officer should monitor customer feedback and service requests.

Interest in, and calls for, creation of a chief innovation officer position has increased substantially in recent years. Di Fiore argued that large companies often lack a mission and framework with respect to their innovation activities.[46] In many cases, innovation efforts are distributed among several different groups, none of which are supporting what is actually needed at the business unit level. Even worse, these groups are competing internally for scarce resources and duplicating efforts. Another fact of life that often

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[45] The discussion in the first two paragraph of this section is adapted from I. Linton, Chief Innovation Officer Responsibilities,
http://work.chron.com/chief-innovation-officer-responsibilities-17017.html [accessed September 13, 2016]

[46] The discussion in this paragraph and below is adapted from A. Di Fiore, A Chief Innovation Officer's Actual Responsibilities, Harvard Business Review (November 26, 2014), https://hbr.org/2014/11/a-chief-innovation-officers-actual-responsibilities [accessed September 13, 2016]

hampers innovation is that most line managers are too focused on pursuing and achieving short-term goals, which means focusing on what they are doing or selling at the present moment, and have little time or incentive to take the longer-term approach that is typically needed in order to bring truly innovative ideas into practice. In the same vein, companies and managers may be reluctant to change what appears to be going right, an understandable reaction but also one that puts the company at risk for being suddenly overtaken by competitors that have been more proactive in anticipating the need for continuous change and innovation.

In order to address the problems discussed above, Di Fiore recommended that companies, particularly larger ones, needed to create the position of chief innovation officer on their executive team to focus on driving the changes that are often resisted at lower levels of the organizational hierarchy, organizing the company's innovation activities and designing what Di Fiore referred to as "a more innovation-friendly organizational environment". Based on work he had participated in at the European Center for Strategic Innovation, Di Fiore proposed the following seven key roles in the mission of the chief innovation officer:

- *Supporting best practices*. The chief innovation officer, sitting at the top of the organizational hierarchy, is well position to identify, establish and support best practices with respect to innovation including scanning for and standardizing market research methods for novel ideas and insights; strategic innovation; promoting open innovation; and introducing group tools and processes that encourage creative thinking.
- *Developing skills*. Working with the human resources department and the leaders of other business groups, the chief innovation officer should take the lead in designing training that provides managers and employees with the skills they need to support innovation and should also develop and apply measures to track improvements in innovation and the skills underpinning them.
- *Supporting business units in new product and service initiatives*. The chief innovation officer should be proactively involved in the activities of the company's innovation teams, pushing them to expand their aspirations and providing them with facilities and other resources as well as guidance on the methods they should be using to achieve success. As the number of innovation projects increases, the chief innovation officer should train other managers to perform similar roles so that all innovation teams receive the required support.
- *Identifying new market spaces*. A chief innovation officer serves a valuable role in identifying new market spaces for the company and its business units and should proactively analyze trends and market disruptions to uncover emerging new market opportunities and bring them to the attention of the CEO and other members of the executive team. Di Fiore noted that in some cases a good opportunity may not fit into the current plans and resources of any of the business units and will need to be developed, at least at the outset, at the corporate level.
- *Helping people generate ideas*. In addition to his or her own efforts to identify new opportunities, the chief innovation officer should encourage and help others throughout the organization to generate ideas by setting up and running ideas

generation platforms and formats such as jam sessions, hackathons, and internal or external crowdsourcing for the benefit of the company.

- *Directing seed funding*. The chief innovation officer should have oversight responsibility for a yearly budget that can be used to fund and pursue "homeless ideas" that are either perceived as being too risky for the business units, or outside of their existing business boundaries. Rather than have good ideas go to waste for lack of funding, they can be incubated and under the eyes of the chief innovation officer until the time is right to hand them off to one of the business units (or a new business unit is created to pursue the idea more aggressively). Funding should be supplemented by other support including facilities and equipment.
- *Designing shelter for promising projects*. Recognizing that it can take a long time for a new idea to come to fruition, the chief innovation officer can play a valuable role in making sure that pursuit of new ideas stays on track from the seed stage and is not derailed by managers who are invested in the status quo. Di Fiore suggested that the chief innovation officer design and oversee resource allocation processes (i.e., portfolio, stage-gate, capex, budgeting etc.).

