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Understanding How Organizations Operate Their IT Capacity-Management Processes

by

Joseph Frederick Bauer

Dissertation

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Dissertation Committee:

Al Bellamy, PhD, Dissertation Chair

Ali Eydgahi, Ph.D.

Dorothy McAllen, Ph.D.

Denise Tanguay, Ph.D.

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Abstract

There is a lack of understanding of how organizations operate their IT capacity-management processes. Within the body of literature on IT capacity-management there is an abundance of advice for organizations on how to set up or run the processes for IT capacity-management, but very little in the way of describing the processes as performed and operated in organizations out in the field.

Using qualitative methods this research sought to gain an understanding of how organizations are operating their IT capacity-management processes in the field. A dozen subjects from 10 organizations were interviewed and the data were analyzed with a grounded theory approach.

Cloud computing was found to be a disruptive technology providing the occasion for major changes in the structures of IT capacity-management. The differences in these structures were expressed through an IT capacity-management structures spectrum. The relative relationships between the roles in these structures as plotted along this spectrum were found to have the IT capacity-management role migrate from mediator, to directly linked to the data center, to largely absent.

The results provide the IT capacity-management field and managers in IT a starting point from which to shape career development and organizational change management efforts as an organization migrates from a classic structure to a cloud structure.

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Introduction

There is a general consensus among authors that the failure of information-system projects is common (Anderson, 2000; Gingnell, Franke, Lagerström, Ericsson, & Lilliesköld, 2014; Heeks, 2006; Howles, 2014; Liebowitz, 1999; McManus & Wood-Harper, 2007; Pan, Hackney, & Pan, 2008). Some put the rate as high as 70 percent (Anderson, 2000; Pan et al., 2008). One of many factors influencing the success or failure of information-system projects is that of proper IT capacity planning (Centers for Medicare & Medical Services, 2013; Howles, 2014; Liebowitz, 1999, p. 17).

The purpose of IT capacity-management is to avoid the waste of resources, avoid running out of resources, facilitate the success of information-system projects, and to aid in budget forecasting (Klosterboer, 2011). When done well, IT capacity-management helps an IT service provider avoid service-performance surprises (Office of Government Commerce, 2011, p. 160). Too much capacity, and you risk incurring too much cost as resources go unused. Too little capacity, and you risk degradations or outages, lowering quality, affecting sales and brand image.

There is no shortage of opinions, recommendations, and best practices on how to implement IT capacity-management processes (Augello, 2000; Gunther, 2010; Molloy, 2003; Office of Government Commerce, 2011; Sheldrake, 2009). However, the body of literature is quite silent on the topic of what is actually happening in organizations out in the field that adopt and perform IT capacity-management. How is it structured? What are the processes? In order to advance the field of IT capacity-management a basic understanding of how it is being operated is required.

Statement of the Problem

There is a lack of understanding of how organizations operate their IT capacity-management processes. Within the body of literature on IT capacity-management there is an abundance of advice for organizations on how to set up or run the processes for IT capacity-management, but very little in the way of describing the processes as performed and operated in organizations out in the field.

Nature and Significance of the Problem

A failure in IT capacity-management can lead to spectacular failures in service delivery. For example, the roll out of the HealthCare.gov website in 2012 was mired by performance issues, in part because capacity needed to be greater (Centers for Medicare & Medical Services, 2013; Howles, 2014). While reading through the literature on critical success factors or failure factors for IT implementations one gets a sense that failure is common (Anderson, 2000; Gingnell et al., 2014; Heeks, 2006; Howles, 2014; Liebowitz, 1999; McManus & Wood-Harper, 2007; Pan et al., 2008). For example, Pan, Hackney, and Pan (2008, p. 259) put the failure rate for information-system implementations at around 70 percent. However, as Heeks (2006, p. 127) observes, it is difficult to find specific and well-sourced statistics for the failure rate of technological implementations. Perhaps it is a statistic many organizations do not feel incentivized to advertise or disclose. One example of the difficulty in getting solid statistics that Heeks (2006, p. 127) gives is an assertion by Anderson (2000) that 70 percent of systems either fail or do not provide end-user satisfaction. But, as Heeks (2006, p. 127) says, this assertion seems to be backed up by surveys without a clear source. While there may not be good, hard statistics to point to, it does seem to be the general consensus of the authors who write on the subject of information system success and failure that failure is quite common.

Looking through the literature, one can also find that proper capacity planning is one of many success factors for information systems (Klosterboer, 2011; Liebowitz, 1999, p. 17). So, if failure is common and one of the success factors is proper capacity planning it would follow that paying some attention to how organizations are operating capacity-management processes is in order.

Objective of the Research

This research seeks to gain an understanding of how organizations are operating their IT capacity-management processes in the field. To do so, it aims to create a model describing the factors that can lead to the creation of substantive theory on how IT capacity-management is practiced.

Research Questions

The following research questions are in alignment with the research objective and were used to guide the creation of the interview questions (see Appendix B for interview questions and Appendix E for a table that shows alignment between research questions, interview questions, and the theoretical frameworks from the literature review).

1. Can a descriptive model be developed for the processes of IT capacity-management as found in practice?
    - Are there dimensions or factors that create distinctions or variants within a descriptive model for different contexts?
    - What is the structure of IT capacity-management?

    - What are the social patterns that create the process of structure in IT capacity-management?
- What are the common processes of IT capacity-management found among the organizations that are interviewed?
    - What are the inputs?
    - What are the activities that make up the process?
    - What are the outputs?
- What are the functions of IT capacity-management?
    - What are the manifest functions of IT capacity-management?
    - What are the latent functions of IT capacity-management?
    - What sustains these functions? What are their requirements or needs? What indicates success of the functions?
    - Are there any functional alternatives to the IT capacity-management functions?
    - What are the social roles that perform the functions of IT capacity-management?

Literature Review

The objective of this research is to generate a descriptive model for how organizations are operating their IT capacity-management processes. A qualitative method with a grounded theory approach is well suited for generating such models. A classical approach to grounded-theory would involve unstructured interviews or observation before literature review and then letting a theory emerge from what is observed without restricting or guiding the focus of topic (Glaser, 1992, p. 15). In the methodology section the specific approach to grounded theory will be discussed, but this is one specific area where the researcher diverts from classical grounded theory in favor of constructivist grounded theory, which acknowledges previous experience and the practical necessities of having to put some scope boundaries on a research effort (Charmaz, 2006).

The following literature review is provided first to illustrate the lack of observations or descriptive models for the given topic and second, to review the broad theoretical frameworks that can be used for framing and contextualizing the qualitatively generated information. These theoretical frameworks provide a starting point and some structure from which to guide the formation of the questions asked during the semi-structured interviews. While these theoretical frameworks may provide heuristic guidance for structuring the resultant descriptive model, they will by no means dictate the content of the model.

Capacity-management

The purpose of IT capacity-management is to avoid the waste of resources, avoid running out of resources, facilitate in the success of information system projects, and to aid in budget forecasting (Klosterboer, 2011). Several fields, not just IT, manage the capacity of resources and have done so for some time.

Capacity-management is used in manufacturing to ensure factories and machinery are used efficiently (Asl & Ulsoy, 2002). Mazzola and Neebe (2012) write about using a mathematical Generalized Assignment Model (GAP) for supply chain capacity-management and reviews the attributes and capabilities of the GAP model and then go through and describes subtle variations of the mathematical model for use in specific situations.

Martínez-Costa, Mas-Machucha, Benedito, and Corominas (2014) take a similar approach by describing capacity-planning problems in the field of manufacturing and then reviewing mathematical models from the literature that are meant to deal with these problems. Though the authors provide little evidence to back it, they claim that quantitative methods and mathematical models have been used for tactical capacity-management and should also be used for strategic-level capacity-management because, they claim, mathematical models have a greater impact on the results (Martínez-Costa et al., 2014, p. 67). The problem that the authors want to address is that capacity-management tries to integrate traditionally isolated areas and to integrate tactical and strategic decisions (Martínez-Costa et al., 2014, p. 69). The authors then review the various mathematical models found in the literature and propose a mathematical model-centered conceptual framework for strategic-capacity planning that includes defining the problem, designing the mathematical model, running the solution procedures of the mathematical model, and then generating the output, such as a capacity plan or financial plan (Martínez-Costa et al., 2014, p. 82).

Xie, Jiang, Zhao, and Hong (2014) also propose a mathematical formula for helping capacity planning and capacity allocation in a manufacturing setting. The formula takes 14 variables into account, including variables about demand, costs, prices, and capacity (Xie et al., 2014, p. 110).

In the automotive manufacturing sector, capacity-management is concerned about where and how much production capacity a production network should have (Volling, Matzke, Grunewald, & Spengler, 2013, p. 241). Through a literature review, Volling et al. (2013, p. 246) have summarized the common attributes of capacity planning for automotive-production networks, which include planning (of location, allocation, layout, etc.), objective planning (profit, costs, etc.), modeling, modeling of demand, technical capacity (modeling), organizational capacity (modeling and decision making), and international factors (modeling exchange rates, taxes, tariffs, etc.).

Jeong, Cho, Jones, Lee, and Lee (2012) propose high-level business-process models for supply-chain planning in open business environments, which include the planning of capacity. The authors describe the business patterns that might be found in an open business environment, such as suppliers, manufacturers, and customers interacting with requests for quotes, negotiations, and so on. It is unclear from where or how the authors established these patterns, but in the end they propose four different high-level business-process models for supply-chain planning (Jeong et al., 2012). These process models work to either maximize throughput or profit while working with constraints like quantity and price requirements and manufacturer capacity and profit (Jeong et al., 2012).

Spencer (1997) presents a detailed description of capacity-planning activities and how capacity-management was integrated into the Verbatim disk manufacturing company. Spencer (1997) describes the integrations between the marketing and manufacturing parts of the organization and gives examples of how Verbatim was able to use capacity planning in order to operate in a just-in-time mode and also run manufacturing facilities at full capacity. A logical model of the manufacturing process was constructed, which had steps like cut and punch, lamination process, and final fold and weld (Spencer, 1997, p. 186). Then the work was redesigned around quality control and just-in-time practices, all the way down to reconfiguring the physical layout of the plant (Spencer, 1997, p. 188). Additionally, monitoring at the line level was implemented, along with Kanban pull methods for production (Spencer, 1997, p. 188). Finally, a master production schedule was created, which was the interface between the marketing side of the organization and the production side of the organization in that it aligned the marketing and production activities (Spencer, 1997, p. 189). Spencer concludes that just-in-time supply methods do not replace the need for capacity-management functions; instead, it integrates into the master production scheduling function (Spencer, 1997, p. 193).

Hospitals and the healthcare industry have also used capacity-management for controlling costs and improving quality (Li & Benton, 2003). In Canada, Zhang and Puterman (2013, p. 272) discuss capacity planning for long-term care where the resource scarcity that is being managed is hospital beds. The process for long-term care is described as an individual patient performing an eligibility assessment, and then if they meet the criteria they enter a waitlist or go directly for care if capacity is available (Zhang & Puterman, 2013, p. 272). Then the individual waits, with home care and other support until capacity is available at a first-come first-serve basis (Zhang & Puterman, 2013, p. 272). The patient remains in the queue until being serviced or until death (Zhang & Puterman, 2013, p. 272). Zhang and Puterman (2013, p. 273) then go on to describe a mathematical model for planning hospital capacity in long-term care given specified wait time service-level criterion.

Rees, Houlahan, and Lavrenz (2014, p. 121) also describe healthcare capacity in terms of beds, but they include available physicians and staff in their list of resources being managed. If a medical center doesn't have enough capacity it has to turn patients away in a practice called "diversion," and in the author’s case study the medical center they studied had to divert 87 patients in 2011 (Rees et al., 2014, p. 121). After implementing capacity-management strategies in 2012, improvements were seen (Rees et al., 2014, p. 122). In 2012 only two patients were diverted and during the first eight months of 2013 only two patients were diverted (Rees et al., 2014, p. 122). The strategies implemented included a communication plan, staffing guidelines, morning rounds, proactive planning, and an escalation process (Rees et al., 2014, p. 122). The communication plan helped to address challenges during low staffing situations (Rees et al., 2014, p. 122). The staffing guidelines were put in place in order to standardize options when making staffing decisions and to develop a flexible workforce approach (Rees et al., 2014, p. 122). For morning rounds, key nursing staff areas that were previously omitted were included (Rees et al., 2014, p. 122). The proactive planning consisted of a 20-hour forecast of capacity needs that was delivered once per day in order to proactively flex capacity and staff accordingly (Rees et al., 2014, p. 122).

Capacity planning is a topic in transportation planning as well. Wei, Grenard, and Shah (2011) discuss developing capacity-planning models for local roundabouts at street intersections in the United States. The process of developing the capacity model includes video data collection, data processing and verification, and model development (Wei et al., 2011, p. 4). The data collection involves a selection of roundabouts with congestion, the determination of collection periods, and then the deployment of video equipment (Wei et al., 2011, p. 4). Data processing and verification includes the processing of the video files to create traffic flow rates, then verifying the data with the video, then reducing the data based on the congested periods (Wei et al., 2011, p. 4). The model development is a step that contains regression analysis for each roundabout entry and outlier removal, and then regression analysis and best fit model selection (Wei et al., 2011, p. 4). Then, finally, a comparison is made of the selected models to the national models (Wei et al., 2011, p. 4). In the end, Wei et al. have proposed a process for developing and selecting mathematical models but have not described any processes or activities for dealing with the outputs of the model (Wei et al., 2011, p. 9).

Similarly, Malavasi, Molková, Ricci, and Rotoli (2014) evaluate multiple mathematical models for planning the carrying capacity of complex railway nodes. The three mathematical models for evaluating railway capacity were the Potthoff method, Probabilistic method, and the Deutsche Bahn method (Malavasi et al., 2014). These models were then applied to real world cases at Frattamaggiore Station in Italy and the Czech stations of Uhersko and Praha Masarykovo (Malavasi et al., 2014). The results from applying the various mathematical models were compared and analyzed, and the authors determined that each model was useful for different aspects of capacity modeling (Malavasi et al., 2014).

Capacity-management is even used in the forest management field where the resources being managed are the supply of wood in trees (Paradis, LeBel, D'Amours, & Bouchard, 2013). In their article, the authors discuss the challenges with large-scale hierarchical forest-management planning and propose linking long-term and short-term planning processes to reduce strategic incoherence (Paradis et al., 2013). At its core, this solution is about aligning two mathematical models rather than aligning the two isolated social structures of government and industry planners (Paradis et al., 2013).

IT Capacity-management

Just as the manufacturing, health care, and transportation industries discussed above, the field of information technology (IT) also manages the capacity of resources. The IT capacity-management field has many published frameworks to choose from. The IT Infrastructure Library (ITIL) is the most popular framework among IT service-management best practices with a 28 percent adoption rate in U.S. companies that are implementing IT service management (IT Governance Institute, 2011, p. 29).

The ITIL framework consists of six publications that cover information like practice fundamentals and principles, processes, roles, and critical success factors (Office of Government Commerce, 2007, p. 6). What does an organization expect to get out of implementing ITIL? Improved IT service, reduced costs, improved customer satisfaction, improved productivity, improved use of skills and expertise, and improved delivery of third-party service (APMG, 2012, para. 5). Out of the six volumes published for defining ITIL, IT capacity-management is defined in the *Service Design* publication with about 20 pages of text (Office of Government Commerce, 2011, pp. 157–179).

The purpose of capacity-management in ITIL is ". . . to ensure that the capacity of IT services and the IT infrastructure meets the agreed capacity and performance-related requirements in a cost-effective and timely manner" (Office of Government Commerce, 2011, p. 158). ITIL goes on to say that without this, the "utility" of the services being managed would be inaccessible, meaning that the features or capabilities that users want would be unavailable (Office of Government Commerce, 2011, p. 158). This would, of course, be bad for the organization. However, "[g]ood capacity-management ensures that there are no surprises with regard to service and component design and performance (Office of Government Commerce, 2011, p. 160).

Capacity-management spans the lifecycle of services, meaning that it is used during all phases of the service lifecycle including designing, building, and running the service (Office of Government Commerce, 2011, p. 157). ITIL notes that capacity-management should have a strong relationship with those doing the strategy and planning of services: “In conjunction with the business and its plans, capacity-management provides a capacity plan that outlines the IT resources and funding needed to support the business plan, together with a cost justification of that expenditure" (Office of Government Commerce, 2011, p. 159).

A key activity is the production of a plan that should include forecasts and recommendations in terms of resources required, cost, benefits, and impacts (Office of Government Commerce, 2011, p. 161). ITIL recommends that this capacity plan be published annually in line with the organization’s budget cycle. Quarterly updates may be necessary in order to take into account any changes in service plans (Office of Government Commerce, 2011, p. 161).

ITIL describes capacity-management as having three sub-processes: business-capacity management, service-capacity management, and component-capacity management (Office of Government Commerce, 2011, p. 161). The business-capacity management sub-process translates business needs and plans into component and service requirements, while the service-capacity management sub-process is concerned with the overall capacity of the service from the customer's perspective and ensures the performance meets the SLAs (Office of Government Commerce, 2011, p. 161). Component-capacity management is concerned with the individual technical components that make up and support the services by monitoring, measuring, analyzing, and reporting on these components (Office of Government Commerce, 2011, p. 161).

