AC 2008-693: A FRAMEWORK FOR BUILDING SUSTAINABLE IT INFRASTRUCTURE TO SUPPORT UNDERGRADUATE EDUCATION IN A DEVELOPING NATION

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A framework for building sustainable IT infrastructure to support undergraduate education in a developing nation

We present a process model for building sustainable information technology infrastructure to support undergraduate education in developing nations. We began applying the model in 2004 in Kabul, Afghanistan at the nation's brand new National Military Academy. Assessments of progress and problems that have occurred there have helped to refine it. The aim of this paper is to describe the model that has been successful thus far as a guide to others engaged in similar work.

Introduction

In our personal experience, leaders of developing nations are eager to follow the examples of India, Pakistan, China, and others to achieve economic and political successes rooted in information technology (IT)-related industry. They rightly believe this must begin with excellent technical education of their populations. "Pulling one's nation up by its bootstraps" in this area is, however, a difficult undertaking. Creating good IT educational environments demands the same know-how and background that the environments are intended to develop. Physical infrastructure, technical staff, teachers, policy-makers, and administrators—which we collectively call *educational infrastructure*—must be developed in parallel and in a synchronized fashion, usually from very modest beginnings.

The old saw says that it's "what you don't know that you don't know that will kill you." Certainly that applies here. The developing nation setting tends to be rich in excellent enthusiasm and audacious goals, yet to be unknowing of the long path to competitiveness in IT in a globalizing economy that is advancing at breakneck speed in this area. It is a primary job of those in the role of consultant, assistant, or (our preferred relationship) mentor to erase the first level of "don't know." That is, she must educate all concerned as to the full scope of work needed to build IT educational infrastructure so that enthusiasm finds productive outlets. In order to do this, the mentor must in turn know what she does not know. Technology education "best practices" of highly developed economies are little help; rather, they are frequently counter-productive. The purpose of this paper is toward filling this blind spot with a model—a framework for thought and action related to educational infrastructure development.

The model can be applied in two ways. First, it can serve as a kind of manual or methodology for the mentor to discover a strategy that will both get development started and sustain it—the key people, relationships, and logistical considerations. Second, it can serve as a common language between the mentor and the people who must finally own and operate whatever is built for the long term.

Overview of the model

Our model begins with an assessment of the environment, accounting for the stark challenges that a university Chief Information Officer or Technology Services Director in a first world setting would not encounter. Local culture and economic conditions have pervasive effects that shape these challenges, ranging from overarching strategic matters to very practical tasks. We confront the "expectation gap" of developing nation leaders, who may have a vision of the successful end state, but little understanding of the costs and breadth of effort required to implement it. We consider unique problems created by the lack of efficiency and potential for corruption in acquisition channels. We account for facilities matters such as adequate workspace, environmental quality, and availability of utilities. Finally, we incorporate human factors, accounting for faculty development and technical staff hiring and training. We place special emphasis on human factors based on our experiences and our realization that a strategy for fostering a sense of ownership of infrastructure is indispensable.

After developing an understanding of the environment, a "staged gap analysis" is undertaken to determine the difference between current conditions and desired appropriate intermediate stages of development along four "axes:"

- physical plant
- technical personnel capability
- faculty/staff capability, and
- governance

Each stage is designed to best support student learning within the constraints of a growth schedule, which is initially an estimate, but is refined as planning proceeds. The principle of stages is needed to ensure that all four axes advance in a parallel, synchronized fashion that avoids bottlenecks.

Refinement is based on analysis of progress towards the next intermediate stage along each axis. The results of the analysis provide the basis for a development plan that addresses the gaps between the current state and the next stage as a set of leadership and management products: long term programs, initiatives, assessment metrics and methods, and milestone review schedules. While such planning products are standard, the particular need for all the axes to advance in concert and in the face of volatile external conditions renders them more complex and interdependent than those encountered in conventional IT planning. We address this using a "crosswalk" technique. The crosswalk may indicate that the choice of stages was overly conservative or aggressive, in which case stages are modified and the development plan is refined.