Research conducted at the Center indicated that the chief innovation officer was generally involved to some extent in each of the roles and functions describe above; however, companies can and should customize the portfolio of the chief innovation officer to suit their current needs and strengths and weaknesses in the innovation pipeline elsewhere in the organization. For example, some companies do not need much help with generating new ideas because processes and incentives are already in place in each of the business units and they have a well-funded and innovation focused R&D function at the corporate level. Areas in which the chief innovation office can generally make an important and immediate contribution include training and providing support and monitoring for innovation projects that are already under way in the business units.

§15   Management of technology activities in technology-based startups

In their earliest stages of development companies generally adopt traditional organizational structures that follow a functional approach based on creation of separate groups or units to manage and perform key business activities. With respect to technology-based activities this means that various aspects of technology development and exploitation would be distributed among separate functional departments focusing primarily on R&D, product development and engineering. In addition, companies will form dedicated groups for other activities in the product value chain, including manufacturing, marketing and technical service and support and all of these functions would interact with so-called "corporate" functional activities such as finance, human resources and legal and regulatory affairs. While each functional group or unit would have a designated lead manager, such as an R&D director or chief engineer, the traditional structure vests senior management responsibility for a number of key technology-based activities in a single office. This person, sometimes referred to as a "technical director" or a VP Development, is responsible for management and oversight of all activities relating to R&D, product development and engineering. In some cases, depending on the size and type of operations of the company, this position might also be

involved in procurement, particularly if technology is a significant factor in purchasing decisions; standards compliance and quality assurance programs.

Combining all of the aforementioned activities under the control of a single manager is an attractive, and often necessary, choice for small companies in their early stages of development. In that situation, the firm lacks the financial resources to recruit and support a large layer of managers for each listed activity. Moreover, assuming the company is involved in no more than a handful of technology and product development initiatives at this stage, integrating all of these activities is a sensible approach since it is likely that employees from all areas will be working together closely and the firm has not reached the point where strict and formal departmental lines have been drawn. Resolving technology strategy issues that cross functional lines is generally not that difficult in the early days after the company is launched because those issues can be and usually are, discussed at regular meetings of senior management leaders from all areas of business, including the CEO, the technical director and directors from finance, operations, manufacturing and marketing. This group, still relatively small and closely involved with the modest number of initial product development efforts can easily share information that normally goes into decisions regarding technology strategy, including R&D priorities, requirements for new product development and manufacturing and engineering issues. These discussions will lead to basic decisions about technology strategy that will guide actions throughout the firm until operations become too complex to be supported by informal communications and lines of authority.

As the company grows, however, the role and value of the technical director position becomes more problematic. For example, the authority of the technical director begins to erode as the various areas assigned to position begin to expand and develop their own unique departmental cultures, which often results in resistance to efforts to coordinate activities with other departments even if they all report to the same senior manager. Also, as companies attempt to combat the inefficiencies that a strict functional organization structure creates for new product development by adopting a matrix or product manager structure, the resources previously assigned to the technical director will be transferred to the control of a product manager who assumes responsibility for all aspects of the innovation process for new products, including design, development, production and marketing. In that situation, the role of the technical director is substantially diminished and is typically limited to tasks that are largely administrative, such as recruitment and making sure that R&D and engineering personnel have the resources necessary to perform the tasks assigned to them by the product manager.

The traditional role of the technical director is also inappropriate for technology-based companies for another important reason—it fails to recognize the need for a member of the senior management team to assume responsibility for the development and management of an overall technology strategy for the company. The primary focus of the traditional technical director role is on managing the activities of various functional areas, such as R&D and product development. While this is important, many of these duties can be delegated to managers within each functional group who would provide

specified reports to a member of the senior management team with overall responsibility for all elements of technology development and use by the business.