At a high level, the ongoing activities of capacity-management follow a Deming-style iterative cycle of monitoring, analysis, tuning, and implementing (Office of Government Commerce, 2011, pp. 168–170). Operating systems, hardware configurations, and applications should be included in monitoring, which should also include information like utilization, transaction information, or response times (Office of Government Commerce, 2011, pp. 168–170). A big part of monitoring is threshold management, where alarms are raised when thresholds are exceeded (Office of Government Commerce, 2011, pp. 168–170). The measurement of user response times is often required because many service-level agreements have user response-time targets in them (Office of Government Commerce, 2011, pp. 168–170). To achieve this, ITIL recommends incorporating specific programming code within client and server applications software, or using “robotic-scripted systems” with terminal emulation software, or using distributed-agent monitoring software, or using specific passive-monitoring systems (Office of Government Commerce, 2011, p. 170). Analysis should be done to establish the trends for baselines, and it should also predict future resource usage (Office of Government Commerce, 2011, pp. 170–171). It then also compares projected business growth against actual growth (Office of Government Commerce, 2011, pp. 170–171). Monitoring and analysis can illuminate areas of the configuration that could be tuned to improve the performance of components or services; then tuning could be employed to do things like balancing workloads and traffic, balancing disk traffic, or tuning the efficient use of memory (Office of Government Commerce, 2011, pp. 171–172). The final step, implementation, enacts or performs any changes recommended out of the monitoring, analysis, and tuning steps (Office of Government Commerce, 2011, p. 172).

In addition to ITIL, there is also the Capability Maturity Model Integration (CMMI) model collection for services, which describes capacity and availability management together as being responsible for ensuring effective performance and effective resource usage in support of service requirements (CMMI Product Team, 2010, p. 124). Even enterprise architecture frameworks, such as the Open Group Architecture Framework (TOGAF), mention capacity-management from a change management and architecture perspective (TOGAF, 2011, para. 7). All of these frameworks provide advice for implementing IT capacity-management processes, but do not offer observations on how organizations are performing it in the field.

Just like the previously discussed fields of capacity-management, the field of IT capacity-management also leans heavily on mathematical models. Ghosh, Longo, Xia, and Trivedi (2014) write about planning the capacity for hosting an infrastructure as a service (IaaS) cloud service (cloud services will be defined and discussed later in this literature review) using a stochastic-mathematical model. Their model helps determine the optimum number of physical machines needed in order to minimize cost (Ghosh et al., 2014, p. 667). The model takes service requirement variables like downtime and job-rejection rates and then calculates the type and number of nodes you would need to meet those requirements with the least amount of operating cost (Ghosh et al., 2014, p. 671). Mohan, Alam, Fowler, and Gopalakrishnan (2014, p. 542) also propose a mathematical model for determining how many servers to include in web-based applications while being able to maintain good quality of service, which is measured as average response times. When dealing with very large databases, Zhuang, Ramachandra, and Xiong (2015) provide a mathematical model for figuring out the minimal amount of resources needed for providing expected service levels. Yexi Jiang, Chang-Shing Perng, Tao Li, and Chang (2013) propose capacity-management mathematical models for organizations that are providing cloud solutions or services. Their model incorporates variables like cost of SLA penalty, cost of resource waste in determining the right amount of resources to have available (Yexi Jiang et al., 2013). All of these descriptions and proposals for mathematical models are not so much descriptions of processes for managing capacity as they are tools for analysis.

The Computer Measurement Group (CMG) is a vibrant international community of IT capacity-management practitioners. Founded in 1975, it aims to advance the field of IT capacity and performance management (Computer Measurement Group, Inc., 2012a). The CMG holds conferences, has a trade journal (*MeasureIT*), and publishes a peer-reviewed journal called the *Journal of Computer Resource Management* (Computer Measurement Group, Inc., 2012b). A survey of the literature from the *Journal of Computer Resource Management* from 2000 to 2013 shows no articles observing or describing IT capacity-management processes as they are found in practice in organizations.

Some authors have interpreted and re-interpreted the ITIL framework as it pertains to IT capacity-management and how to implement it (Grummit, 2009; Molloy, 2003). For example, Lutz, Boucher, and Roustant (2013, p. 332) extend the ITIL framework for IT capacity-management to include better decision-making aids through modelling and monitoring activities. The authors identified two specific challenges they want to address: system complexity and business activities being isolated from capacity planning (Lutz et al., 2013, p. 336). Their research consisted of a case study of a company called STMicroelectronics, where their preliminary survey showed the company had no formalized methods for modeling or monitoring with regard to capacity (Lutz et al., 2013, p. 337). STMicroelectronics was described just as having a complex IT environment and busy IT managers (Lutz et al., 2013, p. 343). Their IT capacity-management modelling process was briefly mentioned as having been "qualitative" and under suspicion by others in the organization for not being objective enough (Lutz et al., 2013, p. 343). Monitoring was described as being manually checked on a regular basis with simple visualization on a spreadsheet (Lutz et al., 2013, p. 343). The authors jump right on into examining how the gap in modelling and monitoring could be fixed and propose modifications to the ITIL framework that involve formal and quantitative mathematical modelling and then daily qualitative observational monitoring (Lutz et al., 2013, p. 342). It is unclear from the article who created it, but a custom statistical software application that monitors and alerts people when there are abnormalities was created for STMicroelectronics (Lutz et al., 2013, p. 349). When the new software sends an alert, experts are then said to gather to analyze the results, but it is unclear if this is an observed fact or a suggested state (Lutz et al., 2013, p. 349). The authors share data the custom statistical-software application generated, but there is nothing in the way of a description of how the people at STMicroelectronics accepted the new technology or what they did with it after it was introduced, or how it was incorporated into their overall processes (Lutz et al., 2013, p. 349).

The body of literature on IT capacity-management lacks insight into how organizations are performing the proposed frameworks, best practices, or recommendations. Indeed, it is difficult to know if organizations are heeding any of this advice. A fundamental requirement for understanding the discipline of IT capacity-management and its effectiveness requires knowing how organizations are operating and practicing IT capacity-management processes. One cannot spell out the current state of the IT capacity-management discipline without a basic understanding of how organizations are or are not operating their IT capacity-management processes.

Cloud Computing

Cloud computing is a disruptive technology that is providing an occasion for change among existing socio-technical structures (Barley, 1986; Kushida, Murray, & Zysman, 2015). Cloud computing is reviewed in detail here because it plays a major role in how the results are interpreted and analyzed.

In simple terms, cloud computing delivers computing services to users at the time, location, and quantity they want, and at a cost that is based only on what is used (Fehling, Leymann, Retter, Schupeck, & Arbitter, 2014, p. 1; Kushida, Murray, & Zysman, 2011, p. 211; Kushida et al., 2015, p. 7). It provides ubiquitous, convenient, and on-demand access to a shared pool of massively scaled resources that can be rapidly provisioned (Beri & Behal, 2015, p. 19; Kushida et al., 2015, p. 6).

It is called cloud computing, in part, because it abstracts out a layer of underlying infrastructure from the user of the service (Beri & Behal, 2015, p. 9; Kushida et al., 2011, p. 210). Cloud computing services are commonly bound to the architecture layer they abstract, such as infrastructure, platform, or software (Kushida et al., 2015, p. 8; National Institute of Standards and Technology, 2011, pp. 2–3). Infrastructure as a service (IaaS) is where the hardware layer of the computing infrastructure is abstracted and provided as a service, like Amazon Web Services or RackSpace (Kushida et al., 2015, p. 8). A user of IaaS still has to install and manage an operating system and software. Platform as a service (PaaS) builds on IaaS by additionally abstracting out the operating system level of the architecture layer and providing that as a service, like Google App Engine or Windows Azure (Kushida et al., 2015, p. 8). Software as a service (SaaS) builds even further upon PaaS and abstracts out the software architecture layer and provides that as a service, like Google Docs or MS Office 365 (Kushida et al., 2015, p. 8).

National Institute of Standards and Technology (NIST) provides a definition of cloud computing that is cited and re-used by others (Beri & Behal, 2015; Fehling et al., 2014; Kushida et al., 2011, 2015). It describes cloud computing as having the five essential characteristics of “on-demand self-service,” “broad network access,” “resource pooling,” “rapid elasticity,” and “measured service” (National Institute of Standards and Technology, 2011, p. 2). You can hear the definitions of cloud computing that opened this section as echoes of the NIST definition. It’s worth repeating: cloud computing delivers computing services to users at the time, location, and quantity they want, and at a cost that is based only on what is used (Fehling et al., 2014, p. 1; Kushida et al., 2011, p. 211, 2015, p. 7). That covers the NIST defined characteristics of “on-demand self-service” (when I want), “broad network access” (where I want), and “measured service” (quantity and cost I want). Then, the other part of the definition covers the rest: It provides ubiquitous, convenient, and on-demand access to a shared pool of massively scaled resources that can be rapidly provisioned (Beri & Behal, 2015, p. 19; Kushida et al., 2015, p. 6). “Resource pooling” and “rapid elasticity” are covered by this part of the definition. It’s worth noting that the concept of elasticity doesn’t just apply to being able to quickly order more stuff. Elasticity is also the ability of the provider to dynamically add or remove resources within the abstracted architecture layer without the other layers being affected (Kushida et al., 2011, p. 212).

NIST and others make a distinction between private and public cloud services (Beri & Behal, 2015, p. 21; Fehling et al., 2014, pp. 62–70; National Institute of Standards and Technology, 2011, p. 3). In public cloud, the computing services are offered to the general public, and the infrastructure is on the premises of the cloud-service provider (Beri & Behal, 2015, p. 21; National Institute of Standards and Technology, 2011, p. 3). With a private cloud, the service is just for one organization and is usually thought of as being internal to one organization (Beri & Behal, 2015, p. 21; National Institute of Standards and Technology, 2011, p. 3). In a private cloud setting, the infrastructure is provisioned just for one organization (National Institute of Standards and Technology, 2011, p. 3).

Theoretical Frameworks

Since the objective of this research is to generate a descriptive model for how organizations are operating their IT capacity-management processes, it is a good idea to understand what is meant by the term process. Through which theoretical lens shall we interpret the meaning of process? What is the language that we use to describe it?

The term IT capacity-management process refers to a type of business process. Since the research takes a snapshot in time of the structure of this particular business process and describes it with a model, structural functional analysis can be quite useful. However, there are certain pitfalls to using structural functional analysis, so a review of structuration, which views structure as a process that evolves over time, can help in avoiding the pitfalls of structural functional analysis.

Business Process. The term ‘process’ is used often in a broader sociological context, but it also has a business-process meaning. Business-process management is the practice of managing processes to make them more efficient and effective (Van Nuffel & De Backer, 2012, p. 131). The basic structure of a business process is where inputs are transformed to outputs through a series of activities (Aguilar-Savén, 2004; Fu-Ren, Yang, & Yu-Hua, 2002; Hammer & Champy, 2003; Parkash & Kaushik, 2011). Davenport (1993, p. 5) is even more specific and says that a business process is a set of work activities in a specific order across time and place that has a beginning, ending, and clearly defined inputs and outputs. Characteristics of a process include a definition of which activities are to be performed, the ability for it to be repeatable, and should have predictable and measurable outputs (Parkash & Kaushik, 2011, p. 4).

There are many modeling languages that are used for abstracting, communicating, and managing processes, like BPMN, EPC, Petri Nets, and SIPOC (Van Nuffel & De Backer, 2012, p. 132). There are multiple layers of process modeling, each with differing levels of detail or abstraction. They can range from the process level, to activity level, and all the way down to the task level (Van Nuffel & De Backer, 2012, p. 133). Since this research effort aims to create a descriptive model of the IT capacity-management business processes, these modeling languages are useful. Instead of inventing a new language to describe the processes, one of the existing modeling languages could be used.

One way to model a process at a high level, rather than detailed activity or task level, is through a SIPOC (Suppliers, Inputs, Process, Outputs, and Customers) model (Parkash & Kaushik, 2011, p. 6). Suppliers are the roles who provide the inputs (materials or information), while the process is the series of steps that transform the inputs into the outputs that are consumed by the customers (Islam & Daud Ahmed, 2012, p. 296). Suppliers and customers answer the "who" question, while inputs and outputs are the "what" and the process answers "how" (Parkash & Kaushik, 2011, p. 6).

Structural functional analysis. This research is concerned with the specific contemporaneous manifestations of business processes that exist to support the existence of the structure of IT capacity-management within organizations. IT capacity-management is the system and structure that is being studied. That system and structure has parts, patterns, and roles, and each of the constituent parts has a function, be it formal or informal (Merton & Sztompka, 1996). IT capacity-management has functions and dysfunctions, whether manifest or latent (Merton & Sztompka, 1996).

Structural functional analysis says that a function, as an object of analysis, is a patterned construct, such as institutional patterns or social norms (Merton, 1957, p. 50). Functions have objective consequences, be they manifest (intended) or latent (unintended) (Merton, 1957, p. 51). A function can be found at several social levels (individual, group, society) and could have different consequences for different social units (Merton, 1957, p. 52). Functions also have requirements, needs, or prerequisites for their existence (Merton, 1957, p. 52). There are social mechanisms that perform a function (such as division of labor, role segmentation, etc.) and there can be functional alternatives to any given function that could provide a range of possible variations in fulfilling a functional requirement (Merton, 1957, p. 52). Since a business process is also a patterned construct, analyzing it in terms of function can be useful.

This research aims to generate a current-state descriptive model of IT capacity-management business processes. Business processes operate within the context of their structure and, therefore, awareness of the functions provides a more holistic view of the processes operating within them. The processes may then be explained by their functions. For example, as the research questions ask: what sustains these functions? What are their requirements or needs? What are the intended (manifest) functions of IT capacity-management? What are the unintended (latent) functions of IT capacity-management? This is not a longitudinal effort, so it takes a snapshot in time, as if freezing a motion video on a particular frame and describing it. However, this is not to be an objective or deterministic exercise. It is understood that the frozen frame stands within a context of motion. To that end, structure is to be seen more as patterns of action influenced by the complex interactions between humans and their social structures rather than as a static, objective, and deterministic artifact (Barley, 1986). Then, why the use of structural functional analysis while also refuting it as static, objective, and deterministic? The use of functionalism here is limited to its utility in describing a model or framework for a given process in a given static snapshot of time, which is the aim of this research. Functionalism's framework offers a heuristic guide for framing the questions of the research and the interviews that is congruent with a research effort that is not longitudinal.

Structuration. Giddens refutes the deterministic views of human agency in structural functionalism, which describes actions as the result of social causes (Giddens & Dallmayr, 1982, p. 15). Giddens proposes the theory of structuration, which is built upon a non-deterministic version of functionalism, along with hermenutics (theory of interpretation), and phenomenology (Giddens & Dallmayr, 1982, p. 7). Structuration takes a theory of the subject approach in order to avoid the objectivist view that holds human agency as a determined outcome of social causes (Giddens & Dallmayr, 1982, p. 8). While refuting objectivism, Giddens is careful to not swing all the way to a purely subjective view of human agency and states that subjects (human agents) and objects (society or institutions) are created and interact together; one is not more important than the other (Giddens & Dallmayr, 1982, p. 8). Undoubtedly influenced by hermeneutics, Giddens asserts that human agency has the ability to make its own decisions or to evaluate a range of possible actions and to make a choice (Giddens & Dallmayr, 1982, p. 9). What Giddens implies here is that humans don't just reflexively react to their social context, but have their own ability to interpret the social context and decide their own actions. This would seem to be validated when, later, Giddens states that "[h]uman beings, however, are not merely inert objects of knowledge, but agents able to -- and prone to -- incorporate social theory and research within their own action" (Giddens & Dallmayr, 1982, p. 16).

The structure in structuration theory refers to the social rules and resources within the social system and not to some physical object (Giddens & Dallmayr, 1982, p. 9). Structuration is a recursive process, whereby structure is both the medium and the output, thus allowing structures to evolve over time (Giddens & Dallmayr, 1982, p. 9).

While functionalism is not incompatible with process analysis, its weakness (in its deterministic views) can be remedied by considering human agency. From structuration we understand that while studying the object of business process, we should also consider the subjective role of human agency. The highly subjective social aspect of human agency is half of the structuration dialog between subject and object that generates the continually evolving structure. Because of this, as the research questions ask, the social patterns that create the process of structure in IT capacity-management must be explored.

Putting the frameworks together. The business processes of IT capacity-management are placed within the context of a dynamic structure (structuration), where it is understood that structure evolves over time in a reflexive social process (see Figure 1. Relating the Theoretical Frameworks). For this research, a snapshot is taken of the present state of the business process structures by using some features of structural functional analysis to help frame the questions for data collection. The structure of the IT capacity-management business processes are not pre-conceived and emerge from the analysis. As the problem statement says, coming into this research, there is a lack of understanding. There is no a priori idea for what the structure is or what the descriptive model will look like.

