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Toward the 24-Hour Knowledge Factory

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The term "24-Hour Knowledge Factory" connotes a globally distributed work environment in which members of the global team work on a project around the clock; each member of the team works the normal workday hours that pertain to his or her time zone. At the end of such a workday, a fellow team member located in a different time zone continues the same task. This creates the shift-style workforce that was originally conceived in the manufacturing sector. A globally distributed 24-hour call center is the simplest manifestation of this paradigm. The true example of the 24-hour factory paradigm discussed in this paper involves groups working together to accomplish a given set of deliverables, such as a software project, and transcending conventional spatial and temporal boundaries.

INTRODUCTION

"The Sun never sets on the British Empire," was a notion emphasized during the eighteenth and nineteenth centuries to highlight that the British Empire was far-flung, and that the sun was always visible from some part of this vast empire. While the British Empire has gradually disintegrated, we can now coin an equivalent notion: "The Sun never sets on the 24-hour Knowledge Factory!"

The notion of the 24-hour Knowledge Factory can be traced back to the industrial revolution. Since the installed equipment was scarce and costly, the employees were scheduled to work in shifts of 8 hours in order to use the manufacturing facilities on a round-the-clock basis. With the advent of electronic computers and diminishing costs for telecommunications, one developed the notion of 24-hour Call Centers. Depending on the time of the call, it is automatically directed to a call center that is active at that time. Using a cluster of 3 to 4 call centers located in time zones 6-8 hours apart from the time zone of the neighboring call center, one can ensure that all employees of these geographically distributed call centers are working during daytime in their respective countries. The notion of multiple support centers was subsequently adapted for supporting global communications networks over time. Now it has become feasible for one to use a

geographically distributed workforce of highly trained professionals to complete a challenging endeavor in a much shorter timeframe as compared to a scenario in which all personnel are based at one location, irrespective of where location is.

For example, by involving specialized microchip design engineers located at multiple places around the world, a semiconductor chip design firm may create virtual "24-hour knowledge factories". This allows for an efficient design process that has a faster turnaround time. It provides the firm with access to high-talent designers who would otherwise have to move to a different country, or work at odd hours of the night; some persons call the latter type of shift as the "graveyard shift". The figure below illustrates a distributed factory with software design operations in three countries around the world. The creation of professional service teams that transcend geographic and temporal boundaries offers the potential to change the face of many industries. This new innovation will dramatically impact the manner in which companies build, test, sell and support their products and services. Years ago, people in India and the United States thought the time difference was a negative - they thought it would hinder their ability to work with US firms. Now that's switched around - for many projects the time difference is a plus, as it enables the creation of the 24-hour Knowledge Factories described in this paper.

The 24-hour Knowledge Factory will involve "offshoring" of part of the endeavor. Today, offshoring is done mainly to reduce costs. We believe that over time, the growth in offshoring will be fueled more by the potential to achieve drastic reductions in turnaround times for major endeavors.
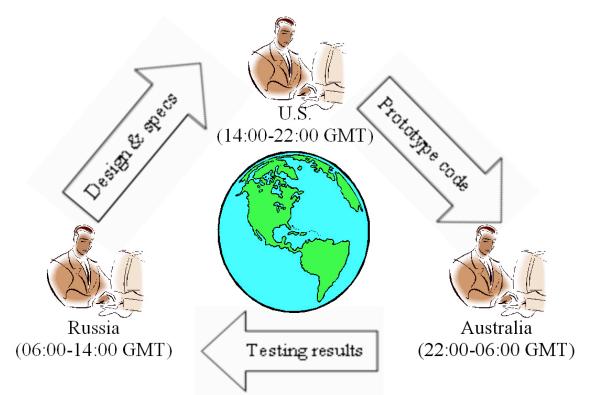
Figure 1: In this sample 24-hour global knowledge factory, a software team increases efficiency by having designing, coding and testing done at different times of the day, so that work that would have been performed over three days may now be done within a 24 hour cycle

FOUNDATIONS OF 24-HOUR KNOWLEDGE FACTORY

Emerging communications and infrastructure technologies can be applied to bridge teams across geographic and temporal boundaries, especially to accomplish rapid development of next generation products with work on a 24-hour/day basis. In order to do this effectively, one needs to develop new paradigms to facilitate interpersonal communications and collaboration. For example, there is a growing need for robust knowledge transfer mechanisms that can facilitate knowledge management on a daily basis, and simultaneously enable the creation of a growing knowledge repository over time.

