The Role of the Chief Technology Officer in Strategic Innovation, Project Execution, and Mentoring

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Executive Overview

The significant role of technology in strategic business decisions has created the need for executives who understand technology and recognize profitable applications to products, services, and processes. Many companies have addressed this need through the appointment of a Chief Technology Officer (CTO) whose responsibilities include monitoring new technologies and assessing their potential to become new products or services, overseeing the selection of research projects to insure that they have the potential to add value to the company, providing reliable technical assessments of potential mergers and acquisitions, explaining company products and future plans to the trade media, and participating in government, academic, and industry groups where there are opportunities to promote the company's reputation and to capture valuable data.

Integrating these technology-based activities into the corporate strategy requires that the CTO nurture effective relationships with key people throughout the company. These include the CEO, members of the Executive Committee, chief scientists, research laboratory directors, and marketing leaders.

Origins of the Chief Technology Officer

In the 1950s and 1960s, many large corporations established beautiful research laboratories at locations remote from their headquarters and manufacturing facilities. The goal was to collect brilliant scientists and allow them to study relevant topics in an environment unhindered by day-to-day business concerns. The director of the laboratory was often a corporate vice president who did not participate in decisions regarding corporate strategy and direction. Instead, his responsibilities were to attract the best scientists, explore new ideas, and publish respected research papers.[1]

By the late 1980s, companies began to anoint R&D laboratory directors as Chief Technology Officers. Technology was becoming such a prevalent part of company products and services that senior management needed an operational executive who could understand it and provide reliable advice on its application. However, executive search agencies, under direction from their corporate customers, continued to fill the CTO position with the same people they had recommended to lead R&D laboratories.[2] Several experiences with these candidates soon made it clear that the responsibilities of the CTO were significantly different from those of the research scientist. The CTO position called for a technologist or scientist who could translate technological capabilities into strategic business decisions. Lewis expresses this very clearly.

> "The CTO's key tasks are not those of lab director writ large but, rather, of a technical businessperson deeply involved in shaping and implementing overall corporate strategy."[3]

Though large companies such as General Electric, Allied-Signal, and ALCOA created the position of CTO in the late 1980s, the position has also played an important role in computer and Internet companies in the late 1990s. Many of these provide products and services that are pure technology. Therefore, the CTO can play a prominent role in directing and shaping their entire business.

Strategic Responsibilities of the CTO

The CTO position is far from being standardized. Each company has unique requirements for its CTO and provides a unique organizational structure into which the person will fit. This section describes some of the more prominently cited responsibilities of the CTO.

Monitoring and Assessing New Technologies

The rate of change of technology guarantees that knowledge and expertise gained several years ago will no longer be completely valid. This creates the need for a technologically current person to serve as an advisor to senior executives during strategic decision-making. Paul O'Neill stated that a CTO should be expected to, "identify, access, [and] investigate high-risk, high-return technologies possessing potential application within existing businesses or for creating new businesses". [4] Knowledge that is several years old cannot effectively guide this type of assessment. If a company is planning to modify its production process or add new products, it must understand how the latest technologies can contribute to those plans. As an illustration of this, Peter Bridenbaugh recognized the significance of technical advancements that made it possible for mini-mills to operate profitably and to assault the markets held by large metal producing companies like Alcoa.[4] Because he was actively monitoring new technologies and assessing their applicability to business opportunities, Bridenbaugh was in a position to advise Alcoa of this threat while mini-mills still occupied a very limited niche in metals production. Though other executives within Alcoa had come up through the operational and scientific ranks, their focus had changed to organizational and financial issues. Because they were

no longer intimately familiar with the latest scientific developments in metal production, the emergence of mini-mills did not appear to be a serious threat to Alcoa's business. Junior engineers, on the other hand, may have realized that new technology made it possible for small mills to produce high quality products at prices competitive to Alcoa's. But, those engineers did not possess the experience necessary to support their opinions to upper management. Neither did they have access to those senior decision-makers. Therefore, a CTO who embodies current knowledge, is networked with company engineers, has years of experience, and has access to executive decision-makers is a valuable resource in recognizing important new technologies and bringing them into the company's strategic decision-making process.