Recognizing the overriding importance of technology issues to the company, as well as the need to address the shortcomings of the technical director model, many technology-based startups create a senior management position designated as the "chief technology officer" ("CTO"), which is placed on the same level as the CEO, chief financial officer ("CFO") and chief operating officer ("COO"). In fact, given the strategic role of technology for these types of companies, a strong argument can be made for designating a CTO when the business is launched or, at the very least, formally assigning certain of the responsibilities below to one of members of the senior management group to ensure that the need for technology strategies and policies is taken seriously. Interestingly, 77% of the companies in a study of technology-based emerging companies conducted by researchers from the University of Chicago had someone serving in a position comparable to CTO at the time of their earliest business plan, clearly a nod to the importance of technology to those companies at the beginning of their lives; however, while the popularity of the CTO position held at 77% at the time the survey companies were completing their IPO it fell dramatically to just 47% on the date of their third annual report following their IPO.[47]

Glasser provided an interesting and straightforward catalogue of what he saw as the key roles of a CTO of a startup company operating in the high-tech arena.[48] His list began with ensuring that the company had the best technology to carry out the specific technology-related activities that were required in order for the company to competitive and this meant creating and continuously engaging with the appropriate suppliers and other allies and making sure that the technology requirements for each company project were clearly understood among the members of the teams working on those projects. In that regard, he noted that "[t]he greatest leverage is when the project is in its earliest phases, when we are deciding on architectures in the context of market requirements and when technology choices are being made". The second item on his list was creating options for the company—either for existing businesses or launching new businesses— and being heavily involved with other functions, such as business development, in incubating opportunities that are based on exploiting technological breakthroughs. Glasser's third activity for the CTO was attending to the health and well-being of the technical community including acting as the public face of technology for the company and making sure that technology optimization is taken into account in all decisions and activities throughout the organization. Finally, the CTO needs to be involved in the formulation and execution of the company's overall business strategies given that Silicon Valley companies are competing by forging technical excellence in the products and in the processes used to create those products. Glasser's ideas were similar to those described by Ries a few years earlier when he argued that "[t] CTO's primary job is to make sure the company's technology strategy serves its business strategy" and then

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[47] S. Kaplan, B. Sensoy and P. Stromberg, What are Firms?: Evolution from Birth to Public Companies (2005).

[48] The discussion of Glasser's arguments in this paragraph is based on L. Glasser, What Does a CTO Do? (2011).

suggested that the effective CTO need to be adept at several specific skills including platform selection and technical design; seeing the "big picture"; providing options; finding ways to "get 80% of the benefit for 20% of the cost; growing technical leaders; and owning the development methodology.[49]

The Role of the CTO in a Technology Company

A discussion by the chief technology officer ("CTO") and co-founder of a firm engaged in the development and sale of fully integrated network communications systems on the role of the CTO in a technology company provided the basis for the following insights on traits, skills and management styles necessary to be an effective and successful CTO:

- A CTO must have a love of technology and learning and be eager and prepared to invest time in reviewing technical books and journals, trade magazines, online publications and locating and trying out new technology tools. A CTO must also possess the ability to think effectively in abstract terms and deal with ambiguity.
- A CTO understand the role that technology plays in driving the business of the company and the context of the technology in terms of other technical areas, the customer's needs, the business impact, and the corporate strategy.
- A CTO must have strong leadership and team-building skills, since technology projects are large and complex and cannot reasonably be completed by one person.
- A CTO must be perceived as a credible technology leader among a wide range of constituencies including other company leaders, employees and customers, and must be able to communicate effectively with each of those constituencies in terms that apply to their specific relationship with the company and its technology plans.
- A CTO must be able to effectively support and enable the business of the company using tools such as technical expertise, technology leadership and using technology for strategic gain.
- A CTO must aggressively identify the strategy value of technology, bring innovative technological ideas to the attention of the other members of the executive team, champion innovative ideas inside and outside of the organization, and help employees in their own efforts to innovate.
- A CTO must set aside time to keep up with technology and maintain an understanding of the business in which he or she is operating, something that can be difficult if he or she does not have a prior background or interest in business management. When keeping abreast of technology, the CTO needs to strike the right balance between depth and breadth and recognize that there will be areas in which he or she needs to rely on technical specialists so that more of the CTO's personal attention can be paid to broader strategic issues.
- A CTO must understand that technology management spans a broad range of activities and that the time will come when different management structures, styles and internal leaders will be required for engineering and product development on the one hand and IT (i.e., internal projects and support) on the other.
- A CTO generally does best with an informal management style that acknowledges that most technical people prefer not to be "managed". The preferred management style depends heavily on the ability to influence people to achieve the desired goals; however, more traditional management tools should be deployed when dealing with business units, projects and budgets.
- A CTO often uses project teams to complete necessary work and it is important to give team members the ability to structure the work in ways that make most sense to them. At the same time, however, the CTO must make sure that teams follow sensible standard processes, including progress tracking and peer reviews. A CTO should also understand that assigning people to various projects is an important tool in helping them with career development and maintaining a dynamic environment.
- A CTO needs to understand the intellectual property rights that are relevant to the development, ownership and use of technology. Creating and protecting a portfolio of intellectual property rights is