Throughout the planning process, a prime concern is that the same environmental volatility that leads to interdependencies along the axes also requires plans to be deeply flexible. Agility is gold, and seldom easily earned. Change along one axis can easily ripple through interdependencies to cause problems on an altogether different one—a delay in the availability of reliable electrical power may leave new teachers and students idle. The model addresses such risks by requiring advance predictions, "what if" branches and sequels, with the goal of minimizing interdependencies and maximizing agility.

In this paper, we use a series of illustrative anecdotes and example experiences of the authors to put the process model in a realistic context.

The Developing Nation Environment

Cultural-social norms

Environmental conditions define the limits of developmental potential, and consequently must be assessed prior to establishing a plan for improving infrastructure. A logical first step during the assessment is to develop a detailed understanding of the people. History, individual experience, cultural background, and values shape who they are, how they have arrived at the current state, and their potential for moving forward. An appreciation for common cultural practices and socioeconomic background are required for developing realistic plans for improvement in the host nation. Moreover, a firm understanding of social norms promotes open, harmonious discussion and prevents potentially uncomfortable and offensive situations created by mentor ignorance. Some particular areas to consider include the length of a typical workday, the role of women in society, and the typical methods of interaction in business settings. Developing this perspective requires preparation and study ahead of time, but it must also be tailored to the particular environment and people upon initiating interaction.

A less tangible, but equally critical component to understanding the people is to develop a sense for their individual and institutional motivation. How willing are the people to work hard to fix their own problems versus asking for help? The answer to this question has to be taken in the context of how capable they are of helping themselves. Understanding the technical capabilities of all actors in the system (leaders, technicians, faculty, and students) shapes the plan and helps to determine an estimate for the output per worker as described by Hall and Jones. They explain that countries with "corrupt government officials, severe impediments to trade, poor contract enforcement, and government interference in production will be unable to achieve levels of output per worker anywhere near the norms of western Europe, northern America, and eastern Asia."[6] A reasonable estimation of cultural norms for the amount of work people produce in a given time period enables development of realistic schedules for improvement, forestalling future disappointment.

In our experience, there is a pervasive expectation that assistance from a first world nation should result in an immediate transformation of the infrastructure to a mature, modern one, a result of general lack of personal experience and expertise among leaders and constituents. The only remedy is an intense but careful educational effort by the mentor to increase understanding while also inspiring patience and dedication to the long term goal of an excellent infrastructure. Frustration among non-technical leaders must be quelled, since it is likely to result in pressure applied to the local IT supervisors, leading to hasty decisions and solutions that are neither maintainable nor expandable. Mentors should guide IT supervisors to focus on realistic goals and arrange forums where supervisors can explain progress to non-technical leaders in an atmosphere of mutual support and trust.

Mentors must also understand how turbulent socioeconomic environments affect technical staff. Once skilled in developing IT solutions, the technicians may be enticed toward more lucrative opportunities with other organizations, thus leaving the institution without the technical workforce to expand and maintain the systems put into place. Promoting a sense of accomplishment and pride in their work must be accompanied by a sense of loyalty to the institution. Keeping the skilled personnel with the organization must be a high priority.

Physical Infrastructure

Understanding the state of physical resources requires first-hand, onsite inspection to develop a true appreciation for the condition of utilities, buildings, and equipment. It is useful to begin the onsite assessment with the elements over which the organization has the least degree of control, because these may introduce developmental constraints in terms of cost and span of influence. A logical first place to start is with the utilities, such as power and external network connections, because they are likely outside of the control of the institution, underdeveloped, intermittent, and very expensive to improve. As external resources, they present considerable challenges requiring interaction with host-nation leadership and long periods of time to address. Identifying the limitations, the appropriate agencies for making improvements, and potential alternatives must occur early in the planning process.

Assessing the state of the institution's buildings also needs to occur early based on the potential need to rely on external contractors. Most buildings were not constructed with IT support in mind and considerations as simple as where to run cables quickly become limiting factors. The materials used in the construction of the buildings dictate the degree of difficulty in making modifications and the extent to which external contractors need to be involved. In extreme circumstances, new buildings may be required. The condition of the buildings will help in determining locations for network devices, a scheme for connecting them, and which resources are placed in which buildings.