Figure 1. Relating the Theoretical Frameworks**.**

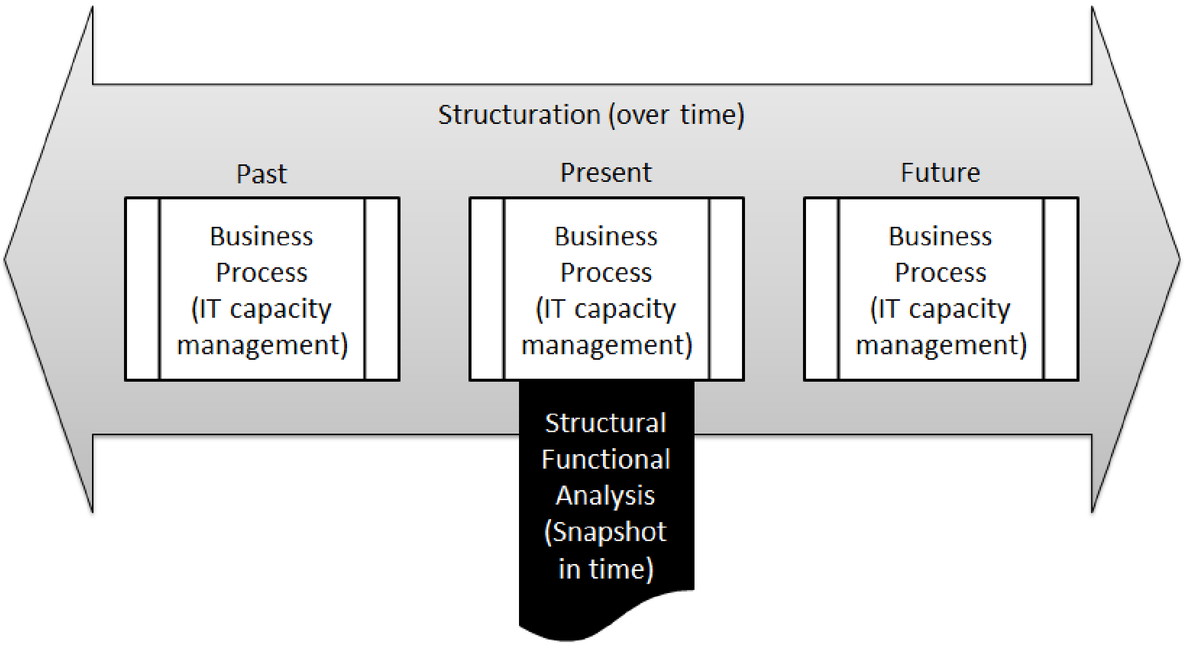


Figure 1. The business processes of IT capacity-management are placed within the context of a dynamic structure (structuration), where it is understood that structure evolves over time in a reflexive social process

These frameworks relate to the research questions by providing a means or a language to answer them in an organized and cogent way. The business-process framework helps when answering the research questions around what the common processes of IT capacity-management are among the organizations that were interviewed. It provides a framework or language for describing the process and also answering the sub-questions about inputs, activities, and outputs. Structural functionalism helps in articulating the functions of IT capacity-management when answering that research question. It also helps when describing the sub-questions about manifest or latent functions, what sustains the functions, and what the social roles are that perform the functions. When answering the research question about what the structure of IT capacity-management is, structuration is utilized to help keep in mind the dynamic nature of structure.

Methodology

This research strives to gain the emic perspective from the insider point of view rather than an etic objective perspective from an outsider (Olson, 2011, p. 15). The qualitative method is especially well suited to learning from the experiences of those who play a role in the research topic (Olson, 2011, p. 15). Since the goal was to generate hypotheses, and not to verify them, the grounded-theory approach to the analysis of qualitative data was used (Glaser, 1992, p. 33).

Research Design

If the objective of the research is to gain an understanding of how organizations are operating their IT capacity-management processes, then why not simply collect process documentation, like process flow charts and organizational structure diagrams? Because business processes (like IT capacity-management) are designed patterns of interactions for a specific organizational objective. Humans are not robots, programmed with a specific set of patterns and switched on to carry them out. Humans have agency and their own priorities, needs, wants, and their interpretations of situations can get in the way of or alter the originally designed process plans. You cannot just look at a process-flow diagram of the intended or planned process flows and think you are seeing what the real processes are. Processes come to life through the interactions of humans. Because of agency these processes can drift from the originally intended into something new. The objective of the research is to understand how organizations are *operating* their processes in the present tense, not how they planned to operate them. This will generate a model that illustrates a snapshot in time of the current state of the practiced processes.

Semi-structured formal interviews with individual IT capacity-management practitioners were utilized. Interviews were used instead of observation because it would have been impractical to perform direct observation given the time and resource constraints for the research effort. Formal interviews were favored over informal interviews because there is no need for the participant to be unaware that they are being interviewed in this research topic. Informal interviews would introduce unnecessary questions around the ethical nature of the interview design (Olson, 2011, p. 44).

Subjects

The subjects consist of twelve IT capacity-management practitioners. As will be seen in the analysis, not all of the subjects identify themselves as a capacity manager, but they all do perform activities consistent with IT capacity-management. Capacity-management practitioners were sought as the subjects because they are people who have spent time thinking about capacity-management and doing capacity-management activities. They are “thoroughly enculturated” in the topic (Olson, 2011, p. 25).

Subject selection began by soliciting participation from practitioners who are members of the Computer Measurement Group (CMG), a community of IT capacity-management practitioners (Computer Measurement Group, Inc., 2012a). Subjects were solicited via email. In order to get more participation from practitioners of cloud-capacity management, the researcher made solicitations via LinkedIn.com professional groups. Twelve subjects from ten organizations were interviewed altogether. The organizations were from varying locations and of varying sizes. Six industries were represented: Insurance, Financial Services, Consulting, Telecommunications, Software, and Higher

Education. The table below summarizes the organizational demographics for each organization being studied.

Table 1

Organizational Demographics Summary

Organization	Industry	Years doing Capacity-management	Number of employees	Location
Organization 01	Insurance	10	2,000	Midwest, USA
Organization 02	Financial Services	9	20,000	Western, USA
Organization 03	Consulting	9	1	Southwest, USA
Organization 04	Consulting	4	250	Eastern, USA
Organization 05	Telecommunications	2	40,000	Brazil
Organization 06	Higher Education	10	5,600	Midwest, USA
Organization 07	Telecommunications	20	100,000	UK
Organization 09	Software	3	30	Midwest, USA
Organization 10	Software	4	30	Midwest, USA
Organization 12	Higher Education	7	2,000	Midwest, USA

Except for Organization 06, each organization had one interviewee with one interview session. Organization 06 had three interviewees with three interview sessions (one each). The table below links the interviewees (columns) with the organizations which they represented (rows).

Table 2

Interviewee to Organization Mapping

	Person 01	Person 02	Person 03	Person 04	Person 05	Person 06	Person 07	Person 08	Person 09	Person 10	Person 11	Person 12
Organization 01	X	-	-	-	-	-	-	-	-	-	-	-
Organization 02	-	X	-	-	-	-	-	-	-	-	-	-
Organization 03	-	-	X	-	-	-	-	-	-	-	-	-
Organization 04	-	-	-	X	-	-	-	-	-	-	-	-
Organization 05	-	-	-	-	X	-	-	-	-	-	-	-
Organization 06	-	-	-	-	-	X	-	X	-	-	X	-
Organization 07	-	-	-	-	-	-	X	-	-	-	-	-
Organization 09	-	-	-	-	-	-	-	-	X	-	-	-
Organization 10	-	-	-	-	-	-	-	-	-	X	-	-
Organization 12	-	-	-	-	-	-	-	-	-	-	-	X

The table below summarizes the demographics of the individual interviewees.

Table 3

Interviewee Demographics

Interviewee	Sex	Job Title	Percent Appointment	Highest Education	Years doing Capacity-management	Years with organization
Person 01	Male	Capacity Planner	50	Bachelor’s	38	10
Person 02	Male	Enterprise IT Architect	0	Bachelor’s	15	9
Person 03	Male	Chief Technical Officer	100	Ph.D.	25	9
Person 04	Female	Global Practice Principle	100	Bachelor’s	25	4
Person 05	Male	Capacity Analyst Senior	100	Unassigned	Unassigned	5
Person 06	Male	Project Manager	40	Bachelor’s	5	18
Person 07	Male	Capacity Manager	100	Bachelor’s	10	40
Person 08	Male	Enterprise Infrastructure Architect	100	Master’s	7	Unassigned
Person 09	Male	Chief Systems Engineer	100	Bachelor’s	5	Unassigned
Person 10	Male	Director of IT and Software Development	100	Master’s	4	4
Person 11	Male	Manager of Core Services	100	Bachelor’s	20	5
Person 12	Male	Systems Administrator Senior	100	Bachelor’s	17	7

Human Subjects Approval. Human subjects approval was sought and obtained from the Eastern Michigan University Human Subjects Review Board. The following precautions were taken to ensure human-subject safety and informed consent.

The interviewees were provided with informed consent and an interview was not to proceed until it was understood and signed. The interviewee was notified that the audio of the conversation would be recorded. The interviewee and his/her organization are to remain anonymous. A name-to-pseudonym key file is kept on encrypted and password-protected USB drive, locked in a safe at the researcher's residence. This key file has the real name, the pseudonym, and the contact information (like email address, phone number, address) needed for coordinating the interviews and the post-interview interactions (such as sending them the final report, if desired). The transcript notes only have the pseudonym recorded. That way, the separate key file is required in order to connect the interview notes with the identity. Audio recordings remained on the recording device (also locked in a safe at the researcher's residence when not in use) only until transcribed by the researcher as soon as possible after the interview, and then were deleted from the recording device. The transcriptions also use the pseudonyms instead of names so that no identifiable information could be gleaned from them. Any identifying information outside of the names were redacted from the transcription. Permission for audio recording was sought at the same time as informed consent was being acquired. Hand-written notes were kept in the safe at the researcher’s residence when not in use and were destroyed after the transcription was created. See Appendix A for a copy of the informed consent form.

Data Collection

The semi-structured interviews were guided by questions designed and selected in advance (see Appendix B). In order to improve reliability, the interview questions were reviewed by a practitioner of IT capacity-management for clarity and understandability. See Table 8 in Appendix E for examples of how the interview questions, research questions, and theoretical frameworks are related. The interview questions support the objectives of the research because they are derived from the research questions, which were guided by the theoretical frameworks that were previously discussed in the literature review.

The date and time of the interview was coordinated over email with the subject in advance with a reminder emailed to the subject the day before the scheduled date of the interview. While scheduling the interview, the subject was sent a copy of the informed-consent agreement. To the extent possible, interview sessions were staggered to give time for performing analysis between each interview.

If an in-person interview was not possible, a telephone-based interview was conducted. Three interviews were performed in person (for organizations nine, ten, and twelve), while the remaining nine were held over the phone.

Before beginning the interview, the subjects were explicitly asked permission to record the audio of the interview for transcription purposes even though they were given notice during subject selection of audio recording.

During the interviews a Livescribe smart pen was utilized to capture audio and handwritten notes digitally. Subjects were allowed to answer the questions however they felt and were not guided in their answers through feedback from the researcher. The researcher was responsible for transcribing the audio recordings and handwritten notes into text in Nvivo software as soon after the interview as possible. Audio recordings remained on the recording device (locked in a safe at the researcher's residence when not in use), but were transcribed by the researcher as soon as possible after the interview and then deleted from the recording device. The transcriptions use pseudonyms instead of names. Any identifying information outside of the names was redacted from the transcription. Hand-written notes were kept in the safe at the researcher’s residence when not in use and were destroyed after the transcription is created.

At the end of each interview, the subject was asked if he/she had any questions for the researcher. Then the subject was reminded that he/she would get an advance copy of the analysis for review (this is called member checking). They were encouraged to provide feedback, but not required. One way to increase reliability is through member checking, which is following up with the subjects after some analysis has been done in order to see if they find the analysis accurate from their perspective (Creswell, 2009, p. 191). After analysis has been conducted, the participants will be emailed a copy and asked for feedback. Any feedback may be incorporated into the final report.

Data Analysis

Grounded theory is about discovery and the development of theory and not about theory validation through logical deductive reasoning (Glaser, 1994, p. 96). In this research, a descriptive model of how IT capacity-management is being performed is absent from the literature and must be discovered and developed. Grounded theory does not aim to verify existing theories or hypotheses, but it does check the developed grounded theory against existing literature and make comparisons (Glaser, 1994, p. 97). Such a comparison can be found in the summary section of this research report.

In 1967 Glaser and Strauss published the successful *Awareness of Dying*, which used a novel analysis approach for the time (Glaser, 1992, p. 8). Because they were fielding so many questions about how they had approached the research for *Awareness of Dying*, they decided to publish about their grounded theory approach in *Discovery of Grounded Theory* (Glaser, 1992, p. 8). This brought together the Chicago and Columbia schools of sociology to create what we call grounded theory (Glaser, 1992, pp. 1–3). However, by 1991 Glaser and Strauss had a falling out over a book Strauss had published in 1988 called *Basic Qualitative Research*, where Strauss diverges from Glaser (Glaser, 1992, pp. 1–3). Strauss' version of grounded theory is pragmatic and slightly more objective in nature, whereas Glaser's version is concerned about creating substantive theory in a more pure, unforced way (not forcing data into categories, for example) (Glaser, 1992). The researcher can appreciate the pragmatic approach of Strauss, but finds Glaser's more inductive version of grounded theory more appropriate to the needs of this research.

Charmaz (2006) built upon Glaser's by providing constructivist grounded theory, which acknowledges the reality that a researcher will come to a topic with some past history and biases but must manage them rather than ignore them. This researcher is coming to this topic with two decades of IT experience and will neither recuse himself from conducting such research nor pretend he is unaware of such past experiences. Instead, Charmaz' specific constructivist flavor of grounded theory will be used over Glaser's classic grounded theory wherever the two diverge.

Following a grounded theory approach, the data analysis consisted of three basic steps: open coding, selective coding, and development of a theory (Glaser, 1992; Leedy & Ormrod, 2010, p. 143). In this case, the “theory” is a descriptive model.

During the first phase of coding one should compare incident to incident (in this case that would be interview to interview) instead of within a single incident (Glaser, 1992, p. 39). The goal is to find patterns within the entire body of data, not just a single source. Glaser (1992, p. 39) suggests asking the neutral question of what category does this incident indicate?

Categories are created and named during coding as they emerge and are discovered (Glaser, 1992, p. 40). A category is a type of concept -- the meaning or pattern within a set of descriptive incidents (Glaser, 1992, p. 38). Open coding is coding but without a preconceived set of categories from which to code (Glaser, 1992, p. 38). While generating codes during open coding, or initial coding as Charmaz (2006, p. 48) puts it, the codes should be action oriented rather than based on topic.

What a category is named is called its label, and in guidance for naming categories Glaser (1992, p. 40) suggests that there are two types of category labels: sociological constructs and in vivo words. Labels based on sociological constructs come from the review of sociological literature, such as the literature review above, whereas in vivo words come from the study of the incidents themselves (Glaser, 1992, p. 40). Special care should be taken with in vivo codes because these are special terms that participants use and are assumed to be understood within their context (Charmaz, 2006, p. 55). The exact meanings of these terms should be understood before using them as codes. Glaser (1992, p. 45) recommends that the sociological construct categories usually represent around 10 percent of the categories, with substantive in vivo categories making up the rest. In this research, five of the 49 categories were sociological constructs, putting it at 10.2 percent (see Appendix J). This lopsided ratio of sociological constructs to in vivo words likely has to do with the goal of grounded theory being to generate substantive theory and not verify a preexisting theory. If not enough concepts come from the data, then the contribution of original theory would be quite limited.

Selective coding occurs after open coding has hit category saturation (Glaser, 1992, p. 75). Category saturation occurs when the compared incidents can be interchangeable for the same concept, and the introduction of new incidents does not yield any new categories or concepts (Glaser, 1992, p. 40). Selective coding is used to guide further data collection and future coding so as to focus on only to the core variables of concern to the theory under development (Glaser, 1992, p. 75).

Finally, during the development of a theory, a model or explanation is proposed that is grounded in the data that were collected (Leedy & Ormrod, 2010, p. 143). In this research a descriptive model is generated. The model that is developed should be based on the codes from the previous steps and should tell a focused, coherent, and analytic story (Charmaz, 2006, p. 63).

The analysis for this research began after the second interview with open coding. The transcripts were read line-by-line and at least one category was created or reused for each sentence (see Appendix I). This generated a large number of categories, but over time it was easy to see which categories were truly patterns and which were not. While coding for the fourth and fifth interview transcripts, it was clear that category saturation had been hit. No new categories were being created and only existing categories were being used. From there, the line-by-line categories were analyzed for whether they represented a true pattern across subjects. Many categories were removed and some were re-organized, hierarchically, into themes. The two highest themes in the hierarchy are for describing the IT capacity-management processes (process) and for describing the structural context within which the processes operated (spectrum).

Reliability. To improve reliability, transcripts were checked for any obvious errors before coding began (Creswell, 2009, p. 190). Nvivo software was utilized to aid in tracking and managing the coding, categorizing, and relationship building during the analysis. The interview transcripts were put into the software, and any themes, codes, or categories were applied directly to the text within the software.

To minimize code drift the transcript portions that matched a code were compared with each other to make sure the meaning of the code did not drift during the coding process (Creswell, 2009, p. 190). This was handled operationally by opening a coding node within NVivo, which presents a view of all the associated text that was coded in one window. A code dictionary was also used during coding to assist with consistent code application (see Appendix D). The definitions of these codes were put in the node property notes within the NVivo software so that they were easy to reference during coding activities.