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[49] E. Ries, What Does a Startup CTO Actually Do? (September 30, 2008).

a fundamental element of strategic technology management and the CTO needs to work with legal and technical professionals with expertise and experience in the technology markets in which the company is operating.

- A CTO needs to anticipate the challenges that will need to be addressed and overcome as the company grows. This means investing time and effort in developing internal leadership that can push forward the company's technology initiatives and instill the appropriate organizational culture in new employees.
- A CTO needs build and maintain the reputation of IT throughout the organization, particularly among the engineering professionals. The CTO needs to advocate for additional resources to upgrade the capabilities of the IT staff and forge relationships with across business units.

Source: Adapted from S. Hart, "Inside the Minds—The Role of the CTO in a Technology Company" in Achieving Success as a CTO: Leading CTOs on Building IT's Reputation, Capitalizing on Employee Strengths and Creating a Productive Environment (Boston MA: Thomson/Aspatore, 2008).

§16   Board-level technology committees

Many have argued that data has become the most important asset for businesses and it is also clear that technology plays a fundamental role in how companies operate and compete.   As such, oversight of the company's technology-related activities and formulation of an effective technology strategy is an essential function of the board of directors and boards should carefully consider the need to create a board-level technology committee.[50] Feldman and Potamianos, noting that creation of technology committees has proceeded slowly, argued that such committees can serve several important roles[51]:

> "It can serve to ensure effective and secure utilization of technology within the corporation, a broad area with a number of sub-responsibilities. It can also evaluate, and advise with respect to, the direction of the corporation's technological evolution– something distinct from the technology management role previously noted and, within a technology-based corporation, a role that dovetails with the overall role of the board of directors in guiding corporate direction – and it can, in the process, oversee effective protection of the corporation's intellectual property. Finally, the Technology Committee can recommend technology and procedures to meet the corporation's financial and regulatory obligations with respect to privacy, data retention and data protection."

As for the key areas that a board-level technology committee could help the entire board satisfy its monitoring and supervisory responsibilities, Feldman and Potamianos mentioned the following:

- Staying abreast of new basic technologies and emerging technologies within and outside of the company's specific industry
- Understanding how technology is used and technology-related security threats

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[50] For detailed discussion of board-level technology committees, see "Technology Committees" in "Governance: A Library of Resources for Sustainable Entrepreneurs" prepared and distributed by the Sustainable Entrepreneurship Project.

[51] S. Feldman and C. Potamianos, "The Technology Committee of the Board of Directors: The Next Wave in Corporate Governance", https://www.pli.edu/emktg/compliance_coun/Tech_Committee.htm

- Advising on long-term strategic goals of the company's science and technology investments
- Evaluating the company's technology position in a competitive environment
- Acquiring and maintaining technology positions, including contracts, grants, collaborative efforts, strategic alliances, mergers and acquisitions
- Finding a chief technology officer and staff
- Protecting the company's intellectual property
- Providing guidance for data retention, privacy and regulatory-mandated recordkeeping

They also noted that emphasis and objectives of technology committees will vary substantially from company-to-company since the mandates of such committees are not regulated by listing standards in the same manner as audit, compensation and nominating committees, thus freeing the board to structure and task technology committees in ways that are best for the particular situation. They explained by suggesting that the technology committee of a company in the computer networking industry might focus on the development of networking standards and evaluating strategic product development, a biotechnology company might have its technology committee concentrate on regulation of product development and a non-technology based company would likely have its technology committee spend relatively little time on technology strategy and devote most of its efforts to information security and business continuation risks.