The state of more traditional IT devices, such as routers, switches, servers, and workstations, is the last area to focus on since it is the easiest to affect. Though needs for external coordination may be small, financial impact is comparatively large. Winning budget support may consume much effort and time, detracting from staff accomplishments and disrupting schedules. Slow or unreliable procurement processes also add schedule risk. Scarcity of resources requires most vendors to order the requested materials, introducing time delays associated with the nation's postal system. Each external agency that is introduced into the process also introduces the risk of corruption or theft. The ability to find the "right" piece of equipment may not even be an option, forcing the acceptance of a suboptimal solution that fits within the constraints of on-hand materials. Even seemingly worst case estimates have proven ambitious in the face of this environmental volatility. The cost of resources in both time and money often exceeds even the most conservative estimates and forces adjustments to the plan.

Rate of change

All of the environmental factors discussed thus far have the potential to slow the rate of improvements. Even though the host nation's leaders may anticipate the rate of change to be comparable to that in the first world, it will necessarily be considerably slower in a developing nation. The internal rate of change at the institution must also be assessed in the context of the rate of change for the nation and region. External factors beyond the immediate control of the institutional administration affect internal decisions. If the supporting environment permits rapid internal growth, then the rate of change can increase, but planners must always be aware of risks that can instantly affect the external environment and halt the potential for progress. The volatile nature of the environment requires planning for contingencies.

Assisting nations

Many IT development efforts are multinational to take advantage of skills and funding from the entire international community. Identifying who is involved helps to coordinate effort and prevent divergent or even conflicting actions. Representatives must openly communicate and be prepared to compromise when necessary. The host nation leaders ultimately need to retain the decision making authority, but close coordination among the assisting representatives presents the best method for arriving at goals on schedule.

IT Developmental Axes

A viable framework for building IT infrastructure must account for development along four axes:

- physical plant
- technical personnel capability
- faculty / staff capability and
- governance

The physical plant axis is used to monitor the expansion and improvement of physical resources, accounting for increased reliability of externally provided utilities, modifications and expansions to buildings, and the integration of newly purchased equipment. The technical personnel capability axis accounts for the hiring and training of a technical staff capable of maintaining the network, the hardware, and the software components of the enterprise. The educational background, degree of experience, and motivation of the faculty constitutes the faculty and staff capability axis. The governance axis tracks the creation of policies for security, computer usage, and enterprise maintenance. The difficulty in planning IT progress in a developing nation is not planning tasks associated with the individual axes themselves, but rather the need to synchronize their progress so that growth proceeds in concert. Our framework relies on several synchronizing concepts to ensure progress remains relatively even across the spectrum.

First, fostering a *sense of ownership and responsibility* is critical. The technicians, administrators, and users alike must enthusiastically embrace the proposed technological advances so that they are motivated to learn all aspects of the new systems. Initially, technicians need to learn and develop experience alongside skilled mentors, but they must embrace tasks on their own so that they can maintain and expand the infrastructure. Sacrificing short term momentum for a slower pace that enhances long term capabilities is critical. Likewise, some external assistance and guidance may initially be necessary to educate leadership, but the leaders must become accustomed to making their own decisions. Finally, the faculty users must assume the responsibility for incorporating new systems and technologies into the learning environment so that the new capabilities are put to good use. As students and teachers become increasingly excited about their technological capabilities, it will begin to change the commitment to information technology.[13] On the other hand, failure to effectively integrate technology into the curriculum will render the resources underutilized.

As a second synchronizing concept, *accounting for physical dependencies* among resources helps to prioritize expenses and resource allocation so that growth is optimized along all four axes. Many tasks on multiple axes may rely on the existence of physical resources before they can even begin. As an example, consider the education and training of the system's actors on a particular technology. They need to have an example system to work with in order to develop proficiency. Assuming, however, that money is scarce, it doesn't make sense to allocate limited funds to physical resources that cannot be immediately incorporated into the infrastructure. Establishing the right plan for resource purchases requires analysis of the state of development along each axis.