Reliability was also improved through the use of a panel of judges, who reviewed the application of the codes to the transcripts. Intercoder agreement means that the judges agreed that the codes match the transcript sections to which they have been applied (Creswell, 2009, p. 191). Intercoder agreement of 80 percent or greater indicates good qualitative reliability (Creswell, 2009, p. 191). The panel was made up of three academic peers familiar with qualitative methodologies. They were given a sheet of paper with five randomly selected portions of transcript and accompanying codes (See

Appendix K). They were asked to mark whether they agreed that the code matched the transcript or not. Intercoder agreement for the panel was found to be 87%.

Validity. Categories and themes must comprise more than two codes across multiple subjects. Otherwise, it cannot be described as a pattern, and could be argued as mere coincidence. Using evidence from multiple subjects to establish categories and themes boosts validity and was a practice adopted by the researcher (Creswell, 2009, p. 191).

A panel of judges, similar to the one used for intercoder reliability, was used to review validity. This is similar to the peer debriefing that Creswell recommends, and it focuses on whether the codes themselves make sense and represent what they purport to represent (Creswell, 2009, p. 192). As with the intercoder reliability panel, 80 percent agreement indicates good validity (Creswell, 2009, p. 191). The three members of this panel were mixed, with some academic peers with sociology experience and some with IT backgrounds. The reason for this mix is because some of the codes are sociologically based and others are in vivo and likely based on IT concepts or constructs. The members were given a sheet of paper with five randomly selected code labels and the code's definition from the code dictionary (See Appendix K). They were asked to mark whether they agreed that the code matched the transcript or not. Agreement for the panel was found to be 100%.

Qualitative research tends toward relativist ontology and constructivist epistemology (Creswell, 2009, pp. 16–17; Olson, 2011, p. 17). This means that qualitative research tends to see the truth as not directly accessed but as being mediated by culture and language (Olson, 2011, p. 16). The tendency to constructivist epistemology means that qualitative researchers see their role as constructing knowledge with the participant instead of extracting knowledge as standalone objects from the participants (Olson, 2011, p. 16). Practicing reflexivity provides a means for monitoring researcher bias throughout the research process (Olson, 2011, p. 17). This requires the researcher to keep a journal of his/her standpoint and perspective of the research topic in order to see if or how it evolves over time (Olson, 2011, p. 17). Over the course of the interviewing and data-analysis process, the researcher kept a running log of personal notes and reflection thoughts. Most commonly it was in the form of a journal entry at the end of an analysis session. The researcher would summarize thoughts, opinions, reactions, and questions.

Results

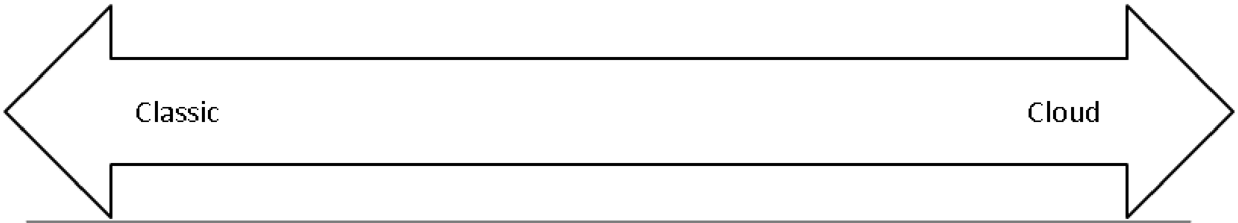
A core research question for this study is whether there are dimensions or factors that create variants within the descriptive model for different contexts. It was originally thought that the demographic information from the interview questions would be the most likely source for differentiation factors (see Appendix B for interview questions). However, analysis showed no significant differentiation based on the demographic information collected. It was cloud computing that seemed to add the biggest factor for possible variants. This dimension for variation will be described below as a spectrum between classic IT capacity-management structures and cloud IT capacity-management structures. These structures will be positioned and described along the spectrum based on the evidence of social patterns that create the processes of structure as found from analysis of the answers to the interview questions (see Appendix E for interview questions).

Spectrum of IT Capacity-Management Structures

The researcher began this project thinking that he would be interviewing people in the profession of IT capacity-management and did not really fully appreciate that there would be a lot of IT capacity-management activities occurring, but not all of it under a professional title for it. From the very first interviews, the topic of cloud computing came up over and over, even from subjects in organizations not using cloud. While performing open coding it became clear that there was some sort of spectrum of IT capacity-management structures. It seemed that on one side was a sort of classic IT capacity-management structure, which emerged from the old mainframe days when computers were extremely expensive. Then, on the other side was a more emerging cloud IT capacity-management structure, where capacity is seen as virtually unlimited. In this structure, not all capacity-management activities were performed by people with a job title that contained the words “capacity-management.” It seems this is especially true the closer to the cloud side of the spectrum you go. The cloud appears to be a disruptive technology that is providing an opportunity for structural change, where the roles, actors, and structure are all in flux (Barley, 1986). Some of the organizations seemed to fit one of the extremes or another of a spectrum, but others were something of a blend between the two extremes. Therefore, a spectrum of IT capacity-management structures is presented (see Figure 2).

The spectrum of IT capacity-management structures provides a way to investigate the research question, “Are there dimensions or factors that create distinctions or variants within a descriptive model for different contexts?” The spectrum provides a convenient means for testing the business process model by supplying a dimension for possible differentiation. Additionally, the spectrum provides the necessary context for understanding the descriptive process model for IT capacity-management that emerged from the research.

Figure 2. Summary of Spectrum of IT Capacity-Management Structures.



Resource scarcity being managed is physical hardware	Resource scarcity being managed is fiscal
Long planning or forecasting horizon (months)	Short planning or forecasting horizon (minutes)
Big, expensive, infrequent bulk purchases of resources	Pay as you go for resources
Reports are a major process output	Reports not present as a process output
Process inputs based more on system configurations than cost	Process inputs based more on cost than system configurations

Figure 2. The spectrum of IT capacity-management structures from classic structures on the left, to cloud structures on the right.

A moment should be taken to step, from left to right, through the spectrum to describe its properties and to illustrate them with evidence grounded in interview data. Then this spectrum will be utilized to contextualize and exercise the IT capacity-management process model that emerged from the research later in this section.

While interviewing subjects about the field of IT capacity-management, there was a general feeling among many subjects that, as a profession, it is in trouble or at least in the midst of some big changes. Sometimes these sentiments would come up while answering questions about their role and they would describe how things have changed for them and their bleak sounding feelings about the future. Other times they would talk about it at the end of the interview, where they were asked if there was anything else the researcher should know about.

For example, Person 3 confided that there are not too many people in the field of IT Capacity-management.

> **Person 3:** "I was talking about it and I always try to talk to people in the same field and unfortunately to be honest with you there are not that many."

The perception that classic IT capacity-management is waning is reinforced by observations that classic IT capacity-management roles are disappearing from organizations. As an example, while asking Person 7 about the roles associated with IT capacity-management in their organization they described how they work on managing the capacity for their organization's private cloud (what they call an "enterprise cloud") and took a moment to reflect on recent history:

> **Researcher:** "Are there others doing IT capacity-management for things other than the enterprise cloud?"
>
> **Person 7:** "I'm just thinking… there used to be. They closed a lot of the departments. They were thinking they don't need quite as much -- as many people doing the job as they used to."

This general sense of the profession as one that is shrinking leads to another trait found among the classic IT Capacity Managers. Something of an urge for professional self-preservation. If the role of IT capacity manager is diminishing, the actors of that role could feel they need to re-assert their relevance in order to preserve their professional role. This can be seen, for example, when Person 01 feels that it needs to be said that IT capacity-management is still relevant as a discipline.

> **Person 1:** “Yes, it’s things like your dissertation hopefully can bring about some of the need for saying [IT] capacity [management] is still very relevant today.”

The shrinking professional role and the perceived need to keep the practice of IT capacity-management relevant stem, in part, from a cost to benefit ratio that has flipped over the last couple of decades (Kushida et al., 2015, pp. 10 – 16). At the end of the interview, while asking if there was anything else the researcher should know about, Person 2 offered an historical perspective of the cost benefit ratio.

> **Person 2:** “So, the nature of capacity planning is just fundamentally changing because the ratio between people costs to hardware costs has changed so fundamentally. It's inverted over the last 20 years.”

The cost ratio has inverted because of the declining cost of computing, but also because there is a perceived change in the nature of the operational management of computing resources (Kushida et al., 2015, pp. 10 – 16). Virtualization and private-cloud computing change the way computing resources can be managed and the cost in managing them, too (Kushida et al., 2015). It is at this point we begin to step from the left part of the spectrum and toward the right side; away from classic IT capacity-management and toward cloud. After giving their historical perspective on the cost and benefit ratio, the researcher asked Person 2 what he/she thought the future held for IT capacity-management, and you can see them wrestle with the common sense impact of the inversion of the classic capacity-management cost ratio.

> **Person 2: “**With the virtualized environments it's like, dude, why don't you just grow? You don't need a capacity planner, you need a loading dock supervisor -- you just keep shoving stuff to the floor, and you let the system auto-balance. And you're able to do that essentially. There are some very good products that allow that kind of stuff to occur on the floor. Before it was just -- it'll tell you automatically where it's recommending you add machines but increasingly there are products that say I'm going to do it for you -- just give me all the resources I'll take care of it -- don't you worry yourself about it.”

Person 2 is talking about automated virtualization resource management, where the management software automatically moves the workloads around on the resources for you. Because of that the unit of management shifts away from being the individual servers to the overall capacity of the data center. He says you just need a loading dock supervisor because at that point the resource management activities that are left to perform are really just the logistics of buying and installing new hardware when the management software tells you it needs more (“ . . . shoving stuff to the floor. . .” (Person 2)). Person 2 was talking about the changes in operational management when virtualization is involved with locally owned resources. It begins to introduce a lot of the characteristics and attributes of cloud, but still remains on premise and on locally owned hardware. On the spectrum of IT capacity-management structures virtualization would fall somewhere near the middle. Because of virtualization and the ability to abstract physical resources, it takes on many similar characteristics as cloud, but still requires physical resources hosted on-site.

On the far right side of the spectrum is the cloud IT capacity-management structure, where there are no local physical resources purchased and capacity is so readily available that it cast the illusion of being infinite. But if capacity is infinite, then what is the resource that is managed? While Person 8 talked about his/her process activities and outputs as he/she shifted toward using cloud solutions, the researcher asked a follow-up question around a shift in what kind of resources Person 8 was managing when he/she started moving to the cloud.

Researcher: “. . . the resource scarcity has changed?”

Person 8: “Yes, absolutely.”

Researcher: “So what’s the new resource scarcity?”

Person 8: “The new scarcity?”

Researcher: “Yes.”

Person 8: “I guess it’s purely money that you’re optimizing now and, you know, in somewhat real time.”

Because there are no physical resources to purchase and manage as a scarce resource and you pay only for what performance is used, the cloud IT capacity-management structure is more focused on financial aspects of vendor-relationship management and contract management.

Person 8: “When you’re dealing with the public cloud issue, capacity itself isn’t really any longer an issue from the perspective of planning to purchase hardware. You know, how large a tape robot[1] are we going to buy? How many NAS[2] devices are we going to put in, how we're going to interconnect them. Those kinds of things that we used to think about become a little less relevant and it's more of -- so, how do we analyze say, for instance, what's the differences between Amazon S3 and Amazon reduced redundancy S3 and Glacier and do we trust having data in Amazon in one region, two regions? Do we want multiple cloud vendors? . . . And then essentially it's kind of a cost optimization, particularly in the compute kind of world and the network world."

As organizations evolve into the use of cloud other existing professional roles do not simply disappear. Many organizations already have people working on legal and financial activities. If IT capacity managers are going to manage the financial and contractual aspects of capacity (since the physical aspects are disappearing), then they could find themselves in competition with people in their organization who, at least nominally, already do that kind of work. This struggle is even observed by the subjects. Person 11 offered his/her view of the future at the end of the interview:

Person 11: "Kind of like I said before, capacity-management in the cloud really isn't what in the traditional sense you'd call capacity-management. It's more management of dollars and cents and efficiency management more than anything else. Capacity-management in general, I think, starts to get affected from a skill set or a way of

[1] Tape robots are used to physically exchange specialized cassette tapes from a storage area to a machine that reads or writes to them. The cassettes are used as inexpensive massive storage for backing up data.

[2] Network Area Storage, a type of hardware storage device that stores data.

> working." As cloud and or colocation or co-hosted data centers crop up, you kind of leave the aspect behind of buying capacity as a large pool of resource and then trying to figure out how to apply your services or objects that are going to consume the resources to it to gain the maximum value out of the investment. The cloud really changes that fundamentally because you kind of forget doing that because the fundamental difference in the cloud is I don't pay for the big chunk up front and then try to use it. I just try to manage and use what it is I actually need to efficiently deliver the service."

Person 11 is getting at the resultant shift of *what* is managed when you move from the classic IT capacity-management structure toward the cloud IT capacity-management structure. Since there is no local hardware to purchase in bulk, the scarcity that is being managed changes. The 'thing" that is measured changes. The capacity being managed is fiscal in nature. Because there is already a role in organizations for managing "things" of a fiscal nature (accounting or finance), it sets up a conflict within the social patterns that create the structure. The resolution to this conflict, among the organizations interviewed, is for IT capacity managers to become more closely linked to the data center operations (during the middle, or transitional part of the spectrum) and then for the formal role to disappear (in the cloud end of the spectrum). While Person 7 was talking about the outputs of their process and the roles who use them, it struck the researcher that a social shift was occurring for them as they moved toward cloud solutions.

> **Researcher: "**Do you feel kinda socially closer to the application teams or the data center teams?"

> **Person 7: "**Probably now to the data center teams. They're trying to close in the silo so we don't talk to the applications. I don't know if that's strategy or side effect, but I used to get very close to the applications, but with the virtualization we're a lot closer to the data center -- the configuration teams. How many blades you need to put in a rack and that sort of thing. So yes, it used to be we were closer to the apps; now we're closer to the data center."

When taken together, the change in which resource is being managed, along with which professional roles that are managing them, a consistent view from the far right position of the spectrum is one where the professional role of IT capacity-management is anachronistic and unnecessary for the most common organizational needs. At the end of the interview, Person 9 offered his view on the professional role of IT capacity-management and where it is likely to go.

> **Person 9: "**The fact of the matter is there are still people who do capacity planning, and it's a really cool job because they do it at places like Amazon, and Google, and Facebook. And they're dealing with a scale that mom and pop shops who are running a thousand servers will never see. When you start talking about hundreds of thousands or millions of hosts then you have really interesting problems. So, you have fewer people who get hired but are at the top of their game. The time of that being a title that people have is fading rapidly."

This view is one where IT capacity-management would remain a professional role only in a select few environments where the financial ratio still makes sense. These are the very large computing environments like Amazon, Facebook, Google, and so on. This is where the cost of resources (because of the volume of them) is still quite higher than the cost of hiring people to manage their capacity. For the majority of the remaining organizations, where the financial ratio doesn’t make sense, the activities done by a capacity manager are distributed to other existing roles. While answering a question about roles associated with process outputs, Person 8, from an organization that doesn’t have a formal capacity manager (Organization 6, which is doing both cloud and local virtualization and placed in the middle of the spectrum), describes the various roles involved with managing capacity for them.

> **Person 8:** “Our virtualization group, which manages our internal virtual environment, also looks at a lot of the trending information in our cloud virtual environment. Our business office[3] receives the bills, and those two groups go through them looking for the coarse grain kind of ‘where can we optimize’ things. And they’ll go back to the services involved.”

Nowhere in that brief process summary is the professional role of IT capacity-management mentioned. Yet, activities around management of resources are taking place. In this kind of environment it doesn’t make sense to hire a dedicated IT Capacity Manager. At the end of the interview with Person 9, during informal conversation, the topic of the cost to benefit ratio came up:

---

[3] The business office handles finance, legal, and accounting activities.

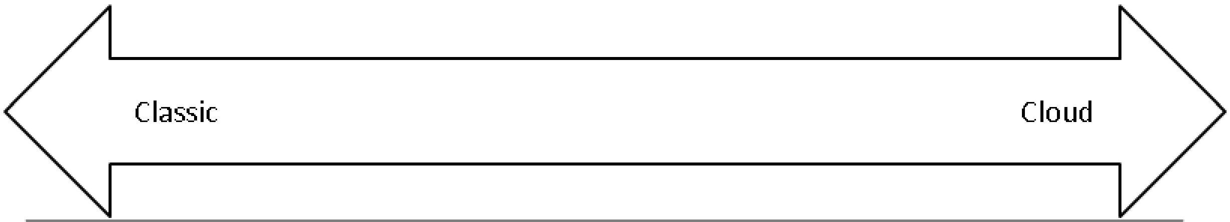
> **Person 9: ?**Why would you hire someone for something one of us could do in like 5 hours per month?"

The financial cost ratio and shift in what resources are managed delineate the far ends of the spectrum of IT capacity-management structures, but they also contain an undercurrent of deterministic progression, where the demise of the classic IT capacity-management profession as a role is widely seen as inevitable. Some were less nuanced about this than others were.

> **Person 9: "**Very few people make carriage axles as well. Sometimes the old ways were bad."
>
> **Person 10: "**I like to think that as technology improves it actually improves."