In a December 2016 report on how board committees among S&P 500 companies had evolved to address new challenges, the EY Center for Board Matters mentioned that companies often created technology committees at the board level to assume responsibility for overseeing and assessing the company's technology-related development and innovation strategies; making recommendations regarding the scope, direction, quality and investment levels; and overseeing the execution of technology strategies formulated by management. Technology committees also reviewed and discussed management's assessment of the company's technology profile and addressed related risks and opportunities. The functions of the technology committee may overlap with the risk and research and development committees. The sectors most likely to have a technology committee included financial services, industrials and materials.[52]

§17   --Statement of purpose

The technology committee should have a charter that begins with a statement of purpose for the committee such as assisting the entire board of directors in fulfilling its oversight responsibilities with respect to the overall role of technology in executing the company's business strategy including, but not limited to, major technology investments and initiatives, technology strategy, operational performance, research and innovation activities, technology-related product quality and safety and technology trends that may affect portfolio issues. Consideration should be given to including a definition of

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[52]   http://www.ey.com/Publication/vwLUAssets/EY-board-committees-evolve-to-address-new-challenges/$FILE/EY-board-committees-evolve-to-address-new-challenges.pdf

"technology" to assist in identifying the scope of the committee's activities. For example, technology may be defined to include hardware, software, personnel, architecture, organizational structure, management, resource allocation, innovation and research and development. In most cases, material risks associated technology (e.g., information security, cybersecurity, disaster recovery and business continuity) are reserved for the entire board or a separate board committee overseeing compliance and risk management; however, as discussed below, if the technology committee will be overseeing technology-related risks provision should be made for appropriate activities in the charter's description of committee duties and responsibilities.

§18 --Composition, meetings and procedures

The technology committee charter should address composition, frequency of meetings, powers and authority of the committee and other procedures. The "independence" requirements that apply to audit, governance and compensation committees under exchange listing standards do not apply to membership of the technology committee; however, it is important that the members of the committee be generally familiar with technology issues applicable to the company's specific line of business and operational activities. It is recommended that at least one of the members of the committee have deep experience and technical skills with respect to the technical fields and intellectual property associated with the company's core business activities, comparable to the qualifications of a financial expert on the audit committee. Given the potential overlap of the work of the two committees, some companies require that at least one member of the technology committee also serve as a member of the risk management committee and may also mandate that the two committee periodically meet in joint session to ensure a comprehensive oversight approach to technology-related risks. While it is unlikely that public companies will have non-director members of a board-level committee, private companies include the chief technology officer or another senior technology officer.

§19 --Scope of duties and responsibilities

The scope of the duties and responsibilities of the board-level technology committee will vary depending on the activities of the company and the decisions that the entire board makes with respect to allocating oversight authority among various committees. Companies that depend heavily on technology development, acquisition and commercialization will generally look to have the board-level technology committee proactively participate in technology planning and strategy. In other cases, the primary concern for the company will be in identifying and managing security risks for the information that the company collects and uses in the course of its business activities (e.g., cybersecurity, business continuity and disaster response). Many technology committees oversee both technology planning and technology-related risks; however, it is not uncommon for technology risk identification, assessment and management to be assigned to the board's risk management committee.

When committee is charged with oversight of all of the company's technology-related activities, including risks and opportunities, the scope of duties and responsibilities of the committee will be quite broad and include responsibility and authority to:

- Review and approve the company's technology planning and strategy, including the financial, tactical and strategic benefits of proposed significant technology-related projects and initiatives.
- Review significant technology investments and expenditures
- Request and receive reports from management, as and when appropriate, concerning the implementation of the company's technology priorities, including the cost compared to budget, the expected benefits and the timelines of implementation
- Remain informed of, assess, and advise the company's senior technology management team with respect to monitoring and evaluating existing and future trends in information technology and new technologies, applications, and systems that relate to or affect the company's technology strategy or programs, including monitoring of overall industry trends
- Receive reports from management concerning the company's technology operations including, among other things, software development project performance, technical operations performance, technology architecture and significant technology investments and approve related policies or recommend such policies to the board for approval, as appropriate.
- Report and make recommendations to the board, as appropriate, as to the scope, direction, quality, investment levels and execution of the company's technology strategies
- Oversee management's programs relating to technology-related risks and opportunities including review, at least annually, of management's IT security program and receipt of frequent updates on IT security from management
- Oversee effective protection of the company's intellectual property right portfolio
- Request and receive periodic reports from management on their strategy for disasters and assess the company's readiness for disasters to ensure continuity of the company's business operations
- Oversee the company's activities relating to sustainable technology management, typically through collaboration with the board-level committee charged with oversight of corporate social responsibility