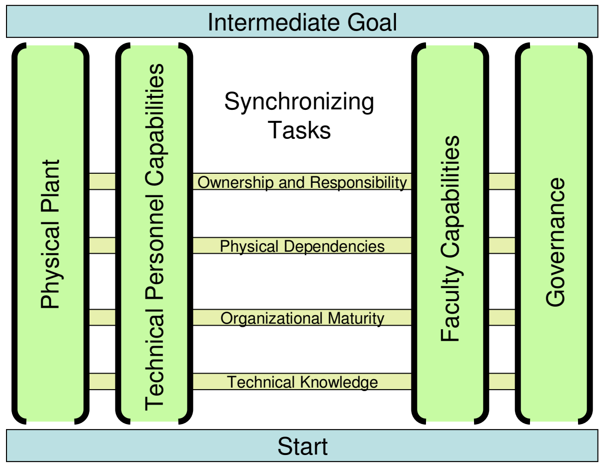

Figure 1
Axes with synchronizing tasks

Third, an assessment of the *organizational maturity* prevents overextending a single axis. As new technologies are added to the environment, the benefits and rules of use need to be explained to all parties so that they understand the effects and impact on their role in the enterprise. It is a requirement to have "a person who understands the region but also has the wider vision to integrate technology, political savvy, and a carefully coordinated plan for a successful implementation."[11] In a mature organization, this integration occurs and avoids stagnation along a given axis. Facilitating the maturation process by analyzing lessons learned helps actors in the system to appreciate their responsibilities and the expectations associated with their role.

Finally, *technical knowledge* is an indispensible synchronizing factor that can easily be overlooked along the separate axes. Clearly the technicians must develop the appropriate skills to add new technology to the infrastructure, but there is an associated requirement to educate the other actors on the system as well. The faculty must understand the technical aspects of how to employ the new systems and the administrators must understand the technical components well enough to develop appropriate policies for use. Sharing the knowledge through communication and training is an essential component to success.

Staged Gap Analysis

Our framework's staged gap analysis is a goal oriented approach to growth that incorporates multiple intermediate objectives to help leaders maintain a focus on student learning. After analyzing the current state of the IT environment, management must determine an estimated schedule for development that fits within the educational and societal constraints.

Looking well into the future, leaders can define a desirable end state where the IT infrastructure adequately supports the educational requirements. The growth between the initial state and this end state will likely require more time and resources than can easily be measured or planned, motivating the need for shorter-term, intermediate goals that can be assessed with quantifiable metrics. Leaders and managers develop a set of standard planning products that include an initial designation of long term programs and initiatives, intermediate objectives, metrics, and milestones to assess progress toward task completion.

Reaching an intermediate goal includes the completion of multiple interrelated tasks. The time period between goals, or stages in our lexicon, should be based on a reasonable approximation of how quickly the associated tasks can be accomplished within the constraints of the environment. The pivotal aspect of determining the duration of stages is to keep them at a length that facilitates continual progress along all axes in unison. Stages that are too short may bog down progress and stymie momentum with managerial tasks, while those that are too long may fail to keep the axes synchronized by introducing many interdependencies. Stages should not be directly tied to a calendar or fixed schedule, but rather they must be capable of fluctuation as changes in the volatile developmental environment are presented. The key is to make sure that individual task milestones are rescheduled in relation to each other.

Synchronizing task development within a stage is critical because of the volatile environment; resources are scarce, environmental conditions are harsh, external social and political pressures may conflict, and changes occur without notice. The scarcity of resources requires that they be allocated where and when they can be used most efficiently. Limited budgets and time prevent committing funds or effort toward tasks that cannot be completed within a stage. Allocating resources toward a given task means that the resources could not be put toward something else. If that task cannot be completed during the stage, then resources were misappropriated and there is great risk of disrupting developmental synchronization. "When buying the equipment is the first step, the second step will be to discover that the teachers are not prepared to integrate the computer activities with their current educational practice."[9]

Identifying the various dependencies between tasks is required for synchronization. As an example, establishing rules for the use of a particular technology implies that the physical resources to support the technology are available, the technicians are capable of employing and maintaining the technology, and the organizational personnel understand how to put the technology to good use. Achieving any subset of these tasks is not sufficient; they all must be complete in order to achieve the goal. If these dependent tasks are not completed within a reasonably short period of one another, then allocation of resources has not been optimized.