A survey of over 50 software executives participating in offshoring highlighted that "offshoring will live or die based on the ability of everyone involved to communicate with each other."[1] Richer collaboration technologies need to become available in order to enable simultaneous use of video, audio and other messaging capabilities to link geographically and temporally separated teams. Such efforts would require deep understanding of evolving technology and business needs.

In the initial instance, the new technologies may be usable for very specific disciplines or applications only. For example, after the collapse of the walkway at a leading hotel in Chicago that resulted in multiple deaths and was ultimately traced to poor communications between the various groups involved in designing and building that walkway, researchers at MIT looked at ways for mitigating such interpersonal and interdisciplinary communication problems. In the case of this hotel disaster, the design for the walkway had passed from the structural engineer, to the architect, to the construction engineers, and finally to the on-site construction crew, with significant changes being made at each point without proper communication between the concerned sets of personnel. As part of the multiyear research endeavor at MIT, one concluded that there was a high degree of domain knowledge that was needed to resolve the underlying problem of effective communication among the concerned parties.

Some parts of the research conducted at MIT, primarily in the Department of Civil and Environmental Engineering, could be readily leveraged for use in other environments; others parts could not. The DRIM and DICE projects grew out of this effort; the techniques developed as part of these projects can be potentially leveraged to help accomplish the full vision for 24-hour knowledge factories. DRIM is a completely specified model for the rationale underlying the design process[2]. The use of such a model in a 24-hour knowledge factory would allow for tasks to be shared between geographies and time zones without requiring the engineers to spend a significant amount of time explaining their work to persons in the next "shift".   The DICE (Distributed and Integrated Collaborative Engineering Environment) methodology offers a platform for collaborative engineering by decomposing each project into a set of modules and allowing work to be conducted in parallel on each section of the project[3]. When the system encounters conflicting decisions about a particular decision from engineers in different modules, it uses the design rationale to help negotiate the outcome. In a 24-hour knowledge factory, where high efficiency is a primary goal, one needs to apply advanced versions of such techniques to integrate the work of many persons working at different times and in different geographic locations.

In a "24-hour development environment" that encompasses three or more development centers located around the world, the distributed team is envisaged to concentrate on the same problem and to perform the same function (whether it be development of code or testing of subsystem) on a successive basis, with each collaborating center retaining ownership of the endeavor for 8-hour periods in every 24-hour cycle. Many industries,

including the software industry, are characterized by a development cycle that relies heavily on sequential performance of specific functions, such as development, testing, and verification. In a traditional software development environment where all parties are located in the same geographic area, a code developer typically waits until a fully functional portion of the product is available before passing it on to an engineer to test it. However with the potential for receiving testing feedback overnight, the developer now has the unprecedented opportunity to build portions of the product on an incremental and more daily basis.

Engineers and other professionals often innovate through personal and group contact, sharing ideas and building on each other's suggestions. These interactions can occur via formal meetings in conference rooms or informal ones in the corridor. While technologies exist to achieve some of this functionality with both synchronous and asynchronous communication capabilities, there still exists a critical need to replicate the culture of free-flowing exchange of ideas without the impediments created by communication tools. One option for supporting interpersonal relationships between the team members is to have them meet in person at various times throughout the duration of the project. The use of any such method will still have to work with the requirement that team members will remain geographically separated for the majority of the time.

Another related issue is the dispersion of knowledge centers regarding teams, projects and technologies. With global teams being created, the opportunity to informally interact with a colleague in the same geography will not exist as much. Dilemmas that are normally solved with casual lunchtime conversation, or hallway meetings, will need to be dealt with using communication technologies such as instant messaging, video and audio conferencing and electronic mail.

One of the greatest challenges is how to collect and disseminate information about which professionals have knowledge about which topics. This challenge needs to be addressed in a manner that does not impede the productivity of the concerned professionals. As the relevant technologies continue to evolve, the nature of communication between professionals on a team will also continue to evolve. Thus, the technological approach to facilitating outsourcing has to constantly re-evaluate the nature of communication within global teams and adapt accordingly.

In order to create an integrated archipelago of knowledge-based assets, one needs to look at new paradigms that can help to effectively transcend national borders, corporate borders, cultural borders, functional borders, and other types of borders, and provide the material needed to

address the individual needs of an increasingly diverse set of users of such systems. By providing effective "on-off ramps" to the emerging information highways, the goal is to drastically enhance drastically the ability to make effective use of large volumes of information obtained from disparate sources (each with its own set of underlying meanings and assumptions), by transforming automatically the incoming streams of information to the desired meaning (or context) needed for a particular job or function in a particular nation or organization.