Bert Thurlings of Philips Research Laboratories has arrived at conclusions similar to those of O'Neill and Bridenbaugh through his field studies of numerous CTOs. These indicate that CTOs themselves feel that one of their most important responsibilities is to monitor, evaluate, and select technologies that can be applied to future products and services.[5] A significant investment in the active exploration of all relevant technical areas is required in order to identify opportunities buried amid all of the information available. Internal company managers and scientists are often qualified to perform this analysis, but are so focused on day-to-day operations that they do not have time to study broadly and deeply enough to locate the technologies that will be essential in the future. These people frequently identify important changes once a competitor has already implemented a similar idea. However, by that time, it is too late for the company to capture the lead in the application of that technology to products, services, and production techniques. Such a company would find itself trying to catch-up to the new leader in the field.

The opinions and experiences expressed by large companies like Alcoa and Philips are echoed by the CTOs of the new generation of information companies as well. Pavan Nigam, CTO of WebMD, reports that an important part of his job is reading and evaluating large amounts of data about new products.[6] Information service vendors are so eager to attract the attention of the media and of customers that their claims are often exaggerated. Managers and scientists within WebMD could be misled by these claims and expend irreplaceable time and money working with products that are not able to deliver the promised capabilities. Therefore, Nigam provides a valuable service by remaining abreast of vendor claims and by learning about the experiences of other companies using those same products and services. This allows him to direct WebMD away from ineffective products and toward others that do solve its problems.

Darren McKnight, the CTO of defense contractor Titan Corp., listed the evaluation of new technologies as his number one responsibility.[7] Titan had developed an electron beam technology to sterilize medical components and the company's senior technologists recognized that this capability could also be used to pasteurize food products. Therefore, Titan created the Surebeam subsidiary to pursue this market. Following the anthrax contaminations in Washington, D.C., McKnight and others recognized that Surebeam's systems could be used to kill anthrax hidden in postal envelopes. Backed by existing research and prior publications on the subject, Titan created a new market for electron beam systems and assigned a facility to sterilize selected mail destined for the nation's capital. The expertise of business executives, unaided by technologists, would not have been sufficient for identifying such a unique opportunity. Situations like this demonstrate the real contributions that can be made by a CTO.

Strategic Innovation

Michael Porter explains that, "companies have to find ways of growing and building advantages rather than just eliminating disadvantages."[8] A significant part of this is strategic innovation. In some industries, new products based on new technology are the lifeblood of the company. In other industries, core products remain unchanged for decades, but the processes used to create them are continually evolving and becoming more efficient. Just as Peter Bridenbaugh learned that emerging technology was creating a new class of competitors for rolled metal products, companies that create commodities like laundry detergent, toilet paper, gasoline, and furniture must apply technology to improve their production processes and add an edge to their products that competitors cannot match. O'Neill emphasizes that established companies need a CTO to "assure development of fundamental technologies offering clear competitive advantage for current and future businesses." Walter Robb, former CTO of General Electric Medical Systems, believes that "it is the responsibility of the CTO to push the boundary on risk taking."[10] The CTO's relationships with the R&D scientists equip him with knowledge about the state-of-the-art that will allow him to recommend risks that have a high probability of success. GE's innovative designs for CAT scanners and magnetic resonance imaging systems accepted high levels of risk in order to create unique products containing features beyond the technical reach of their competitors. Those calculated risks led to a market dominating position that extended over a decade.

CTOs like Robb take risks because they have a vision for where the company should take its products in the future. Such product vision is one of the key reasons for employing a CTO. Ron Moritz, CTO of Symantec, says

> "One of the key roles of the CTO is to provide the technical vision to complement the business vision, setting the tone and direction for the company's technologies. Leadership, in this context, comes from being able to set the technical course and from being able to define what the company's products and technologies might look like in two, three, or more years."[6]

Product vision should be based on an intimate understanding of the power of the current technology component of the product and knowledge about innovations and changes that are occurring in related fields.

Michael Earl emphasized that investments in technology and innovation must be connected directly to business strategy. In fact, he found that the most successful approach was when a company did not have a separate technology strategy. Instead, the best technology strategies were those that were fully integrated with the business strategy.[11] CTOs are now expected to contribute technology expertise to business strategies, not to create independent research laboratories and strategies that are only loosely coupled to the company's profit engine.