Synchronizing progress along all axes requires analyzing related individual tasks in terms of metrics and milestones associated with each axis. Milestones represent points in time when individual tasks need to be completed; they are not goals themselves, but rather time dependent indicators of progress. Metrics are tangible, quantifiable evidence that validate claims of progress. A gap is created when progress along one axis exceeds progress along any *one* of the other axes. The presence of a small gap indicates the need to apply synchronizing concepts that can be handled with relatively minor adjustments, such as shifting the priorities of the individuals involved. Large gaps, on the other hand, serve as indicators of larger problems that may require adjustments to the overall the plan.

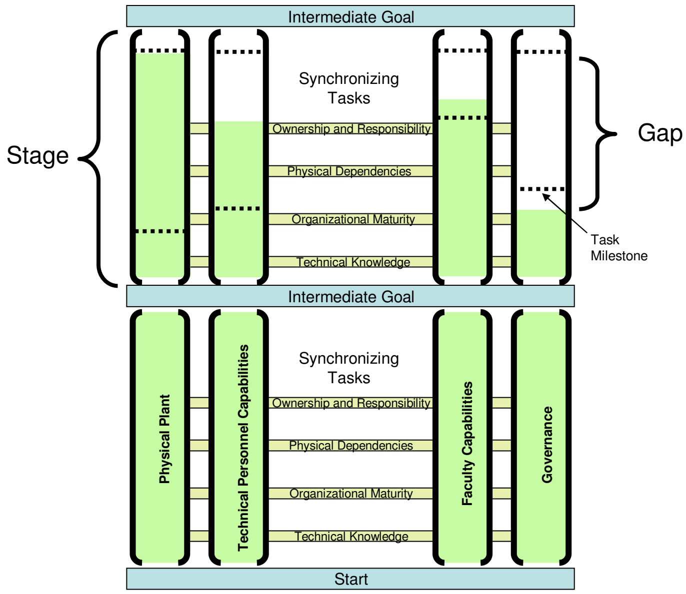

Figure 2
Staged-gap analysis

Planning

While the planning goals cannot be compromised, the programs, initiatives, milestones, and schedules may need revision to address the lack of synchronization indicated by the gaps. Periodic assessment of progress toward goal completion includes a cross-walk of each stage-related task. Approaching or reaching individual task milestones determines where progress is along the axes. Viewing a task in terms of its associated, time-dependent tasks requires "walking" to the next axis and determining where along that axis the related tasks are. If there is a gap, measuring how substantial it is helps to determine how to adjust the rate of progress of the tasks along the associated axes. Applying this technique is critical in developing nations based of the volatility of the environment. Planners cannot control the rate at which purchased resource become available, or control the external societal pressures that affect which employees arrive at work each day, or control how quickly personnel develop an understanding of technical concepts.

Maintaining flexibility in plans helps to ensure continual progress. In the absence of flexibility, failure to reach a milestone along a given axis requires slowing the rate of development of associated tasks along the other axes for the sake of synchronization; environmental volatility necessitates synchronization. Slowing progress, however, is clearly counterproductive and introduces risk of failing to meet objectives. To mitigate these risks, leaders and managers need to develop branches and sequels to plans. Branches and sequels are the result of performing "what if" analysis that affords managers the ability to dynamically reallocate resources toward other tasks. The critical aspect is to perform this contingency analysis ahead of time so that stalling on a single task does not halt overall progress in the middle of a stage.