Continued exploration of the technology issues would ultimately lead to a new optimal balance in the service arena, this could be similar to the balance attained in the manufacturing arena. In the end-scenario, workers in the U.S. may concentrate on design and development of high level products and features, rather than on low-paying tasks such as software maintenance that require less education and training.

SAMPLE TECHNOLOGIES FOR SURMOUNTING BOUNDARIES

Two sample technologies were developed by the authors, building on design methods developed by colleagues at the SSPARC project at MIT. These technologies demonstrate potentially useful methods in building the 24-hour knowledge factory. Both were tested in a real-world situation involving the design of satellites.

The MATE Interview Software Tool (MIST) was built to support the Multi-Attribute Tradespace Exploration (MATE) system, which focuses on the issue of capturing and processing the goals and the requirements of decentralized stakeholders in the design process. The MATE system was built by Adam Ross and Nathan Diller as part of the SSPARC project at MIT[4]. It provides a formalized means of exploring a tradespace by incorporating preferences into decision criteria with methods based in economic and operations research theory*. Both utility analysis methods and cost-benefit analysis methods are employed to obtain information from all of the stakeholders in the geographically and organizationally decentralized design process and to facilitate communication between them. The principle means of eliciting information is by conducting a series of interviews with the stakeholders designed to help capture their preferences regarding the various attributes of the design architecture. These data are then used to drive the design process, by providing information about the utility and cost of each potential architectural alternative. In the 24-hour knowledge factory, such a system would allow for the opinions of the decision-makers' to be represented even when they are not available at the same time or place. The overall approach provides a formal, mathematical framework for

incorporating the views of all stakeholders in a systematic manner, even when some of these stakeholders may be on the other side of the world.

The SSPARCy system is geared to capture, reuse and better exploit valuable information assets, with the objective of mitigating temporal and spatial barriers in large multi-organizational multidisciplinary endeavors. In a number of applications ranging from marketing campaigns of new products to the design of new systems, each campaign or design process is frequently conducted as a new endeavor. Very little knowledge, if any, is carried over from the previous episode or campaign. In order to provide better inspection and analysis of the future simulation files, a new approach was developed to provide automated capture and storage of important information (name, value, rationale, author, etc) relating to each component of the project, along with the history of these data. While most of this functionality is automated, the user is prompted to document the rationale when significant changes are made to the design or the implementation. This concept demonstration system can facilitate the 24-hour knowledge factory by allowing projects to be transferred easily between teams, without requiring each team to invest time in transferring the knowledge of previous projects. It also allows teams to look at decisions made on earlier projects that involved decisions on similar issues.

ECONOMIC & POLICY CHALLENGES

The potential distribution of teams across geographic and temporal boundaries requires careful consideration of the economic ramifications of alternative distribution models in order to elicit the optimal benefits from the globally distributed model. While some lessons can be learned from the experiences of globalization in manufacturing industries, the inherent distributed nature of the 24-hour global knowledge factory presents many new challenges. The significant costs for collaboration, as well as for replicated hardware and software, may gradually rise with increasing use of outsourcing concepts. One may consider the possibility of using the same hardware across borders for testing and other purposes. Further, there are costs involved in establishing effective hiring processes, and in travel between onshore and offshore locations[5]* – both of these factors impose financial overheads whose benefits may be hard to quantify.

Another major change is the widening of the competitive landscape. The lowering of costs in the software industry is making it possible for smaller firms to compete much more readily with larger firms, because they have access to a greater labor pool much more easily*[5]. With many professional services, the startup costs are lower, and do not involve the

significant capital investments that characterize the manufacturing scenario. These facts allow smaller competitors to enter new markets and to maintain a small core of designers onshore with a large pool of offshore professional service workers to carry out the tasks.

Changes in government policies will impact this field too. On one side, evolving labor and trade regulations may limit the amount of offshore work that can be performed abroad. On the other, the tightening of the Visa regulations to control the number of foreign workers into the U.S. will actually serve as a catalyst to the growth of the 24-hour Knowledge Factory.