While walking through the spectrum, the differences in the structures become evident. That is to say, there is a dimension upon which variations within a descriptive model for IT capacity-management can appear. This brings us to a research question: Does being at one end or another on the capacity-management structure spectrum mean that there are different and distinct processes for IT capacity-management in use? We can find out by plotting the organizations that were studied along the spectrum and then, in the next section, compare the usage of the capacity-management process model across the spectrum to see if there are significant differentiating factors. You can see in Figure 3 that the organizations studied were somewhat balanced across the spectrum. Four fall within classic capacity-management, three in cloud, and three were somewhere in between classic and cloud. An organization could fall in between by having both local resources for some services but also using cloud (public or private) for other services.

Figure 3. Organizations Positioned within the IT Capacity-management Structures Spectrum.



Organization 1	Organization 4	Organization 7
Organization 2	Organization 6	Organization 9
Organization 3	Organization 12	Organization 10
Organization 5		

Figure 3. The interviewed organizations plotted along the IT capacity-management structures spectrum.

In the next section, after introducing the descriptive model of IT capacity-management processes that emerged from the research, we will take the spectrum from above and see if an organization’s position on the spectrum is a factor for differentiation in the way an organization operates its IT capacity-management processes.

IT Capacity-management Business Process Model

The high-level research question for this research effort is: “Can a descriptive model be developed for the processes of IT capacity-management as found in practice”? Here, the sub-question of “What are the common processes of IT capacity-management found among the organizations that are interviewed?” will be addressed, along with describing the inputs, activities, and outputs. After presenting the model of processes for IT capacity-management that emerged from this research, it will be compared with the spectrum of IT capacity-management structures from above to identify any dimensions or factors that could create distinctions or variants within the descriptive model.

While none of the organizations interviewed practiced identical IT capacity-management processes down to a step-by-step task level, there is still room for a high level process model that describes the current practice of IT capacity-management. Common to all processes is a structure of suppliers, inputs, process activities, outputs, and consumers, also known as SIPOC (see the literature review for details on SIPOC models). The IT capacity-management process model is no different. It has roles that supply the necessary inputs for the process activities to create the desired outputs that the consuming roles consume. As will be explored in more detail, the difference between organizations is on the focus, time frames, and paths between supplier, to input, to process activity, to output, to consumer.

Figure 4, below, is the descriptive model that emerged from the research. It is described using the SIPOC modeling language and shows the suppliers, inputs, process activities, outputs, and consumers that were found in this research. The shapes within it represent individual patterns (categories) found to occur between organizations. An individual IT capacity-management process connects the shapes moving from left to right in a connect-the-dots type fashion. Later in this section we'll do exactly that with a few scenarios from the different positions within the IT capacity-management structure spectrum. But first, let us get familiar with the individual parts of the IT capacity-management process model that emerged from the analysis (see Figure 4).

Figure 4. Model of IT Capacity-management Processes.

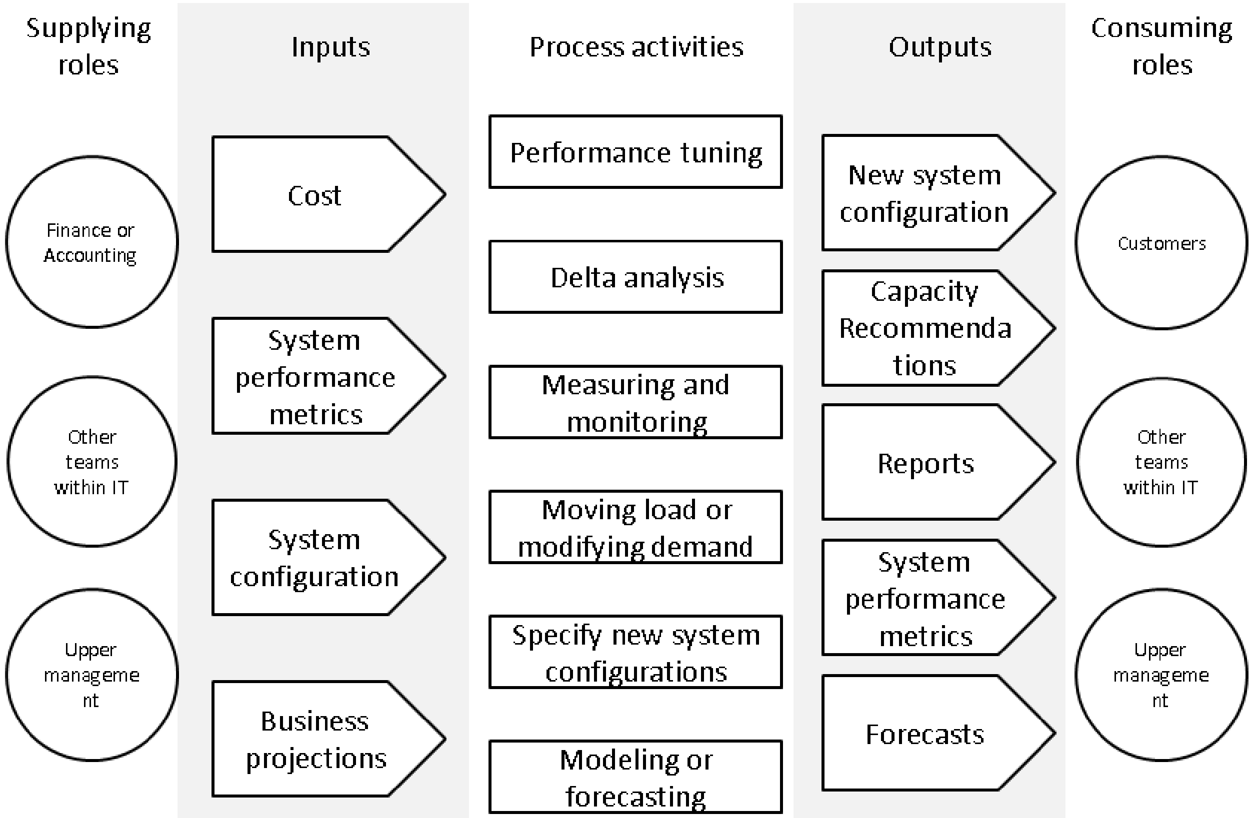


Figure 4. A SIPOC process model of the IT capacity-management processes as found operating in the organizations that were interviewed.

At a high level, one of the first things you might notice is that the supplying and consuming roles overlap by about two thirds. This reflects the somewhat iterative nature of the IT capacity-management processes that were discovered. That is to say, the outputs sometimes circle back to become part of the input again in a continuous feedback loop, which makes sense when you consider the Deming-style loop ITIL espouses of its IT capacity-management model recommendations (Office of Government Commerce, 2011, pp. 167–168). While reviewing the individual parts of the model, the summary data behind each category that constructs it may be found in Appendix F.

Related Roles. The three roles that supply the inputs are, Other Teams within IT, Finance or Accounting, or Upper Management. These roles were identified during the interviews while asking questions about the subjects role and whether there were any related roles. There were also follow-up questions to the inputs and outputs questions that asked who supplied or consumed them (see Appendix B). These three roles accounted for the creation or supply of the four inputs for the IT capacity-management process activities. The consuming roles are the same, except that Customers takes the place of Finance or Accounting. Let us step through the roles individually in more detail:

Other Teams within IT. This role includes teams within the area of the organization that handles IT but are not in the subject's team. It most commonly included teams such as analysts, architects, data center operations, programmers, application designers, or other operational IT teams. This is the role that most commonly supplied the inputs for system-performance metrics and system configuration.

> **Person 4:** "So you've got one group who's doing the application development and QA and test. And then you have totally separate group who's in charge of servers, and another one in charge of network, and another group that's in charge of mainframe, and another one that's in charge of storage, and yet another one that's in charge of the facility and the data center."

Finance or Accounting. Finance or accounting is the role that manages the money and budget for the organization. Sometimes they are also the purchasing authority. This role is most commonly the supplier of the cost input.

> **Person 7: "**And a good relationship with the finance people to get more resources as required. The finance people got to trust the capacity-management team to know and not just over estimate when more capacity is required."

Upper Management. The Upper Management role is one that represents members of management and leadership all the way up to the CxO level (or equivalent). Commonly this role and the Finance or Accounting role were merged together and referred to by the subjects as the "business" people. This is the role that most commonly supplied the information for the business projections input.

> **Person 2: "**The only time things go very, very wrong is for the business guys, and this is not either the high side or the low side -- they overestimate, they're too hungry, saying this is our business model; we're going to blow the top off of this particular market; we're going to increase our capacity by 400% so you go out and you make an early buy of hardware to support their 400% increase, and then it doesn't materialize."

> **Person 5: "**The business area gives me projection of the business for 1 year or 2 years, and I take the business projection and put my projection of infrastructure. Sometimes the projection business is not correct."

Inputs. Inputs are the things that feed into the IT capacity-management process activities. They provide the raw materials for the activities that result in the outputs that the consumers expect from the processes. The inputs can take many forms and do not need to be physical. It can be information, for example. The categories, each described in turn below, emerged from the interview questions and follow up questions that specifically asked the subjects where resources came from that were required to do their activities (See Appendix B).

Cost. The cost input contains information about the cost of resources or services. The cost is not necessarily contained to the cost of buying physical assets or purchasing something from a vendor, but also contains things like the cost of employees, facilities, power, cooling, and so on.

> **Person 6: "**They say we know how much it costs us to maintain things here, so therefore we're going to look at a cloud solution. That's one example."

System-Performance Metrics. System-performance metrics include information about the technical performance of systems. This commonly includes things like snapshots of the current state of CPU, memory, or network utilization. It can also contain information about the performance, like transaction times or throughput rates.

System-performance metrics usually come from measuring and monitoring activities and usually feed into performance tuning, moving load or modifying demand, and modeling or forecasting.

System Configuration. It's the System Configuration input that represents the current technical system attributes that are owned, configured, or managed by the organization. For example, the amount of memory or CPU that is installed in a given server. This includes not just systems in a data center that are owned or leased by the organization, but also systems that are rented or leased either in a different "co-location" data center or a cloud vendor. This input is meant to represent the full capabilities (utilized or not) of the organization's IT resources at hand that can be utilized in the delivery of its business services.

Business Projections. The projections, plans, or goals from the business or non-IT area of the organization are the business-projections input. These usually come from the upper management role and often times come through qualitative means, like an interview or discussion.

> **Person 1:** "And the interview process of the business leaders was something that was crucial to get in the input of what the future was going to be."

Process Activities. The following process activities emerged primarily from the interview question, "What activities are carried out when performing capacity-management?" (see Appendix B). The activities are what happen in the IT capacity-management processes that take the inputs and turn them into the outputs that the consuming roles expect.

Modeling or Forecasting. This included any references to the creation of mathematical models to describe or forecast something. Sometimes these models were quite simple.

> **Person 2: "**We said ok, for the run of the mill stuff you'll use CPU metrics and you'll see how much you're consuming now and you'll make linear predictions basically navigating by our wake to project forward, and if you get any information from the business side that says we're planning on a major initiative this year and we're going to double

workload, that would be figured in."

Sometimes the modeling or forecasts were quite complex.

> **Person 3:** "Throughout the process we're using a lot of machine learning. I use a lot of artificial neural networks in capacity studies. I use a lot of artificial neural networks for scalability studies. We use support-vector machines in the data post-processing phase. We use some clustering algorithms to get a feel for the different workload behaviors so we can actually quantify different workload patterns that we can feed into our mathematical models to do the performance study first and the capacity evaluation if necessary."

Modeling and forecasting was the most widespread of all the activities with all but one subject mentioning that they do some sort of activity related to it. This means that both those doing classic IT capacity-management and those doing cloud IT capacity-management perform this activity. However, there were differences in the emphasis of what they were modeling and the time horizons they were forecasting out for. In classic IT capacity-management the models were based more on attributes of the hardware being utilized.

> **Person 4:** " . . . you go model what the current footprint looks like, what the current infrastructure looks like . . . ."

The forecasts that classic IT capacity-management practitioners created tended to go out a year or more.

Person 5: “I make a prediction for 12 or 18 months.”

This prediction horizon makes sense when you remember they have to factor in enough lead time to purchase and install new hardware. In the cloud, the lead time to get new resources is much shorter and that has the effect of shortening and changing the nature of the forecasts. Person 9 reflects on this in his cloud environment:

> **Person 9:** “Because there’s a period of time it takes to scale up, in some cases I’ve worked with some applications where it took a half hour to scale because it took that long to page everything into cache. But in most cases you can have new instances in clusters especially in stable services within a couple minutes. So you just have to have enough headroom for a couple minutes.”

In this case, Person 9 speaks of a half hour as being a long time to provision new resources. The forecast horizon is reduced to just a few minutes and is built into scripts that run continuously, rather than pictures of graphs that are put into a document and read by humans to make a decision. The modeling and forecasting that the humans do is around a different metric. The focus is more on budget and finances.

Measuring and Monitoring. Measuring and monitoring is the activity of collecting, filtering, and sorting information. Commonly, this is information from system configuration or system-performance metrics. In this case, it is common for this collection activity to be automated and essentially a continuous stream of data. However, measuring and monitoring is not limited to just system information as it can also be cost, financial, or business information.

Specify New System Configurations. This pattern covers the analysis activities used to create new specifications for technical system configurations. This can include adding, removing, or modifying resources. It also contains a call-out to the activities of actually performing the modifications to system configuration, which are usually handled by other teams within IT.

> **Person 3**: "So maybe you add more memory or CPU. Sort of the vertical increase in physical resource. Or you add nodes into the equation."

Delta Analysis. When doing analysis for capacity-management, one of the common activities was to compare one variable against another. For example, amount of resources on hand vs. amount of resources consumed. Or, how something performed in the past against how it is performing currently. Sometimes the delta analysis would involve a threshold value that gets compared against a sampled value. As an example, Person 3 takes workload profiles (data on how the systems are performing) and compares it against a hardware profile (a threshold generated by a model that represents the highest possible performance).

> **Person 3:** "We have status quo governed by the workload profiles and we have ceilings that is [sic] governed by the hardware profile and we basically determine the delta."

In this example, the delta that Person 3 talks about represents the available capacity of the system under analysis.

Performance Tuning. There were times when the person doing capacity-management would be involved in (or even performing) performance tuning. These activities include finding areas where the technical architecture or configuration can be changed in order to run more efficiently. For example, accomplishing the same tasks with fewer system resources or servers.

> **Person 3:** "We allow the application to run at full potential of the hardware that's available. So this is an optimization phase that we have to go through. Otherwise our capacity analysis would overshoot the target. Again, saves a lot of money if you do it right. Costs an arm and a leg if you don't."

Before doing capacity analysis, Person 3 does performance tuning to make sure the application is running at full potential. Otherwise, they argue, you'll overshoot your capacity target, meaning that you could end up adding more resources than are necessary.

Moving Load or Modifying Demand. This activity involves changing where jobs or tasks (work) are performed. Such as storing files in a different location. Or, changing the behavior of user activity. For example, setting specific hours users can access a certain system.

> **Person 11**: "Yeah, so for instance, let's say we had three storage units in a physical data center world. If one started to near capacity, instead of going and buying another one maybe across another two you'd probably look at the second one over here and he's got

plenty of capacity so you'd look at all your internal resources and you'd see if you could shift something over."

In one case, it even meant setting hours of availability for the system:

Person 1: "We are going to publicize when people can be on the system so they can have a good experience and tell people if you don't adhere to this it's going to be a very bad experience for everybody."

Outputs. A business process takes inputs from suppliers and then uses process activities to turn them into outputs that a consumer expects. The following are the output-related categories that emerged from the interview question that was the follow up to asking a subject to describe the activities they perform. The question asks "dWhat is the output of capacity-management?" (See Appendix B).

New System Configurations. This output represents added (including buying), removed, or modified technical system configurations. For example, added or removed memory or CPU. It also includes new allocations to a virtual machine hosted in the cloud. This output is the actual physical reconfiguration of the owned or managed resources, not just recommendations or specifications to do so. Sometimes the modifications would be made by the person filling the capacity-management role, and other times it would be someone from a different IT role.

Person 10: ". . . I'd go in and make modifications as necessary."

Capacity Recommendations. The capacity recommendations output includes suggestions or recommendations to a different role for capacity-related action. It usually contained recommendations for new system configurations, tuning opportunities, or forecasts for the future. The difference between the “new system configuration” output and the “capacity recommendations” output is that a recommendation may lead to a new system configuration, but is not, itself, the actual reconfiguration of the resources. The reason this is separated this way is because a recommendation, as you’ll see later when we step through the model, can iterate back into the beginning of the process. A recommendation usually goes to management before it is acted on.

Reports. A document (physical or virtual) given to or accessed by another role. A report could contain other outputs, like capacity recommendations or forecasts, for example. Reports are for human consumption. That is to say, these are not clusters of data transmitted from one machine to another in order to be acted upon by another machine. These reports are meant for human consumption, so that humans can analyze the information and make decisions or take specific actions.

Forecasts. Forecasts are predictions about the future. This prediction could be created by complex mathematical models, or it could be someone’s guess. Either way, it is some sort of prediction about some sort of variable in the future. The time horizon for these forecasts could be anywhere from a few minutes to two years out. Forecasts can end up in other outputs and are not only consumed by humans. In the case of a time horizon of only a few minutes, a computer automatically acts on the forecast.

The Variants Within IT Capacity-Management Processes

In a previous section, a spectrum of IT capacity-management structures was described and the organizations under study were plotted along the spectrum (see Figure 3). In the previous section a descriptive model of how these organizations are performing IT capacity-management processes was described. Now, we will compare the positions along the spectrum with the attributes of the IT capacity-management model to see if there are significant differences in the model between the positions on the spectrum. In other words, if an organization is on one side of the spectrum does it show up in the capacity-management model differently from organizations that are on the opposite side of the spectrum? Is the spectrum a dimension or factor for differentiation or variation in IT capacity-management processes?