An Application of the Framework: National Military Academy of Afghanistan

Environment

The nation of Afghanistan has been ravaged by centuries of war. Even though the conventional aspects of the current war are being fought almost exclusively in rural regions, less than a decade ago, opposing forces fought artillery duels down the streets of Kabul destroying the city's physical infrastructure. The war's second and third order effects have included killing the technically competent workforce and forcing experienced professors to flee the country. The people who have remained in Kabul have been forced to deal with oppression and the absence of typical resources for daily living. They have become resilient, but have had no exposure to first world technologies. The skills that they currently possess have all been learned in the few years since the ouster of the Taliban.

Afghanis are a proud people who want to showcase their resilience, and who welcome guests into their homes without reservation. They are very willing to listen to recommendations for improvement, and have an open mind with regards to technological developments. They are hard workers, but their work capacity is limited by a shortage of physical resources. Most of the faculty at NMAA lives many miles away from the campus, requiring vehicular transportation to and from work each day. Very few can afford cars or gas which forces them to rely on public transportation. The last bus that leaves NMAA for the central Kabul bus station departs at 4pm, placing an external limit on the ability of the individuals to work.

Other physical resources have a dramatic impact on the potential for IT development. Upon arrival at NMAA, we found buildings that were decades old and in ill repair, utilities that were intermittent if available at all, and no technical equipment to speak of. The buildings were not constructed to support IT resources with no locations to run cables, power outlets that were scarce and placed inconveniently at eye level on the walls, and no easy means to modify their cement foundation. The government provided power to the facility, but power requirements from the rest of the city depleted the insufficient resources resulting in rolling, unpredictable blackouts. There was no network in Afghanistan implying that whatever network resources we developed at NMAA must be self-sustaining. NMAA had no computer or network resources, nor any technicians or faculty who were knowledgeable of their use. The situation was bleak and likely representative of many other developing regions.

The external rate of change in Afghanistan is very slow. In spite of the Afghani and international community's efforts, making improvements to a degraded or non-existent infrastructure requires considerable amounts of time. Most people involved in the process can identify what needs to be done, but affecting change happens slowly. NMAA's reliance on any external agency becomes subject to a tremendous slow down.

Stages

After spending several months defining the environment and learning methods of dealing with the people, we loosely identified four intermediate stages for the long term IT plan for NMAA: the starting stage, the developing stage, the mature stage and the future stage. The focus of the *starting stage* was to provide immediate support to the academic mission by putting computers in front of students and faculty so that they could begin hands-on learning with a machine. Initially the technology objectives were limited to learning the use of existing software applications for planning and management purposes. We also recognized the immediate need to provide limited internet connectivity for the staff and faculty to facilitate development of educational resources. The *developing stage* objective was to enhance classroom presentation techniques with mobile computer and projector kits. Instructors would have the ability to maximize the limited resources by moving them from classroom to classroom. The *mature stage* included a considerable expansion through the development of an intranet for increasing the capabilities for classroom interaction, lesson preparation, and student out-of-class assignments. The intranet would have that added benefits of simplifying administration and enterprise maintenance and providing Internet access to all machines. Finally, the goal for the *future stage* was to provide a robust environment including additional management services, e-mail services, enhancement to Internet connectivity, and a portable computer for each cadet.

With these stages we established an initial five year plan for development. We defined multiple programs and initiatives with associated milestones and metrics that fit into the stages. Thus far, we have completed the starting and developing stages and we are well on our way to completing the mature stage. For the purpose of explaining our framework, we will describe the progress toward achieving the goals of the mature stage in some detail. NMAA has not yet entered the future stage.

Mature Stage

In order to create a sustainable intranet, we needed to implement directory services to administer the machines, control the use of the computing resources, and efficiently provide network resources to students and faculty. We defined several tasks associated with our goal and then categorized them along one or more of the axes. A demonstrative subset of the tasks is listed in Table 1.