Mergers and Acquisitions

Mergers and acquisitions (M&A) are an important part of the growth strategy of many companies. These involve important strategies in financing, governmental oversight,

taxation, corporate culture, and technological synergy. Unfortunately, after studying more than 5,000 acquisitions, divestitures, spin-offs, equity investments, and alliances, Frick and Torres discovered that over half of the deals resulted in a lower market value for the resulting entities.[12] Other McKinsey studies in the late 1980's reported that, at that time, more than seventy percent of acquisitions failed to earn back the cost of capital used to purchase the company.[2] Frick and Torres maintain that there are two major causes of this problem. First, the acquisition becomes an exercise in financial engineering. It focuses on successfully structuring the finances required to make the acquisition possible and loses sight of the strategic objectives of the acquisition. Second, it is a form of corporate ego boosting. Corporate leaders are eager to build an empire or capture high profile products. Frick and Torres contend that, in contrast to these two motives, value creating mergers and acquisitions are focused on the strategic value that can be achieved through the transaction. However, to make this happen, it is essential that the due diligence leading up to the deal include an evaluation of the value of the technologies being acquired. The CTO's role in due diligence includes evaluating patents, reviewing technical publications, and studying trade data to determine the value of the target company and to rank it against its competitors. Darren McKnight at Titan Corporation includes these types of investigations in his list of key responsibilities.[7] At Titan each deal has included a strategic evaluation of the technologies within the target company and the synergies that those technologies could generate within the Titan family.

Marketing and Media Relations

Media attention to company products and capabilities plays an important role in the success of those products. Constructing the information and images released to the public is primarily the responsibility of the marketing and sales departments. However, technical expertise is required to accurately translate some product details into terms that can be marketed. Rajeev Bharadwaj, the CTO of Ejasent, plays an active role in communicating with the media.[13] He believes that the CTO must translate technical details into real customer advantages that are superior to those of competing products. Internet start-ups must also create convincing presentations and demonstrations for venture capitalists (VCs). The VCs provide the initial revenue stream necessary to turn an idea into a viable product. In the early stages of a company, the VCs are the customers and the marketing story is focused on them rather than the actual consumers.

In addition to creating media worthy stories for publication, companies create media worthy experts to be interviewed and quoted. Trade magazines and television producers rely upon statements by insiders and experts who can speak authoritatively on a subject. These experts "are like politicians – they're made, nurtured, and coached."[8] They are also made constantly accessible to the media for consultation. Ron Moritz, CTO of Symantec, was an expert in Internet security, but the media was not aware of his expertise. Therefore, Symantec's President took it upon himself to turn Moritz into a media recognized and consulted expert.[6] This was part of the corporate strategy at Symantec and contributed to the success of its security products.

Government, Academia, Professional Organizations

Prominent technologists are often called upon to provide services to government, academia, and professional organizations. These services combine civic and professional duty with the opportunity to convey a positive image of the company and its products.

Governmental committees investigate issues of national importance. Service on these committees is an honor, but it also requires the dedication of time, energy, and money that could be focused on other pursuits. Participation brings several rewards that are an alternative form of payment.

- Tacit recognition as a leader in the field,
- Opportunities to influence the decisions of the committee in a professionally positive manner, and
- Having early and intimate access to the work generated by the committee.

Since many CTOs possess advanced college degrees, they tend to have multiple relationships with members of academia. These relationships lead to partnerships and funding for research that is of mutual interest. Companies participating in these activities generally structure the partnership such that they have first access to the results of the research. One of the most commercially successful and widely recognized industry/academia partnerships is the Media Lab at MIT. This lab investigates the application of computer technologies to practical social problems. In 2001, the lab received 95% of its $36 million budget from 140 corporate sponsors.[14] There are hundreds of similar, but smaller, examples of corporate and academic partnerships that can involve participation or oversight by the CTO. As a businessman, the CTO must insure that money and time spent on such projects is aligned with the corporate strategy

and has a realistic potential of contributing to the company's competitive advantage in the foreseeable future.

Finally, CTOs are called upon to participate in professional organizations and their associated meetings. Similar to government committees, these are an opportunity to project a positive image within the profession and to communicate important messages. Presentations allow the CTO to tell partners, suppliers, competitors, and customers about their expertise, products, future strategy, or commitment to an industry. Both, Bill Waite, President of Aegis Technologies, and David Zeltzer, CTO of the Fraunhofer Center for Research in Computer Graphics, maintain that the relationships that they build through professional organizations contribute to their business base.[15, 16]

Company Culture

Earlier sections described how the CTO could contribute to strategy, acquisitions, media relations, government committees, and academic research. But, the CTO can also serve an important role in creating the internal culture. The CTO should initiate activities and policies that create a technology-friendly culture aligned with the company's business strategy.

Other technology leaders throughout a company may create policies and practices that attempt to attract and retain the highest quality people available. However, if these are not aligned with the corporate business strategy, they may attract excellent people who are not able to contribute to business objectives.