When necessary, the charter should address potential overlaps with the duties and responsibilities of other board committees. For example, as mentioned above, responsibility for the oversight of risks associated with technology, including risk assessment and risk management, will often be reserved to the board's compliance and risk management committee; however, provision should be made for that committee to report regularly to the technology committee on steps taken to mitigate technology-related risks and for the technology committee to have access to company executives with responsibility for important information technology initiatives and providing for security of the company's intellectual property.

§20   --Technology planning and strategy

Feldman and Potamianos observed that a board-level technology committee can provide an invaluable role in evaluating the long-term strategic impact of various technologies on the company, a focus that is often difficult for management to take on as they struggle to keep up with day-to-day technology needs at the operational level.[53] The duties and responsibilities of the technology committee with respect to technology planning and strategy are sometimes broken down into specific elements such as overseeing the company's research, innovation and technology initiatives in the context of the overall corporate strategy, goals and objectives, including review and consideration of the strategic goals, objectives and direction of the company's research programs and the alignment of those programs with the company's portfolio of businesses and its long-term business objectives and strategic goals; the relationship of the company's strategic research plan to the company's overall approach to technical and commercial innovation and technology acquisition; the company's product development pipeline; the company's major technology positions and strategies relative to emerging technologies and changing market requirements; the processes for identifying and prioritizing, and, as applicable, the development of, innovative technologies that arise from within and outside the company; the company's ability to internally develop technology being, or proposed to be, developed, or to access and maintain such technology from third parties through acquisitions, licensing, collaborations, alliances, investments or otherwise; and the potential impact on the company in the event that technology being, or proposed to be, developed is not developed or accessed by the company. In order to fulfill its duties and responsibilities in this area provision must be made for extensive interaction between committee members and the chief technology officer and his or her staff. Feldman and Potamianos also suggested that the committee contain "a mix of senior in-house technologists, as well as respected outside authorities who have a broader focus than the in-house technologists and a more dispassionate perspective on a corporation's existing technology and direction".[54]

§21   --Information technology

One of the most significant issues for the board of directors is oversight of the company information technology ("IT") activities; however, until recently directors paid relatively little attention to IT even though their companies often were spending significant amounts of money on IT, information was becoming an essential strategic asset and the financial and reputational risks of breaches of information security were becoming more and more apparent.[55] In many cases the directors were content to leave IT issues to management, particularly the chief information officer, and devoted a limited amount of time to discussions of IT at board meetings. Since the beginning of the 2000s the situation has changed dramatically as larger companies began to invest heavily in IT

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[53] S. Feldman and C. Potamianos, "The Technology Committee of the Board of Directors: The Next Wave in Corporate Governance", https://www.pli.edu/emktg/compliance_coun/Tech_Committee.htm
[54] Id.
[55] N. Lankton and J. Price, "Board-level Information Technology Committees", ISACA Journal, 2016(2). (citing R. Nolan and F. McFarlan; "Information Technology and the Board of Directors", Harvard Business Review (October 2005), https://hbr.org/2005/10/information-technology-and-the-board-of-directors/ar/1)

assets in order to comply with new requirements regarding the integrity of the internal controls within their financial reporting systems. Directors and senior executives also became more aware of the role that IT systems played in creating a competitive advantage and adding value to the business. As a result, companies gradually began to establish board-level committees that focused, in whole or in part, on IT risks and opportunities. Many companies limit the duties and responsibilities of their board-level technology committee to oversight of the companies with IT activities, with management being responsible for day-to-day management, monitoring and reporting. In those cases, the duties of the technology committee with respect to its oversight role might be limited to the following functions and responsibilities:

- Reviewing at least annually the company's IT and operational strategies, costs and planning, including the financial, tactical and strategic benefits of proposed major IT and operational related initiatives
- Approving major IT and operational initiatives and the IT and operational budget for each calendar year
- Receiving a quarterly report from management that provides information on management's progress in executing on major IT initiatives, technology architecture decisions (as applicable) and IT priorities as well as overall IT performance, including metrics concerning technology investments, talent management, and system availability, integrity, capacity and performance
- Reviewing at least annually the adequacy of the company's management of information security risks
- Approving all material changes to written policies related to the management of information security risks and recommending such changes to the board for approval
- Receiving reports from management that provide information on the effectiveness of the management of information security risks and the company's crisis management plan
- Monitoring and assess the overall adequacy of the company's IT and operational control environment, including the implementation of key controls in response to regulatory requirements

Similar to the caveat above, a technology committee's review of information security risks will generally be a shared activity with the board-level risk management committee.

In 2015 Lankton and Price compiled a list of companies with board-level IT committees by searching the web sites of all Fortune 500 companies and reviewing the charters of each committee containing the word "technology" in its name.[56] After setting aside committees that were primarily focused on research and development within the company rather than on IT, Lankton and Price settled on IT committees of 23 companies for further analysis.[57] Lankton and Price reviewed the roles and responsibilities of the committees as listed in their charters and coded them into five primary governance

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[56] N. Lankton and J. Price, "Board-level Information Technology Committees", ISACA Journal, 2016(2).
[57] Lankton and Price noted that the board-level IT committees had various names other than the "technology" committee including "corporate development and technology", "environmental, health, safety and technology" and "information technology oversight"

domains: strategic alignment; value delivery; resource management; risk management; and performance measurement.[58] Most of the companies did not include roles and responsibilities for all five domains. They found that "strategic alignment" was clearly the most often cited role for board-level IT committees, a topic which included:

- Verifying that IT strategy is aligned with business strategy
- Making decisions about priorities and the focus of IT resources
- Clarifying the role of IT
- Monitoring the impact of IT infrastructure and applications
- Evaluating benefits delivered by IT projects
- Communicating goals and objectives through policies
- Issuing high-level policy guidance
- Enabling business strategy
- Monitoring industry trends

At the other end of the spectrum, "value delivery" roles and responsibilities (e.g., optimizing expenses and proving the value of IT, monitoring the return and competitive aspects of IT and balancing the risks and benefits of IT) were mentioned least often overall and by the fewest companies. The IT committees of 20 of the 23 companies analyzed by Lankton and Price had roles and responsibilities relating to "resource management", which included oversight of IT expenditures; providing staff development and recruiting and retaining skilled IT staff; overseeing IT asset deployment; and ensuring that IT had competent, sufficient and efficient applications, information, infrastructure and people. 78% of the charters included at least one role relating to performance measurement, which included activities such as tracking project delivery and resource usage, monitoring IT services and establishing a balanced scorecard for IT and measuring IT performance and the contribution of IT to the business. Finally, just over two-thirds of the charters required committees to address risk management and issues relating to IT security, internal controls, audits and disaster recovery plans.

§22   --Intellectual property strategy

The creation, protection and thoughtful commercialization of intellectual property rights have become an important matter for companies of all sizes and across all types of industries. The competitive impact of intellectual property rights is illustrated by the explosion in patent applications coupled with escalating legal costs for companies prosecuting and defending intellectual property litigation. Intellectual property is a high value and high risk asset for the company and requires the attention of the board of directors as part of their broader fiduciary duties to the company and its stakeholders. Members of the board of directors must be prepared to oversee the company's intellectual property rights portfolio and, as such, must be regularly briefed by senior management and provided with training on the nuances of intellectual property law. Board members

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[58] The five governance domains were based on the areas depicted in a 2003 IT Governance Institute publication titled "Board Briefing on IT Governance (2nd Edition)", www.isaca.org/Knowledge-Center/Research/ResearchDeliverables/Pages/Board-Briefing-on-IT-Governance-2nd-Edition.aspx

must also be informed of intellectual property activities of competitors and the role that intellectual property is and will play in the evolution of the company's markets.