The following figures show the different attributes from the IT capacity-management process model and the organizations that had a subject speak about it (vertical axis). The horizontal axis represents the three locations on the spectrum model: classic, cloud, and middle (or in between). The percentage is the relative representation of the makeup of the attributes for the spectrum position. For example, in Figure 5, the involvement of the Upper management role decreased between classic and cloud-capacity management structures on the spectrum, where it tails off to zero percent. If all organizations, regardless of cloud or classic-capacity management, mentioned interactions with all the roles, then the figures below would show parallel horizontal lines of equal vertical spacing. Subjects from cloud organizations did not mention Upper Management as a related role; therefore, in this study, that role is represented as zero percent of the cloud capacity-management structure of IT capacity-management.

Figure 5. Roles across the Spectrum.

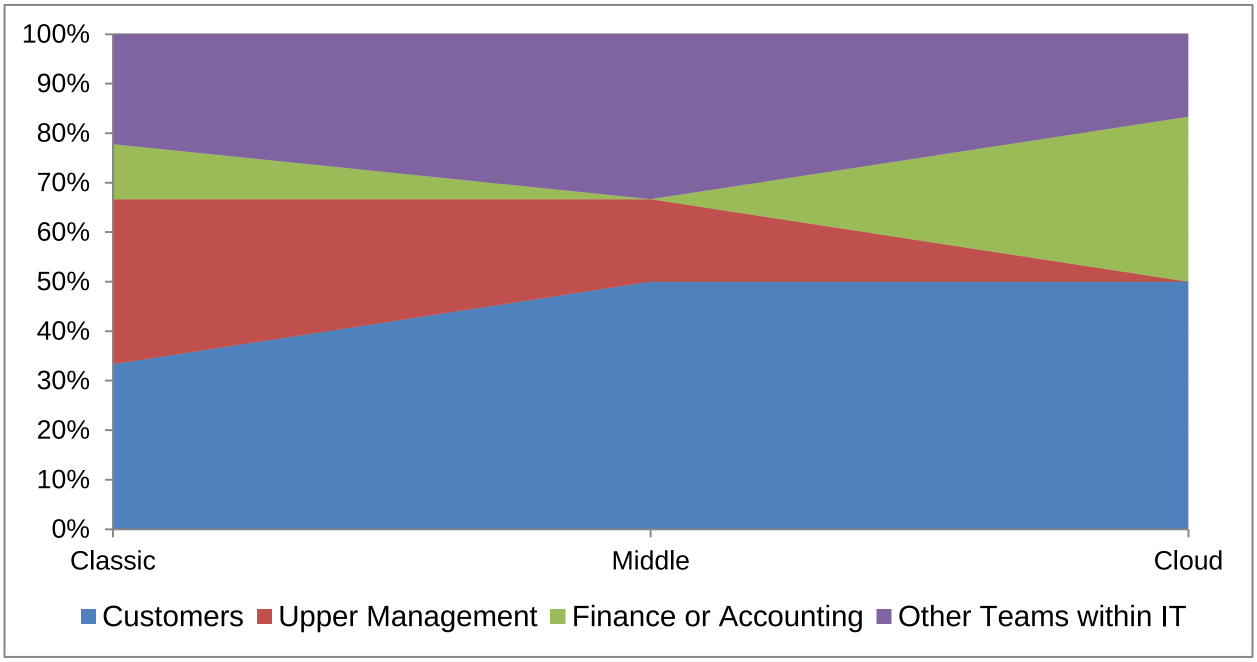


Figure 5. The percentage of organizations that supplied evidence of specific roles, plotted across the IT capacity-management structures spectrum.

Figure 6. Inputs across the Spectrum.

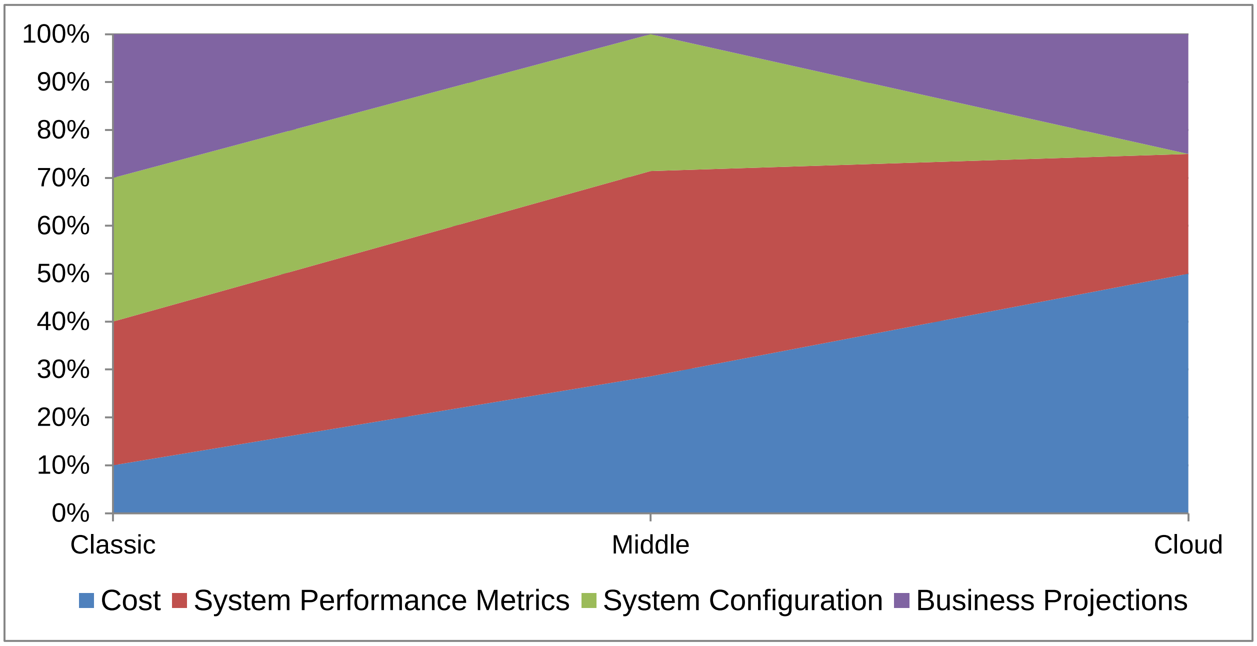


Figure 6. The percentage of organizations that supplied evidence of specific inputs, plotted across the IT capacity-management structures spectrum.

Figure 7. Activities across the Spectrum.

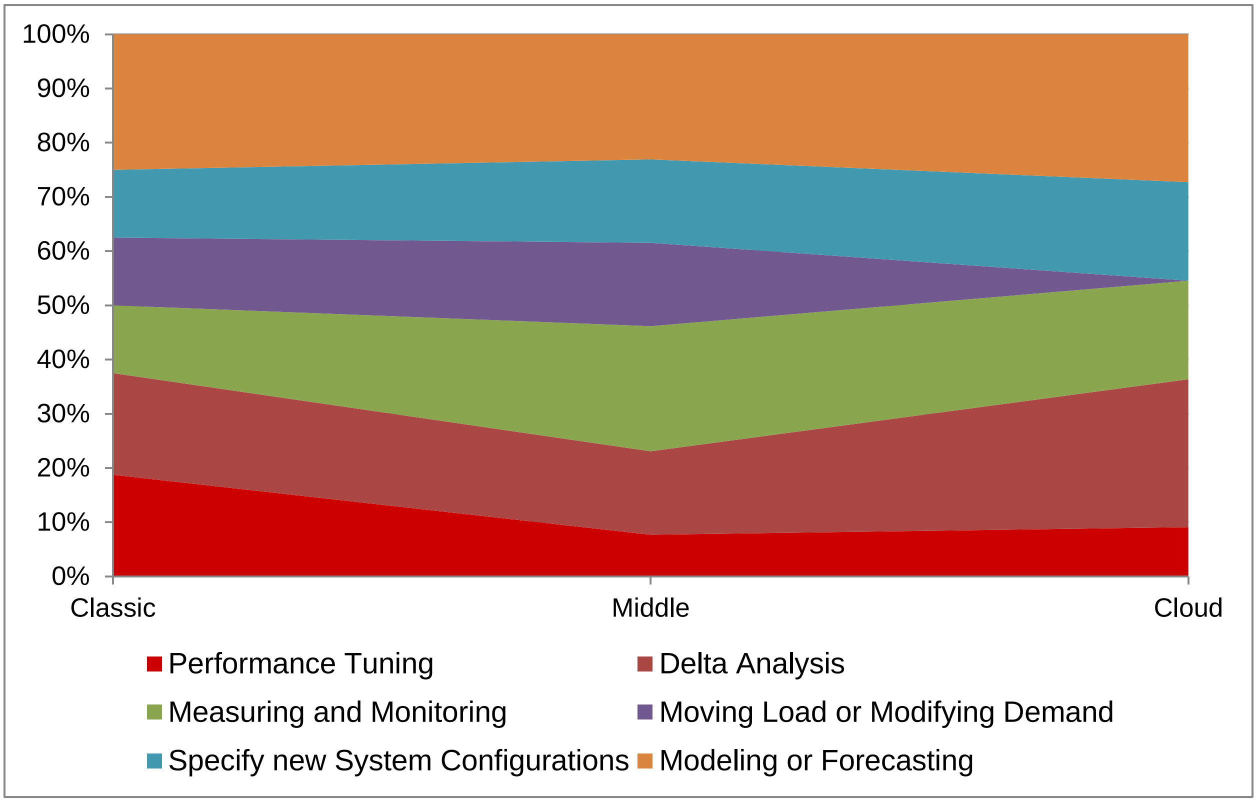


Figure 7. The percentage of organizations that supplied evidence of specific activities, plotted across the IT capacity-management structures spectrum.

Figure 8. Outputs across the Spectrum.

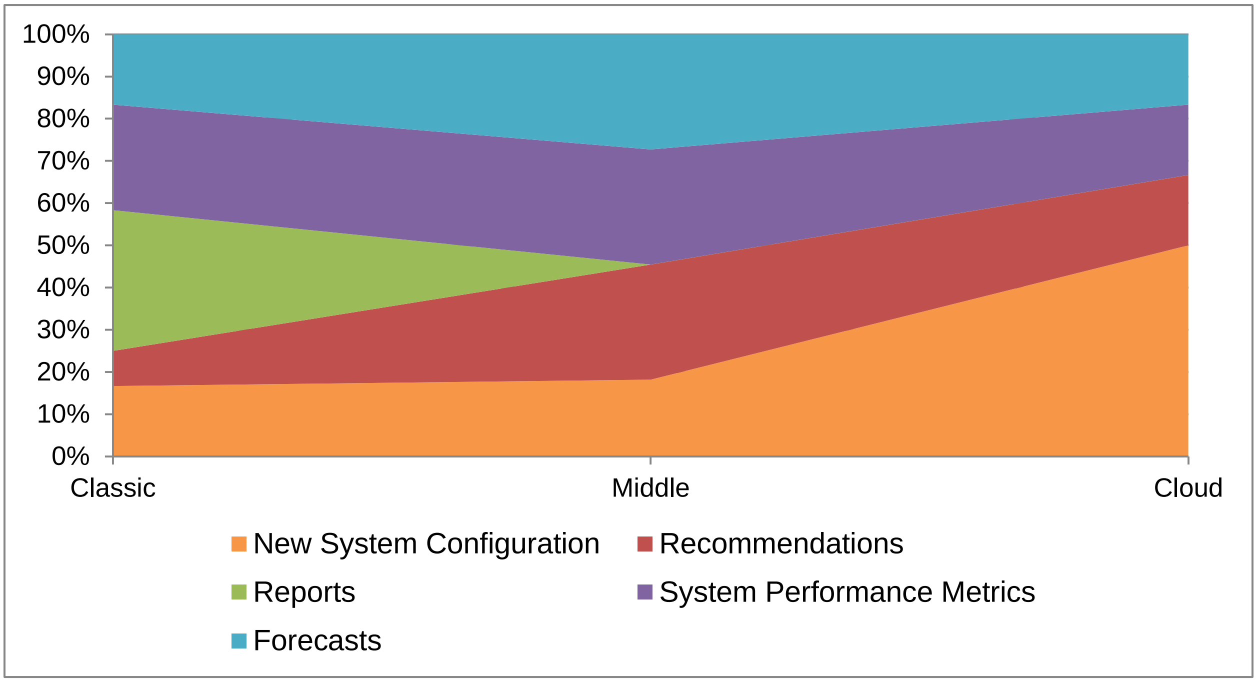


Figure 8. The percentage of organizations that supplied evidence of specific outputs, plotted across the IT capacity-management structures spectrum.

Looking past the small vertical wobbles and focusing more on the bigger trends, even between the figures, one can start to paint a picture of the differences between classic and cloud-capacity management through the lens of the IT capacity-management model. Among roles, classic has more upper management involvement, while cloud has more finance and accounting. Inputs and outputs change dramatically between classic and cloud. Classic uses more system configuration as an input and generates more reports as an output, whereas cloud uses cost as an input more and ends up with new system configurations more often. Within activities, the differences are minimal with one exception. Classic does moving load or modifying demand, where cloud-structured organizations never mentioned it as an activity.

Taken together, these summarized differences look something like this:

Table 4

Summary of Spectral Differences among Model Attributes

SIPOC Elements	Classic	Cloud
Roles	More Upper Management	More Finance
Inputs	More System Configurations	More Cost
Activities	More Moving Load or Modifying Demand	
Outputs	More Reports	More New System Configurations

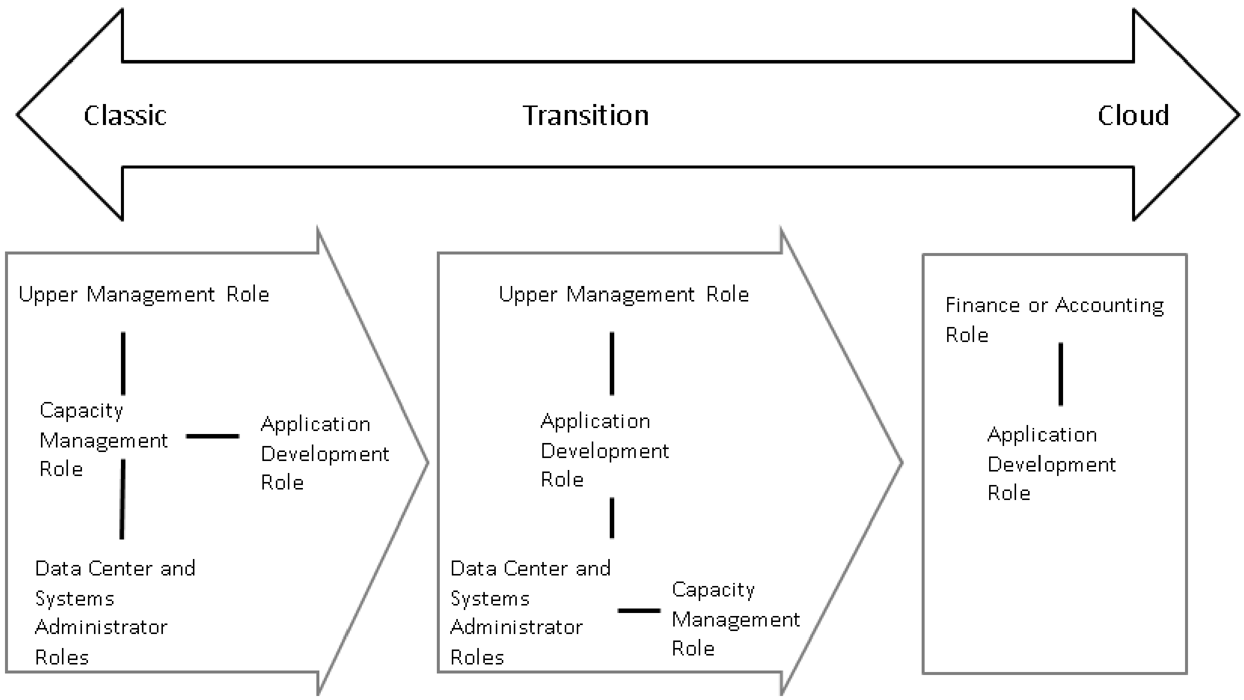
Between classic and cloud, we can see that while the inputs and outputs have some significant differences, the activities, at least at a high level, are not too dissimilar when they are spread across the spectrum. Care must be taken not to exaggerate the differences between classic and cloud-structure processes, but a high level story that steps through the IT capacity-management process model from the perspectives of each extreme on the structure spectrum is possible. Based on just the unique emphases on attributes, a classic structure would be described as taking technical system configurations from other teams in IT and taking business projections from upper management, then doing some measuring and monitoring, forecasting, and delta analysis in order to generate reports to hand off to people in upper management roles. For cloud structures it would be taking in cost data from the finance or accounting roles to set up measuring and monitoring with other IT teams, which then lead to new system configurations that support customer experience.