The CTO should insure that policies and practices are constructed to attract the right kind, right number, and right placement of technologists. This will require the establishment of formal and informal networks to implement the policies and to insure that they are aligned throughout the company.[3] These networks will also serve as the conduits through which corporate vision and direction can be communicated.

Informal networks of technologists can be used to mediate organizational problems that extend beyond the control of operational managers. In some companies these networks tend to catalyze unofficial practices that are aimed at improving internal performance. Lewis reports the emergence of internal publications, technical seminars, lists of known experts, and technical expositions.[3]

Relationships that Empower the CTO

The CTO position was initially created to insure that senior management paid appropriate attention to their corporate technological capability.[17] Attracting this attention and operating as an effective member of the executive team, requires that the CTO nurture relationships with a number of people and groups internal and external to the company.

Chief Executive Officer and Executive Committees

Providing strategic advice to the CEO and the Executive Committee requires much more than technical expertise. The CTO must earn the trust and confidence of the CEO. In previous positions, the CTO may have earned the respect and confidence of peers and superiors through technical prowess and performance. But, this new position requires business prowess and financial performance.[1] The CTO must exhibit a clear understanding of and dedication to improving the competitive position of the company.

The acceptance of the CTO as a business strategist is an important step. It will determine whether the CTO is treated as an equal member of the executive team or is isolated as an outside source for technical advice and information. Ed Roberts' study of the strategic management of technology indicates that most companies include the CTO on the Executive Committee along with the CEO, COO, CFO, and CIO. In North America 60% of the companies surveyed included the CTO on this committee. In Europe the number was 67% and in Japan it was 91%. [18] In some companies the CTO actually teaches senior management about the importance of technology in their industry. The goal is to ingrain technology as a significant consideration in all executive decision-making.[19, 20]

CTOs are not the first officers to face the challenge of inclusion or exclusion from the strategic process. When the CIO position emerged, they too were branded as technologists who could not function as business strategists.[21] This image has diminished as CIOs have shown themselves to be just as effective at making business decisions as their management-schooled peers. Kwak cites the results of a study of pairs of executives at 69 companies that indicated that the business acumen of CIOs was equal to that of their executive peers. Another study of 417 construction company executives found that eighty percent of the CIOs in those companies were considered equal contributors of the strategic decision making process.[22] Therefore, the CTO should be able to learn from the integration experience of the CIO. Executive Committee members should also recognize that the technological stereotype that was not accurate for the CIO might also prove to be inaccurate for the CTO.

If the CTO is to provide business decisions and advice, there needs to be some measure of the quality of this advice. The CTOs performance should be measured against a plan worked out with the CEO. This plan may include achieving milestones, introducing new products, reducing costs, reducing uncertainty, and selecting the right research projects to fund. Bill Waite advocates a customized set of metrics for the CTO. Within his company, these included maintaining and teaching technology within the organization, measuring the speed at which technology is brought into the organization, the rate at which the CTO turns technology into salable intellectual property, and the CTO's effectiveness as the custodian for research and development money.

Chief Information Officer

Many organizations have a difficult time separating the responsibilities of the CTO from those of the CIO, which can make the working relationship between the two very difficult. At the 2001 InfoWorld CTO Forum, CTOs from Sun Microsystems, eBay, Dell Computer, and other companies identified their responsibilities as being externally focused while the CIO's responsibilities were internally focused.[24] Corporations have realized that they need a CIO to oversee the application of technology to internal operations. This has included computer systems for accounting, billing, telephony, security, and a host of other functions. Prior to the creation of the CTO position, the CIO was the only executive technologist and was often called upon to support manufacturing computerization, the purchase of computer aided design packages, and strategic decisions for injecting technology into products.[21]

The internal/external division of responsibilities is a very useful differentiation, but it leaves significant gray areas that can result in turf wars between the two players. Therefore, the CTO's relationship with the CIO should be based on a more clearly defined division of responsibility. The goal is to create a complementary and supportive relationship that maximizes contributions to corporate strategy and profitability.

Chief Scientists

Chief Scientists are much more intimately involved in the day-to-day execution of scientific and technical projects. Each of these is usually limited to the laboratory, division, or facility in which he or she resides. As described earlier, senior technologists are often very eager to explore new areas. But, these explorations should be harnessed to contribute to the company's strategic direction. Earl maintained that a company should

not have a separate technology strategy. Supporting this perspective, one study has found that short-term, product focused R&D is positively correlated with the financial performance of the company, while long-term R&D is negatively correlated with it.[18] That is one reason that it is important for the CTO to mentor the Chief Scientists and to direct their focus such that it contributes to the success of the company.