An important role for the board of directors and the members of the executive team is developing and implementing an intellectual property strategy that identifies the areas that the company needs focus its creative and innovative efforts and aligns those areas with the company's overall goals and objectives for effectively competing in the market and otherwise meeting the expectations of its stakeholders. As with any strategy, the intellectual property strategy must effectively address the specific needs of the company and assist the company in achieving its commercial goals and objective. The intellectual property strategy should also include programs and tools, such as an intellectual property compliance program, that will stimulate creativity within the organization and facilitate the collection of ideas and the steps that are needed in order to perfect, maintain, exploit and enforce valuable intellectual property rights. The intellectual property strategy will impact core activities such as new product development and commercialization and the information gathered during the course of developing the intellectual property strategy should reduce the risk that investments in innovation will be wasted due to the failure to create products and services that can protected and that do not infringe upon the intellectual property rights of others.

While there are many ways to develop an intellectual property strategy, it is important to begin with identifying the business goals and objectives of the company and figuring out how those goals and objectives can be achieved from an intellectual property rights perspective. The next step is to audit the company's existing intellectual property rights and evaluate the competitive intellectual property landscape in which the company is operating. The company should then determine what will need to be done in order to align its intellectual property rights with its business goals and develop appropriate strategies and tactics for acquiring, through development, licensing or purchasing, the missing intellectual property rights and fortifying those rights to strengthen them in the face of competition.[59]

Since intellectual property is a valuable asset of the company, the board of directors has a fiduciary duty to the company's stockholders to preserve and manage the company's intellectual property in a manner that conforms to the duty of care. In order to fulfill their duties, directors must inform themselves prior to making any business decision relating to the company's intellectual property assets of all material information reasonably available to them. Directors must proactively seek adequate information and educate themselves so that they can independently assess the quality of the information and not simply rely on the opinions of others. Educational activities should include regular briefings by senior management on the scope of the company's intellectual property rights portfolio, the impact of intellectual property on the company's markets and the effectiveness of the company's intellectual property rights strategy (e.g., budgets and reserves; assessments of the proprietary position of key products and services, as well as

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[59] For discussion of intellectual property strategy, see "Intellectual Property Strategy" in "Technology Management: A Library of Resources for Sustainable Entrepreneurs" prepared and distributed by the Sustainable Entrepreneurship Project.

'freedom to operate' issues; a competitive analysis of the company's intellectual property position and enforcement by competitors). Directors must also have access to training on the nuances of intellectual property law including important legal developments and trends in the company's industry, and such training should be provided by experts from the company's outside law firm. The records of board meetings should reflect the actions taken to ensure that the members are able to carry out their duty of care with respect to the company's intellectual property assets.

§23   --Cybersecurity, data retention and privacy

Cybersecurity has emerging as one of the most challenging issues for governments, businesses and citizens, all of whom have experienced the adverse consequences of hacking and cyber-crime attacks. Companies run the risk of having sensitive business information compromised and misappropriated and are subject to substantial reputational and financial harm if they are unable to protection the personal information of their customers and clients. Technology committees, often in collaboration with a board-level risk management committee and the audit committee, should carefully oversee and monitor the policies and practices implemented by management with respect to information security and catastrophic failures of the company's computer and communications systems. In the event that the company does suffer a breach of its data systems, the technology committee should monitor management's response to ensure that the company complies with applicable data breach laws and regulations and communicates quickly and transparently with all parties that would potentially be harmed by the breach.

Feldman and Potamianos recommended that board-level technology committees be involved in the developing and monitoring guidelines and procedures for legally-mandated data retention, recordkeeping and other compliance programs; proposing, developing and evaluating appropriate data retention strategies and procedures to effectively manage the company's internal data; and actively participate in setting and monitoring the company's privacy policy, both as it applies to internal data, as well as to the collection, utilization and dissemination of customer data.[60] This is an area that is continuously expanding as regulators and consumers have become more concerned about the failure of many companies to adequately protect the personal information of individuals that they collect and store. The members of the committee will need to be involved in the development and implementation of privacy policies and procedures and receive regular reports on privacy-related issues from yet another executive team member: the "chief privacy officer".

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[60] S. Feldman and C. Potamianos, "The Technology Committee of the Board of Directors: The Next Wave in Corporate Governance", https://www.pli.edu/emktg/compliance_coun/Tech_Committee.htm