These high level stories about the differences between classic and cloud are in alignment with the qualitative descriptions of the structures spectrum (see Figure 2). Relative to classic, cloud is more action-oriented. A report that goes to upper management is a less action oriented outcome than new system configurations that quickly adjust the capacity of a system that customers use. The difference in the inputs aligns with the fundamental difference between classic and cloud, where, for classic, the resource scarcity being managed is hardware, but for cloud it is monetary resources. In that light, the omission of moving load or modifying demand from the cloud activities makes more sense because in cloud that layer of hardware management is abstracted out as a feature of the service. In cloud, moving load would not result in a change in cost. But, in classic, moving load may extend the useful life of a piece of owned equipment, which would save costs. The modification of demand or changing the behavior of users to suit the capabilities of the technical infrastructure may be a difference in cultural or organizational values. With the inputs and activities being centered on technology, it is possible classic is more technology oriented, where cloud is more service oriented. A more service oriented cloud organization may not think of attempting to change user behavior for technical reasons a viable service focused option.

Summary

Cloud computing appears to be playing the role of a disruptive technology that is providing the occasion for changes in IT capacity-management structure (Barley, 1986; Kushida et al., 2015). While this study did not follow a single organization in a longitudinal fashion to observe its structural transformation from the classic side of the spectrum to the cloud side of the spectrum, several organizations which were on one side or another, or in transition, were studied. By piecing together the patterns of roles and their relationships a tentative model of change across the spectrum can be constructed (See Figure 9). Figure 9 shows the observed relationships between roles within IT capacity-management structures along the IT capacity-management structures spectrum. This observational model shows the differences in the roles that are associated with operating IT capacity-management processes within the studied organizations as one moves focus from classic to cloud. This is not a model of technical or even organizational structure. It also only shows the social roles related to the operation of the IT capacity-management processes as described by the subjects. This model is based only on the organizations studied in this research, so future research would be needed to validate it for external validity. Ideally, an organization would be studied longitudinally from the classic structure all the way through its evolution into a cloud structure.

Figure 9. The observed role relationships in IT capacity-management processes.



In the classic structure, the IT capacity manager role is something of a mediator between upper management and the rest of the IT roles. Here, the category for “other teams within IT” is broken out to two specific social roles for clarity. One for the “application development role,” representing those who have a role in application development, user experience design, business analysis, and so on; then one for “data center and systems administrator roles” for those who work on the physical hardware up to the operating system. In this structure, as described in the results section, the capacity manager commonly works with upper management to get business forecasts and requirements, then works with application development roles, data center and systems administrator roles to monitor and measure the systems. Then the capacity manager generates a report with capacity recommendations for upper management to consider. In this sense, the capacity manager plays something of a translator role between upper management and the other IT roles.

As you shift away from the classic structure and move toward the cloud structure a curious thing seems to occur with the capacity-management role in the transition. The capacity-manager role gives up their position as mediator and bonds themselves closely with the data center. As virtualization (often a localized precursor to cloud computing) comes in, its resource management is such that the application and operating system level capacity-management is handled automatically by the virtualization software. Therefore, a shift in what the capacity manager manages occurs. They end up managing the capacity of the data centers themselves, rather than individual applications or servers. This shift bonds them closely, socially, with the data center and heavily de-emphasizes the relationship with the application development and upper management roles. An example of this was described quite succinctly by Person 7 while reflecting on their own organization's transition:

> **Researcher: "**Do you feel kinda socially closer to the application teams or the data-center teams?"
>
> **Person 7: "**Probably now to the data-center teams. They're trying to close in the silo so we don't talk to the [application developer roles]. I don't know if that's strategy or side effect, but I used to get very close to the [application developer roles], but with the virtualization we're a lot closer to the data center -- the configuration teams. How many blades you need to put in a rack and that sort of thing. So yes, it used to be we were closer to the apps, now we're closer to the data center."

Of course, one of the defining traits of cloud computing is that you do not have to bear the cost or risk of owning a data center. So, as you shift over to looking at the pure cloud structure on the spectrum, all the social roles related with data center management are absent because that work is no longer done at the organization. The cloud abstracts out the physical hardware and even the operating system if you want. Therefore, a data center and all the roles associated with it are no longer required. What appears to happen to the capacity-management role, since it bonded itself with the data center during the transitional phase, is that it disappears along with the data-center roles. As the research has shown, this does not mean that capacity-management activities are no longer performed, they just change slightly in nature and are performed by different roles (finance or accounting, and the application-development roles, for example). Also, those interviewed in the cloud structure had stronger relationships with accounting and financial roles than they did with upper management. This is likely because resource procurement is done more in a subscription model and no longer in the form of infrequent, massive capital expenditures that require senior-leadership approval.

Based on this tentative model, it appears that if an individual capacity manager wants to remain relevant as an organization moves from a classic structure to a pure cloud structure, he/she should find a way to bond himself more closely to the application development and finance or accounting roles and should probably look to divest themselves of the formal title of capacity manager. This could prove difficult depending on the social background of the individual capacity manager. In the researcher’s 20 years of experience in IT, he has observed something of a social stratification within the culture of IT where those who deal with the application layer have a higher social stature than those who physically stack servers and string cables in a data center. It is a social structure that is often reflected in boundaries of teams in the organizational structure, which, itself, is often a reflection of the structure of IT itself. It may prove difficult for a capacity manager who comes from more of a data center or server hardware background to bond themselves more closely with application layer people because of this social stratification. Whether social stratification within IT culture is a factor in capacity-manager longevity while an organization moves to a cloud structure is another topic for future research.

Relating the Results to the Literature

After looking at the model for how organizations are operating their IT capacity-management processes (see Figure 4), a natural question forms: how does the model compare with the best practices that were discussed in the literature review? Of all the organizations, four reported using some sort of homemade or custom framework for their processes. Three said they followed no frameworks or best practices. ITIL was reported by three organizations as the published framework or best practice that they follow. When plotted along the IT capacity-management structure spectrum, no obvious patterns emerge.

Table 5.

Self-reported Frameworks or Best Practices in Use by Organizations.

Framework or Best Practice	Classic Organizations	In-Between Organizations	Cloud Organizations
ITIL	1	1	1
Custom (self-created)	2	2	0
None	1	0	2

Since ITIL is the only published framework that was referenced by the organizations, it will be the one compared to the IT capacity-management process model. To do so, it is helpful to first deconstruct the ITIL framework into its SIPOC components (supplying roles, inputs, activities, outputs, and consuming roles) so it can then be compared with the IT capacity-management model (See Appendix H for a full comparison). Below, in Table 6, a summary of just the SIPOC attributes that did not match up is presented.

Table 6.

ITIL and Capacity Model Comparison Summary.

ITIL SIPOC Attributes	IT Capacity-management Process Model SIPOC Attributes
Inputs	
Service performance issue information - incidents and problems (Office of Government Commerce, 2011, pp. 174–175)	No match
Service information - Service Level Agreements (Office of Government Commerce, 2011, pp. 174–175)	No match
Change information - schedule of changes, impact of changes on capacity (Office of Government Commerce, 2011, pp. 174–175)	No match
CMS (Configuration Management System) - information about the relationships between services and the supporting technologies (Office of Government Commerce, 2011, pp. 174–175)	No match
Workload information - Schedules of all work that needs to be run (Office of Government Commerce, 2011, pp. 174–175)	No match
Activities	
Assisting with specific performance issues (Office of Government Commerce, 2011, pp. 162 – 163)	No match
Outputs	
CMIS (Capacity-management Information System) - Holds all the data required by the capacity-management process (Office of Government Commerce, 2011, p. 175)	No match

Roles	
ITSCM (IT Service Continuity Management) - Assisting in risk reduction and recovery options (Office of Government Commerce, 2011, p. 176)	No match
No match	Finance or Accounting
No match	Customers

When taken together, the inputs, outputs, and activities found in ITIL but not in the IT capacity-management process model suggest a somewhat isolated or less fully integrated process in operation than what ITIL recommends. For example, the inputs missing from the capacity model but included in ITIL mostly have to do with outputs from other processes (possibly other teams or roles within the organization). This seems to indicate that ITIL specifies an ideal level of integration with other processes and teams or roles that has not yet materialized. Future research on this topic is advised.

The two roles in the capacity model that are not found in ITIL may be more of a reflection of the inclusion of the cloud structure in the capacity model. If you look back at Figure 5 both “finance or accounting” and “customers” are more prevalent in the cloud end of the structure spectrum than the classic end of the spectrum. When compared with the attributes of the IT capacity-management structure spectrum, ITIL appears to hew to the classic side more than the cloud side. An example from the ITIL literature can help illustrate this point.

A key activity in ITIL is the production of a plan that should include forecasts and recommendations in terms of resources required, cost, benefits, and impacts (Office of Government Commerce, 2011, p. 161). ITIL recommends that this capacity plan be published annually in line with the organization's budget cycle. Quarterly updates may be necessary in order to take into account any changes in service plans (Office of Government Commerce, 2011, p. 161). As discussed in the results section, the time horizon for capacity planning in the cloud structure side of the spectrum is far shorter than annually or quarterly. Indeed, Figure 8 shows that none of the cloud-structure organizations said that a report of any fashion was one of their outputs as a process.

While interviewing the three subjects from the cloud structure organizations, it is worth noting their opinions of ITIL and similar published best practices. While answering the question on whether their organization followed any best practices or frameworks for IT capacity-management, Person 7 added some opinions about ITIL after responding that he didn't follow any.

> **Person 7:** "I've had to look at ITIL, and I know the concepts, but I learned more from my colleagues than from reading the ITIL documents."

After the conclusion of the formal interview with Person 9 and Person 10, an informal conversation ensued. On the topic of this research effort, they asked if the researcher would be doing a gap analysis between what the literature (like ITIL) says an IT organization should be doing versus what it actually is doing.

> **Person 9: "**So it's interesting the difference between "should" and "is." Sometimes it's ignorance, but sometimes it's just the "should" is just wrong. It's an error."

Person 10: "The "should" just doesn't have a good grasp on reality. It's like really easy to talk about things and imagine them and have no bearing on reality."

Further research on the opinions and practiced interactions with best-practice frameworks and organizations of a cloud-type structure could produce valuable results for the field of IT.

Conclusion

This research sought to gain an understanding of how organizations are operating their IT capacity-management processes in the field. By utilizing qualitative methods and grounding the analysis in the data, a model of how a dozen organizations are operating their IT capacity-management processes has been developed. Evidence has been provided to illustrate just how large the impact cloud computing is to the field of IT capacity-management. It is shown here as a differentiation factor between IT capacity-management structures, creating distinctions between IT capacity-management processes. The manifest functions, or unintended consequences of IT capacity-management trying to "stay relevant" during a transition to cloud appears to lead to its own obsolescence.

This research may be used as a starting point for the creation of a substantive theory on how IT capacity-management is practiced. Factors that could lead to a substantive theory were identified and further specific research efforts to advance the creation of such a substantive theory were identified. Identifying a possible path of evolution for IT capacity-management as it moves from classic to cloud is useful to practitioners so that they may begin to study it and take steps to reshape the path for the field as a whole. For managers in IT, this research can be used as a starting point for more proactive career development for current IT capacity managers if their organization is about to transition to cloud.

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Appendix A: Informed Consent Form

Informed Consent Form

Title: Understanding How Organizations Operate Their IT Capacity-management Processes

Investigator: Joe Bauer, Graduate Student, Eastern Michigan University

Purpose of the Study: This research seeks to gain an understanding of how organizations are operating their IT capacity-management processes.

Procedure: After this informed consent, you will be asked a series of questions about how your organization is operating its IT capacity-management. The interview is expected to last about one hour. Your audible answers will be recorded for transcription purposes only. Audio recordings will be deleted after transcription. You will receive an advance copy of the research analysis and your feedback will be encouraged, but not required.

Confidentiality: Your participation in this interview is anonymous. No identifying information will be retained. Data from this interview will be secured on a password protected removable drive and stored in a locked safe. Audio recordings will be deleted after transcription. The final report may utilize direct quotes from the interview, but pseudonyms will replace any identifying information.

Expected Risks: The risks involved with participating in this interview are minimal.

Expected Benefits: There is no personal benefit involved in completing this interview.

Voluntary Participation: Participation in this interview is voluntary, and you can decide to discontinue of the interview at any time without penalty or loss of benefits.

Use of Research Results: Results will be presented in aggregate form only. Personally identifying information (such as names) will not be used. Results may be presented at academic conferences and published in academic journals.

Questions: If you have any questions about your participation in this study, now or in the future, please contact the principal investigator, Joe Bauer at 734-[personal phone number] or by email at jbauer4@emich.edu. You may contact the researcher at [shool email]@emich.edu for a copy of the interview. You may also contact the researcher at [shool email]@emich.edu for the results.

Human Subjects Review Board: This research protocol and informed consent document has been reviewed and approved by the Eastern Michigan University Human Subjects Review Committee (UHSRC) for use from _________ to _________ (date). If you have questions about the approval process, please contact the UHSRC at human.subjects@emich.edu or call 734-487-0042.

Consent to Participate: I have read or have had read to me all the above information about this research study, including the research procedures, possible risks, side effects, and the likelihood of any benefit to me. The content and meaning of this information has been explained and I understand. All my questions, at this time, have been answered. I give my consent and I do voluntarily offer to follow the study requirements and take part in the study.

Signature: ____ Date: ______________________

Appendix B: Interview Questions

- Demographics
    - Organization
        - In which field or industry is your organization?
        - How many employees are at the organization?
        - How long has your organization been doing IT capacity-management?
        - Location
        - Is there a framework or best practice that is being followed? (ITIL? COBIT? Etc.)
    - Subject
        - What is your job title?
        - Is this a full time role for you?
        - What is the highest level of education you have completed?
        - Have you had any formal IT capacity-management training?
            - If so, what?
        - How long have you been practicing IT capacity-management?
        - How long have you been with this organization?
- What is your role in capacity-management at your organization?
    - Are there any other roles associated with capacity-management at your organization?
    - Anyone else doing IT capacity-management with you?
- What is IT capacity-management supposed to do in your organization?
    - What needs does it fulfill?
- How do you know when IT capacity-management is successful?

  - Who defines success?
- What activities are carried out when performing capacity-management?
  - What are the inputs of capacity-management?
    - Who does it come from?
  - What is the output of capacity-management?
    - Who receives these outputs?
- What needs to be in place in order for capacity-management to function properly in your organization?
  - Example of when it went well? Or Bad?
- Are there cases where people go outside of the capacity-management process?
  - If so, what is it they are doing?
- Have there been any unintended consequences associated with doing IT capacity-management at your organization?
  - Have you noticed any positive or negative effects that weren't intended?
- Anything else you think I should know about?
- Interested in the final report? Yes --- no
- Thanks

Appendix C: Initial Contact Solicitation Email

Dear [PROSPECTIVE SUBJECT],

My name is Joe Bauer and I'm a PhD student at Eastern Michigan University. For my dissertation I'm studying how organizations operate their IT capacity-management processes. You have been identified as someone who works with IT capacity-management and I would like to invite you to participate in a one hour interview to describe how it is done at your organization. Participation is voluntary and your responses will be kept anonymous in the final report. To take part, simply reply to this email and then I will coordinate with you on when and where the one hour interview should take place.

For more information about the topic, please see my article in CMG's MeasureIT: http://www.cmg.org/wp-content/uploads/2013/03/m_96_7.pdf

Thank you,

Joe Bauer

PhD Student, College of Technology, Eastern Michigan University

734-[personal phone number] (cell)

[school email address]@emich.edu

Appendix D: Code Dictionary

Table 7

Code Dictionary.

Theme	Category label	Description
Activities	Cost or Budget Analysis	Financial calculations.
	Delta analysis	Comparing one variable against another. For example, amount of resources on hand vs. amount of resources consumed.
	Measuring and Monitoring	Collecting, filtering, sorting information.
	Modeling or forecasting	The creation of mathematical models to describe or forecast.
	Moving load or modifying demand	Changing where jobs or tasks (work) is performed. Such as storing files in a different location. Or, changing the behavior of user activity. For example, setting specific hours users can access a certain system.
	Performance Tuning	Finding areas where the technical architecture or configuration can be changed in order to run more efficiently or for work to complete more quickly (or both). For example, accomplishing the same tasks with fewer system resources or servers.
	Specify new system configuration	The act of creating specifications for new technical system configurations (add/remove/modify).

	Training or Mentoring	Supplying others with knowledge, wisdom, or advice. Sometimes a single or limited transaction, other times an ongoing relationship.
Inputs	Business Projections	The projections, plans, or goals from the business or non-IT area of the organization.
	Cost	Information about the cost of resources or services.
	System Configuration	The current technical system attributes that are owned or managed by the organization. For example, how much memory or CPU is installed in a given server.
	System Performance Metrics	Information about the technical performance of systems. Things like CPU, memory, network, etc. Not how much is installed (that's system configuration) or how it is configured, but how much is being used.
Outputs	Forecasts	Predictions about the future.
	New System Configuration	Added (including buying), removed, modified technical system configurations. For example, added or removed memory or CPU.
	Capacity recommendations	Suggestions or recommendations to a different role for action.

	Reports	A document (physical or virtual) given to or accessed by another role. Could contain other outputs, like recommendations or forecasts, for example.
Related roles	Customers	The people who purchase or use the services the organization offers. In the case of consultants, the customer is the organization that hired them to provide IT capacity-management as a service.
	Upper management	Represents members of upper management all the way up to the CxO level (or equivalent).
	Finance or accounting	The role that manages the money and budget for the organization. Sometimes they are also the purchasing authority.
	Other teams within IT	Teams within the area of the organization that handles IT, but not the team that has the IT capacity-management role in it. It most commonly includes teams such as analysts, architects, data center operations, programmers, application designers, or other operational IT teams.