Physical Plant	Technical Personnel Capabilities	Faculty Capabilities	Governance
Designate a room for servers	Learn about directory services (Active Directory)	Understand benefits and limitations of Active Directory	Establish security for server room
Procure server and associated software	Build a Windows 2003 domain	Establish accounts	Establish policies for server administration
	Implement Global Policy Objects (GPOs)	Incorporate AD into classroom environment	Determine policies for administering GPOs

Table 1
List of tasks

We then determined the time dependencies for the tasks so that we could begin to develop a tentative schedule. Along with the schedule, we determined the other interdependencies between the tasks so that we could allocate initial resources. We introduce some of the interdependencies through a discussion of purchasing servers. We knew that we could not build a domain without a server, but that we couldn't purchase a server unless we had a place to store it and operate it. This required a room in building with adequate power, air conditioning, and security. We also knew that there would have to be limited access to the server room, requiring a policy for controlling access. The policy and the room needed to be prepared prior to the servers arriving so that they could be secured immediately. In addition, we knew that we needed to begin training the IT staff on how to build and administer an Active Directory domain so that they would be prepared to do it themselves when the physical resources arrived.

The *complexity* of the interdependencies comes from the volatility of the environment. Although it seems reasonable to allocate a room and an air conditioner to create a server environment, the Afghan administrators who controlled the allocation of building space at NMAA did not want to give up any room or a valuable air conditioner. In a culture where so many things have been forcibly removed from the people, they are reluctant to release possession of anything even if they don't personally own it. Moreover, the building administrators did not appreciate the need for a server room since they did not understand how the technology would be of benefit, so they were not motivated to support the request. Justifying the reallocation of space required a detailed explanation and presentation all the way up the administrative hierarchy to the Dean. In the interim, effort in preparing presentations to justify the server room to the leadership detracted from the IT staff's ability to study and learn how to administer a domain.

Having developed an understanding of the environment, we knew that the procurement process was lengthy and required multiple bids on a contract before even placing an order. After the order was placed, we knew that shipment would take weeks through the antiquated Afghan postal service. So even though having a secure room was a prerequisite for the arrival of the servers, we initiated the ordering action to begin parallel activity. In this particular instance, it was fortunate that the corrupt and inefficient ordering process had to travel through many echelons of bureaucracy so that the servers would not arrive prior to the staff being able to accommodate them.

Staged-Gap Analysis

Upon receiving an approximate delivery date for the servers from the vendor, we were able to schedule a meeting to perform our first staged-gap analysis for this task. This analysis identified only minor gaps in progress along the four axes. We had initiated the purchase process for the physical resources (physical plant), the IT staff had been training and studying how to build and manage an Active Directory domain (technical personnel capabilities) and the IT staff conducted a preliminary briefing to the faculty (faculty capabilities) to introduce the concept of an intranet, but the administration had not begun to discuss the policies for administering a server (governance). Here is where the synchronizing concepts were used to adjust progress along the governance axis. Understanding the physical dependencies and the need to take ownership for their infrastructure, the IT staff organized a meeting with the Dean to explain the technical aspects of an Active Directory domain. Specifically, they highlighted the significance of a domain administrator's authority and the need to regulate server admin actions with policies. The minor adjustment in priorities made by the IT staff was sufficient to energize the academy administration to put increased effort toward developing the required policy.

After the servers arrived and the IT staff had time to build them, we needed to perform a second staged-gap analysis. We identified that progress along the physical plant axis and the technical capabilities axis had significantly outpaced the faculty capabilities and governance axes (see Figure 3 below). Our effort was not synchronized and we were at risk for failing to meet our objective. As a result, we performed a cross-walk of the related tasks to help us identify how to adjust our plan. We could not change permissions across the domain that adjusted how all users interacted with their machines until there was a policy in place governing how such changes should be conducted. We also could not make the change until the users understood how to operate in the adjusted environment. We had to stop progress along the technical capabilities axis until the faculty capabilities and governance axes closed the gap.