Chief Scientists may also have informal networks of technologists that span business areas, but they do not have the official charter to cross-pollinate technologies. The CTO can organize an internal council of technologists to search out and apply the best technologies available across the company.[9] Darren McKnight of Titan reports that he sponsored internal summits to bring leading technologists together to share ideas. He viewed it as his responsibility to create leverage across many different business groups to identify potential combinations of technology that could become new products or services. He is currently working on plans to create a network of technologists similar to that described by Brunner.

CMGI was one of the leading incubators of the Internet business explosion. Daniel Jaye, the CTO of Engage, a CMGI incubated company, felt that the cross-pollination of technologies within CMGI could identify valuable opportunities and solve local problems. Therefore, acting as the ad hoc CTO of the parent company, he organized technology summits for all CMGI technology leaders. One of these summits led to the realization that two CMGI companies were buying services from the same vendor. The leaders reasoned that the vendor would be a good fit under the CMGI umbrella and

purchased the company, reducing outsourcing costs and adding a proven product to the CMGI family.[6]

Research and Development Laboratories

Since the 1960s, research and development laboratories have been transformed from independent scientists working on challenging, but questionably marketable technologies, to organizations that are expected to make direct contributions to company profits. The CTO can play an important role in monitoring and directing these labs. Erickson recommends several principles that a CTO should use for directing R&D. First R&D personnel should be kept in touch with the company's customers and markets. Few labs can seclude themselves from the market and conduct research for its own sake. Second, the CTO should foster open communications between R&D staff, manufacturing engineers, and the marketing department. Third, the CTO should hold the R&D labs to schedule and budget commitments. If an R&D project is not delivering results, it may need to be terminated and the funds applied more productively elsewhere. Some long-standing projects constantly show great promise and absorb resources, but produce nothing. These projects, though considered "pillars of the lab," must be held accountable and face termination if they do not produce results.[11]

R&D laboratory budgets should be the topic of critical reviews by the executive staff. The CTO should lead initial funding reviews in which R&D projects present the expectations for the project, its applicability to market needs, the position relative to competitors, and a record of past successes. The CTO should also hold in-progress reviews to monitor problems and successes. A CTO can serve as an honest broker in

these reviews because he or she comes from outside of the laboratory and is not personally involved in the projects.[10, 14]

Sales and Marketing

Earlier sections have extolled the importance of aligning technology with business strategy. CTOs like Rajeev Bharadwaj at Ejasent and Ron Moritz at Symantec are actively involved in marketing products and services. These CTOs recognize that some products are so technically sophisticated that explaining them to the trade media requires a technical representative. When the CTO is used to explain the subtle, but significant, differences between the company's products and those of competitors, he or she becomes a de facto member of the marketing staff.[27]

Working with the sales and marketing departments also insures that the CTO remains rooted in the customers' need for the product, rather than the technical sophistication of the product. Supporting this perspective, Michael Wolfe of Kana Communications says that, "Creating a product is mapping what a customer needs to what you can build."[6] Making this mapping requires regular and detailed interactions with customers and the marketplace.

Technology and Executive Leadership

Companies began adding Chief Technology Officers to the executive ranks in the 1980s because technology was becoming an integral part of many strategic decisions and future plans. The CIO already provided strong expertise on the internal application of technology. But, senior managers needed expert advice regarding the inclusion of technologies in existing products and the creation of new products and services with large technical components. A CTO that is actively involved in monitoring new technologies, separating marketing rhetoric from technical facts, and identifying profitable applications for those technologies can make a significant difference in the company's competitive future. The CTO can also add value to the company by participating in government, academic, and industry groups in a manner that creates positive attention for the company.

Technology companies are involved in thousands of acquisitions every year. Selecting the best target for an acquisition often requires reliable advice on technical issues at the executive level. The CTO is also a valuable tool in addressing the increasingly well-informed media about the products, services, and the future plans of the company. CTOs can speak as peers to other technologists and can play a role in convincing the media that the company's decisions are sound and will add value for the company's stakeholders.

It is important that the CTO not become the senior technologist of the company. Instead, he or she is the senior business executive with a focus on technology. In the CTO position, senior management is not looking for enthusiastic advice from a research scientist. Instead, they need sound advice on business decisions involving technology.

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