Further, data security, privacy standards, and export regulations on encryption technology are issues on which developing nations do not have the same standards that the United States does. This disparity serves as an impediment to the execution of the same task across nations in a 24-hour knowledge factory.

The 24-hour knowledge factory model can also influence the strategic direction to be taken by developed nations in attempting to maintain jobs for professional service workers who might otherwise be losing their jobs to offshore labor markets. In testimony before the U.S. House of Representatives Committee on Small Business, Assistant Secretary for Technology Policy Bruce Mehlman has cited the United States policy strategy to be based on an investment in education, infrastructure, innovation, and to highlight existing benefits such as intellectual property protection[5]. Such a strategy, in the context of a 24-hour knowledge factory model, suggests that the most sustainable model will be to prepare U.S. professional service workers to perform higher level tasks and allow tasks which require less education, training and infrastructure to be performed abroad. Rather than use these strategies to build a legislative wall around the United States, if the 24-hour knowledge factory model is adopted, tasks will be performed much more efficiently because the U.S. engineers will be equipped to handle the more specialized parts of the shared onshore-offshore projects. These strategies are necessary for the United States to remain competitive, but they must also take into account the fact that outsourcing may change the way firms perceive their interests. For example, a recent report[1] reveals that software executives do not prioritize intellectual property protection as highly as anticipated when making decisions related to outsourcing.

The following table summarizes the benefits of onshore and offshore engagements, as reported by the U.S. Department of Commerce Office of Technology Policy after convening business, university and government leaders[5]:

	Onshore Benefits	Offshore Benefits
People	Talent pool is unmatched	Untapped talent pool
Business Climate	Entrepreneurial, market-based, easy access to capital	Less burdensome taxation, regulation, litigation
Infrastructure	Telecom, energy, transport	New global clusters created
Market Access	Innovation in largest market	Untapped markets
Intellectual Property	Commitment to patents	
Government	Political stability	
Quality of Life	Freedom, health care, security, environment	
Cost		Talent, facilities cost less
Proximity to manufacturing		Plants are already offshore

The win-win potential of the 24-hour knowledge factory can be established by taking the best from both onshore and offshore markets and combining them into one model with concurrent engagement on professional services tasks. For example, the untapped foreign talent pool can be engaged without requiring major financial, organizational and educational infrastructure investment. Both the total development time and costs can be substantially reduced. Accordingly, pertinent government agencies are likely to favor policies that facilitate a 24-hour knowledge factory model, rather than a completely onshore model (which will most likely lead to a segregated offshore model).

In understanding the strategic direction to be taken in terms of educating and re-educating the professional services workforce of the United States to better compete or co-exist with offshore professional service labor, it is important to understand the complex requirements of the job market. The U.S. Secretary of Commerce's report entitled "Education and Training for the Information Technology Workforce" states that IT employers are looking for a specific blend of technical and business skills, and prioritize a minimal amount of training[6]. This notion of flexible training that will allow workers to succeed in a changing marketplace for professional services is useful in determining the strategic direction for both onshore and offshore

firms. The burden will increase on practicing engineers and other professional service workers to take on more organizational and cultural leadership, both to interact with foreign counterparts and to take on higher-level tasks. The policy for dealing with offshore outsourcing should be to acknowledge this fact, and should nucleate the training needed to enable U.S. engineers to work in 24-hour knowledge factories, instead of in highly guarded, isolated onshore teams.

Finally, the inherent nature of strategic and political relations requires that a firm incorporate the risk of unexpectedly severing relations with foreign professionals who possess much of their intellectual and institutional knowledge. If firms are actively engaged in 24-hour knowledge factories, some of this diversification is built into the model. Losing an offshore team will not mean losing an entire project, as may happen if entire tasks are outsourced. The overriding importance of maintaining a knowledge base as diverse and redundant as possible promotes the 24-hour knowledge factory model.

CONCLUSION

Professional services have the opportunity to move towards the "24-hour global knowledge factory" where active progress on professionally intensive tasks is accomplished on a round-the-clock basis. This future will be realized through careful consideration of the needs and expectations of the concerned stakeholders at the strategic, technical, economic and organizational dimensions. Once firms, governments, and individual workers adopt a unified approach, all constituencies will benefit through the use of the 24-hour knowledge factory concept. As the relevant issues are addressed, outsourcing of appropriate components of knowledge jobs to less-expensive labor markets will be increasingly perceived as an opportunity for U.S. businesses to offer new products sooner to the global market, and with better returns both to customers and shareholders.

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