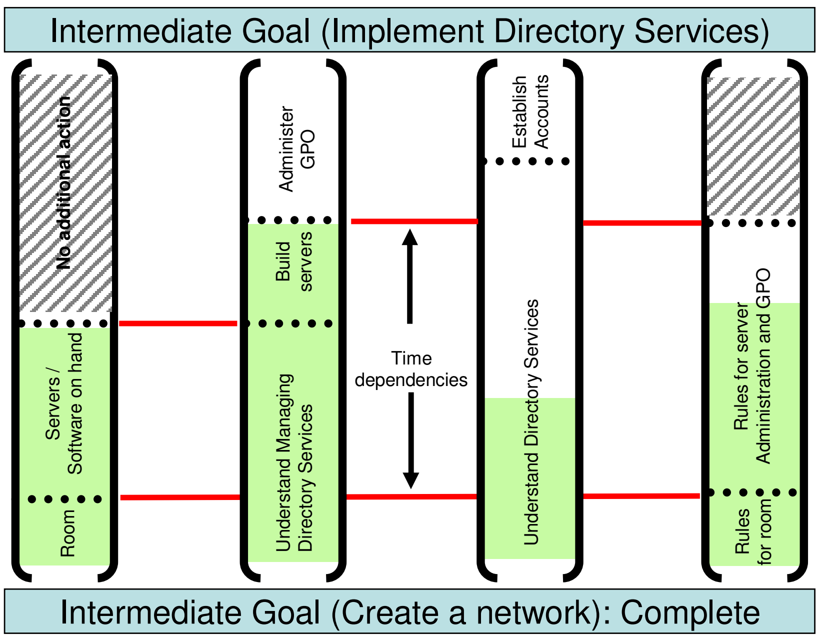

Figure 3
An example application of the framework

Planning

In addition to the obvious decline in productivity, stopping progress along axes can have deleterious effects on the motivation of the workforce. The use of branches and sequels helps to prevent this. Our example highlights the benefits associated with contingency analysis and planning. Failure to plan for contingencies would have resulted in the IT staff having nothing constructive to do until progress along the other axes caught up. However, the preplanned branches and sequels helped to maintain overall progress. The IT staff had identified several tasks that they could perform that would assist in closing identified gaps. Realizing that the faculty needed to visit the IT section to create accounts and passwords for access to the domain, the IT staff used the face-to-face interaction as a means to explain and motivate the purpose of the new technology. They helped to increase the faculty capabilities and to explain the domain policies, increasing the pace of progress along the axes that were lagging behind.

Relegating their efforts solely to creating passwords would be an incredibly inefficient use of the IT staff's time, so they also created branches to the plan to promote parallel work. They diverted a portion of their work effort toward creating computer images on the network to ease their administrative responsibilities. Since the physical resources were already established, the faculty didn't need to know about the capability, and there was no immediate need for a policy controlling the images, there were no interdependencies on other tasks that prevented the staff from making progress. Their efforts did not widen the identified gap, but still kept them fully engaged. With an image, the staff could maintain multiple computers in the labs both simultaneously and remotely.

At the time of our departure in July, 2007, NMAA had a working intranet with all of the faculty and students having domain accounts. All of the computers had been added to the domain and an appropriate Global Policy Object had been applied for administrative purposes. The faculty had attended a seminar on the benefits of the new resources and a few had begun to employ them effectively. The technical staff was administering the domain entirely by itself.

Conclusion

Building IT infrastructure in a developing nation requires careful thought and analysis to overcome environmental constraints and to build deep roots that promote long term sustainability and evolution. While the same can be said for IT development in the first world, special consideration is required in developing nations for synchronizing effort and resources along multiple axes to maximize developmental potential. Our framework brings these considerations to the forefront and provides general guidelines that can be applied in any underdeveloped region.

We have begun to validate our framework through our efforts with the National Military Academy of Afghanistan. With three years of effort invested in our assistance to NMAA, we have thoroughly defined the environment and each of the developmental axes, we have identified long term goals with intermediate stages, and we have initiated and refined multiple plans for achieving our goals. We have made significant progress measured by the current application of IT in the educational process at NMAA, but we have also identified the need to satisfy many additional requirements before achieving our long term goals. Our framework's staged gap analysis and cross walking techniques continue to help us make progress while providing us with the flexibility to adapt to rapid changes in the volatile environment.

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