Appendix E: Interview Questions, Research Questions, and Theoretical Frameworks Alignment

Table 8

Interview Questions Aligned with Research Questions and Theoretical Frameworks.

Research Questions	Interview Questions	Theoretical Frameworks
Can a descriptive model be developed for the processes of IT capacity-management as found in practice?	Emerges from analysis of questions below.	Business Process, structural functionalism, structuration
Are there dimensions or factors that create distinctions or variants within a descriptive model for different contexts?	Emerges from analysis of questions below in addition to the comparisons of patterns between demographic questions.	Business Process, structural functionalism, structuration
What is the structure of IT capacity-management?	Emerges from analysis	Structuration
What are the social patterns that create the process of structure in IT capacity-management?	• What is your role in capacity-management at your organization? ○ Are there any other roles associated with capacity-management at your organization? • Anyone else doing IT capacity-management with you?	Structuration

What are the common processes of IT capacity-management found among the organizations that are interviewed?	• What activities are carried out when performing capacity-management?
	  ○ What are the inputs of capacity-management?
	    ▪ Who does it come from?
	  ○ What is the output of capacity-management?
	    ▪ Who receives these outputs?
		Business Process

What are the inputs?	• What are the inputs of capacity-management? o Who does it come from?	Business Process
What are the activities?	• What activities are carried out when performing capacity-management?	Business Process
What are the outputs?	• What is the output of capacity-management? o Who receives these outputs?	Business Process
What are the functions of IT capacity-management?	Emerges from analysis	Structural functionalism
What are the manifest functions of IT capacity-management?	• What is IT capacity-management supposed to do in your organization? o What needs does it fulfill?	Structural functionalism
What are the latent functions of IT capacity-management?	• Have there been any unintended consequences associated with doing IT capacity-management at your organization? o Have you noticed any positive or negative effects that weren’t intended?	Structural functionalism

What sustains these functions? What are their requirements or needs?	• What needs to be in place in order for capacity-management to function properly in your organization?
	    o Example of when it went well? Or Bad?
	• How do you know when IT capacity-management is successful?
	    o Who defines success?
		Structural functionalism

Are there any functional alternatives to the IT capacity-management functions?	• Are there cases where people go outside of the capacity-management process? ○ If so, what is it they are doing?	Structural functionalism
What are the social roles that perform the functions of IT capacity-management?	• What is your role in capacity-management at your organization? ○ Are there any other roles associated with capacity-management at your organization? ○ Anyone else doing IT capacity-management with you?	Structural functionalism

Appendix F: Organization Coding to Model Attributes Summaries

The following tables compare the attributes of the proposed capacity model with the organizations in the research. A "yes" means the subject(s) provided evidence that their organization contained the related attribute from the proposed capacity model.

Table 9

Organizations by Capacity Model Roles.

Organization	Customers	Upper management	Finance or accounting	Other teams within IT
Organization 1	Yes	Yes	Yes	No
Organization 2	Yes	No	No	Yes
Organization 3	Yes	Yes	No	No
Organization 4	Yes	No	No	Yes
Organization 5	No	Yes	No	Yes
Organization 6	Yes	Yes	No	Yes
Organization 7	Yes	No	Yes	Yes
Organization 9	Yes	No	Yes	No
Organization 10	Yes	No	No	No
Organization 12	Yes	No	No	No

Table 10

Organizations by Capacity Model Inputs.

Organization	Cost	System Performance Metrics	System Configuration	Business Projections
Organization 1	Yes	No	No	Yes
Organization 2	No	Yes	Yes	Yes
Organization 3	No	Yes	Yes	No
Organization 4	Yes	Yes	Yes	No
Organization 5	No	Yes	Yes	Yes
Organization 6	Yes	Yes	Yes	No
Organization 7	No	Yes	No	No
Organization 9	Yes	No	No	No
Organization 10	Yes	No	No	Yes
Organization 12	No	Yes	No	No

Table 11

Organizations by Capacity Model Activities.

Organization	Performance Tuning	Delta analysis	Measuring and monitoring	Moving load or modifying demand	Specify new system configurations	Modeling or forecasting
Organization 1	Yes	Yes	No	Yes	No	Yes
Organization 2	Yes	No	Yes	No	No	Yes
Organization 3	Yes	Yes	Yes	Yes	Yes	Yes
Organization 4	Yes	Yes	Yes	Yes	No	Yes
Organization 5	No	Yes	No	No	Yes	Yes
Organization 6	No	Yes	Yes	Yes	Yes	Yes
Organization 7	No	Yes	Yes	No	Yes	Yes
Organization 9	Yes	Yes	Yes	No	Yes	Yes
Organization 10	No	Yes	No	No	No	Yes
Organization 12	No	No	Yes	No	Yes	Yes

Table 12

Organizations by Capacity Model Outputs.

Organization	New System Configuration	Capacity recommendations	Reports	System Performance Metrics	Forecasts
Organization 1	No	No	Yes	No	Yes
Organization 2	Yes	Yes	Yes	Yes	No
Organization 3	No	No	Yes	Yes	No
Organization 4	No	Yes	No	Yes	Yes
Organization 5	Yes	No	Yes	Yes	Yes
Organization 6	Yes	Yes	No	Yes	Yes
Organization 7	Yes	Yes	No	Yes	No
Organization 9	Yes	No	No	No	Yes
Organization 10	Yes	No	No	No	No
Organization 12	Yes	Yes	No	Yes	Yes

Appendix G: Coding References by Organization

The following tables show the number of references for each code by organization.

Table 13

Organization references by Role Codes.

Organization	Customers	Upper management	Finance or accounting	Other teams within IT
Organization 01	1	3	1	0
Organization 02	3	0	0	1
Organization 03	7	1	0	0
Organization 04	3	0	0	1
Organization 05	0	2	0	1
Organization 06	1	2	0	4
Organization 07	1	0	2	4
Organization 09	1	0	1	0
Organization 10	2	0	0	0
Organization 12	1	0	0	0

Table 14

Organization References by Input Codes.

Organization	Business Projections	Cost	System Configuration	System Performance Metrics
Organization 01	4	2	0	0
Organization 02	1	0	1	5
Organization 03	0	0	2	2
Organization 04	0	1	2	1
Organization 05	3	0	1	1
Organization 06	0	4	2	1
Organization 07	0	0	0	1
Organization 09	0	1	0	0
Organization 10	1	2	0	0
Organization 12	0	0	0	1

Table 15

Organization references by Process Activity Codes

Organization	Delta analysis	Measuring and Monitoring	Modeling or forecasting	Moving load or modifying demand	Performance Tuning	Specify new system configuration
Organization 01	2	0	1	2	3	0
Organization 02	0	6	2	0	2	0
Organization 03	2	1	5	1	2	1
Organization 04	3	1	2	2	1	0
Organization 05	1	0	2	0	0	1
Organization 06	1	1	4	2	0	1
Organization 07	1	3	1	0	0	2
Organization 09	1	3	1	0	1	2
Organization 10	2	0	1	0	0	0
Organization 12	0	1	1	0	0	2

Table 16

Organization References by Output Codes.

Organization	Forecasts	New System Configuration	Capacity recommendations	Reports	System Performance Metrics
Organization 01	2	0	0	1	0
Organization 02	0	4	1	1	5
Organization 03	0	0	0	3	2
Organization 04	1	0	3	0	1
Organization 05	1	1	0	1	1
Organization 06	1	2	3	0	1
Organization 07	0	2	2	0	1
Organization 09	1	5	0	0	0
Organization 10	0	2	0	0	0
Organization 12	2	1	3	0	1

Appendix H: ITIL and IT Capacity-management Model Attributes Comparison

Table 17

Comparison of ITIL Attributes Against IT Capacity-management Model Attributes

ITIL SIPOC Attributes	IT Capacity-management Process Model SIPOC Attributes
Inputs	
Service plans and technology plans (Office of Government Commerce, 2011, pp. 174–175)	Business Projections
Component performance and capacity information (Office of Government Commerce, 2011, pp. 174–175)	System performance metrics, and System configuration
Service performance issue information - incidents and problems (Office of Government Commerce, 2011, pp. 174–175)	No match
Service information - Service Level Agreements (Office of Government Commerce, 2011, pp. 174–175)	No match
Financial information - cost of service provisioning, cost of resources, etc. (Office of Government Commerce, 2011, pp. 174–175)	Cost
Change information - schedule of changes, impact of changes on capacity (Office of Government Commerce, 2011, pp. 174–175)	No match
Performance information - Current performance of services and IT components (Office of Government Commerce, 2011, pp. 174–175)	System performance metrics
CMS (Configuration Management System) - information about the relationships between services and	No match

the supporting technologies (Office of Government Commerce, 2011, pp. 174–175)	
Workload information - Schedules of all work that needs to be run (Office of Government Commerce, 2011, pp. 174–175)	No match
Activities	
Forecasting (Office of Government Commerce, 2011, p. 161)	Modeling or forecasting
Modeling (pp. 162-163)	Modeling or forecasting
Making recommendations (Office of Government Commerce, 2011, p. 161)	Specify new system configurations, and Capacity recommendations (however, as an output in the proposed model)
Monitoring - components, hardware, systems (Office of Government Commerce, 2011, pp. 161 – 170)	Measuring and monitoring
Threshold management with alarms (Office of Government Commerce, 2011, pp. 168 – 170)	Measuring and monitoring
Analysis (Office of Government Commerce, 2011, p. 161)	Delta analysis
Reports (Office of Government Commerce, 2011, p. 161)	Reports (however, as an output in the model)
Performance improvement and tuning (Office of Government Commerce, 2011, pp. 162 – 163)	Performance tuning
Balancing workloads (Office of Government Commerce, 2011, pp. 171 – 172)	Moving load or modifying demand
Taking corrective action on capacity-related threshold events (Office of Government Commerce, 2011, pp. 162 – 163)	A combination of Performance tuning, measuring and monitoring, and New system configuration (an output in the model)
Assisting with specific performance	No match

issues (Office of Government Commerce, 2011, pp. 162 – 163)	
Implementing changes (Office of Government Commerce, 2011, p. 172)	New system configuration (as an output in the model)
Outputs	
Component and service requirements (Office of Government Commerce, 2011, p. 161)	Possibly, Capacity recommendations
CMIS (Capacity-management Information System) - Holds all the data required by the capacity-management process (Office of Government Commerce, 2011, p. 175)	No match
Capacity plan (Office of Government Commerce, 2011, p. 175)	Reports
Service performance information and reports (Office of Government Commerce, 2011, p. 175)	Reports
Workload analysis and reports - used by IT operations and capacity-management to manage workload to ensure effective and efficient use of available resources (Office of Government Commerce, 2011, p. 175)	System performance metrics, and Reports
Ad hoc capacity and performance reports - used to resolve service and performance issues (Office of Government Commerce, 2011, p. 175)	Reports
Forecasts and predictive reports - for analysis of business and IT scenarios (Office of Government Commerce, 2011, p. 175)	Forecasts
Thresholds, alerts, and events (Office of Government Commerce, 2011, p.	Measuring and monitoring (however, as an activity in the model)

175)	
Improvement actions (Office of Government Commerce, 2011, p. 175)	New system configuration
Making recommendations (however, as an activity in ITIL)	Capacity recommendations
Roles	
Availability management - work together to determine resources needed to ensure required availability of services and components (Office of Government Commerce, 2011, p. 176)	Possibly, Other teams within IT
Service level management - Determine capacity targets (Office of Government Commerce, 2011, p. 176)	Possibly, Upper management
ITSCM (IT Service Continuity Management) - Assisting in risk reduction and recovery options (Office of Government Commerce, 2011, p. 176)	No match
Incident and problem management - Assisting with resolution of incidents and problems (Office of Government Commerce, 2011, p. 176)	Possibly, Other teams within IT
Demand management - Helping identify means for influencing demand (Office of Government Commerce, 2011, p. 176)	Possibly, Upper management
No match	Finance or Accounting
No match	Customers

Appendix I: Open Coding Categories

Figure 10. Open Coding Categories

Capacity-management Process Steps
Activity
Code path analysis
Justifying capacity-management
Load testing
Looking for patterns
Lots of labor
Maintenance scheduling
Mapping transaction paths
Mathematical modeling
Performance tuning
Predictions
Wind gauge
Root cause investigation
Systems Assurance
Testing DR-BC
Throttle demand
Tools
Transparency
Input
Data collection from machines
Hardware profile
Information from business
Business plans drive capacity demand
Hard to know what business plans are
Output
Action
Add resources
Measured load limits
Meetings or conversations
Plan
Predictions
Presentations
Re-Architecture
Capacity recommendations
Reports
Prerequisites
enough staff
Expensive resources
Goals and objectives
must be part of infrastructure
proper training
Tools
Characteristics of capacity-management

Capacity-management is changing	
Capacity-management is related to Performance Management	
Capacity-management is still relevant	
Capacity-management on the decline	
Field is convoluted	
no one size fits all approach	
Consequences of bad capacity planning	
Customers leave	
Too much equipment	
Culture glimpses	
Business view of IT	
IT view of business	
Frameworks or best practices	
Based practices on Software Physics	
Home Grown	
CERN based	
Light weight	
No formal best practices	
Purpose of Capacity-management	
Assure enough resources for services required	
Avoid outages	
Avoid problems	
Avoid running out of resorces	
Avoids surprises	
Capacity-management can help with Cloud Sprawl	
Cost avoidance	
Customer satisfaction	
Meet business needs	
Meet performance expectation	
Utilize resources to their maximum	
Related roles	
Success	
Who defines success	
Unintended consequences	
Want to do	
Better prototyping	

Appendix J: Selective Coding Categories and Themes

Figure 11. Selective Coding Categories and Themes.

- Selective Coding
  - Process
    - Activities
      - Delta analysis
      - Measuring and Monitoring
      - Meetings or communications
      - Modeling or forecasting
      - Moving load or modifying demand
      - Performance Tuning
      - Specify new system configuration
    - Inputs
      - Business Projections
      - Cost
      - System Configuration
      - System Performance Metrics
    - Outputs
      - Forecasts
      - New System Configuration
      - Capacity recommendations
      - Reports
    - Related roles
      - Customers
      - Upper management
      - Finance or accounting
      - Other teams within IT
        - Analysts
        - Architects
        - Data Center Operations
        - Operational IT Teams
        - Programmers or Application Designers
  - Spectrum
    - Defining
      - Characteristics of Capacity-management
      - Purpose of Capacity-management
    - Influencing forces
      - Change
      - Culture Glimpses
      - Frameworks or best practices or guides
        - Custom
        - ITIL
        - None
    - Opinions and Feelings
    - Org Structure
    - Success

	Consecutive of bad capacity-management	
	Prerequisites	
	Type	
	Classic	
	Cloud	

Appendix K: Panel of Judges Sheets

What follows are copies of the sheets provided to the panels of judges for validity and reliability checks (see methodology section).

Does the **code** represent the content of the **transcript**?

Code: "Performance Tuning"

Transcript: "They're tuneable in the app space and tuneable in the OS and there are tuneables in the hardware. What we do is we optimize the codepath. We allow the application to run at full potential of the hardware that's available. So this is an optimization phase that we have to go through."

◯ Yes, the code represents the transcript. ◯ No, the code does not represent the transcript.

Code: "System Configuration"

Transcript: "I need to know my infrastructure. If my computers has 2 cores or 4 cores."

◯ Yes, the code represents the transcript. ◯ No, the code does not represent the transcript.

Code: "Reports"

Transcript: "Yes I make reports. And I make the reports and they are for 6 months. I make one report that's a projection - capacity plan."

◯ Yes, the code represents the transcript. ◯ No, the code does not represent the transcript.

Code: "Finance or accounting"

Transcript: "And a good relationship with the finance people to get more resources as required. The finance people got to trust the capacity-management team to know and not just over estimate when more capacity is required."

○ Yes, the code represents the transcript. ○ No, the code does not represent the transcript.

Code: "Measuring and monitoring"

Transcript: "ok, for the run of the mill stuff we're collecting four basic metrics, CPU, memory, I/O, network."

○ Yes, the code represents the transcript. ○ No, the code does not represent the transcript.

Does the **definition** match the **code**?

Code: "Performance Tuning"

Definition: Finding areas where the technical architecture or configuration can be changed in order to run more efficiently or for work to complete more quickly (or both). For example, accomplishing the same tasks with fewer system resources or servers.

○ Yes, the definition matches the code. ○ No, the definition does not match the code.

Code: "System Configuration"

Definition: The current technical system attributes that are owned or managed by the organization. For example, how much memory or CPU is installed in a given server.

○ Yes, the definition matches the code. ○ No, the definition does not match the code.

Code: "Reports"

Definition: A document (physical or virtual) given to or accessed by another role. Could contain other outputs, like capacity recommendations or forecasts, for example.

◯ Yes, the definition matches the code. ◯ No, the definition does not match the code.

Code: "Finance or accounting"

Definition: The role that manages the money and budget for the organization. Sometimes they are also the purchasing authority.

◯ Yes, the definition matches the code. ◯ No, the definition does not match the code.

Code: "Measuring and Monitoring"

Definition: Collecting, filtering, sorting information.

◯ Yes, the definition matches the code. ◯ No, the definition does not match the code.