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COST ESTIMATION OF GLOBALLY OUTSOURCED IS DEVELOPMENT PROJECTS

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ABSTRACT

Global outsourcing – also known as offshore outsourcing -- is generally dual sourcing involving both offshore and onshore activities because certain activities such as requirements analysis have to be performed onshore in consultation with users. The amount of onshore work or offshore work depends on the nature of IS being developed and vary among IS projects. Vendors charge higher hourly rate for onshore work compared to offshore work because the vendor has to incur travel and living expenses for the developers, and pay prevailing wages in the high wages country. An accurate estimation of the mix of onshore/offshore activities is essential to determine the cost of IS development, profit for the offshore vendor, and savings for the outsourcing firm. Such an estimate is critical to successful project management. No literature exists for cost estimation of IS projects with users and developers in a distributed environment such as in offshore outsourcing. This article describes various characteristics of an IS project that make certain activities amenable to offshore and certain other activities requiring onshore work. The article also describes how to determine the mix of offshore/onshore activities based on such characteristics and use the mix to estimate the system development cost accurately.

Keywords: cost estimation, systems development, global outsourcing, offshore outsourcing, dual outsourcing

INTRODUCTION

Firms outsource information system (IS) development projects to focus on their core competencies, free resources to develop critical applications, reduce backlogs in development projects, manage IS personnel turnover, separate personnel liability, reduce costs, enter world markets, tap resources that are not available internally, improve IS quality, reduce time to market products, and control development costs [16, 26]. Although many advantages are cited in the literature, empirical studies show that organizations outsource mainly for cost considerations [3, 24]. Many companies outsource IS development projects to developing countries such as India to take advantage of low labor cost of technical skills in those countries. Global outsourcing – also known as offshore outsourcing -- of IS development projects continue to increase throughout the world. India's software trade group, NASSCOM, has estimated that India is expected to export about $70 billion worth of software and services with a growth rate of about 18% in 2012 [10, 29]. The US and European regions account for about 85% of revenues in the IT sector [10, 29].

IS development is a knowledge-intensive collaborative work involving various IS professionals and system users, and therefore, the IS development cost depends mostly on the human effort to develop the system. Offshore outsourcing is generally dual sourcing involving development effort on offshore as well as onshore because activities such as requirements analysis have to be performed onshore in consultation with users. Vendors charge higher hourly rate for onshore work compared to offshore work because the vendor has to incur travel and

living expenses for the developers in the high wages country. For example, Indian software companies charge about $60 - $80 per hour for onshore work in the US and charge about $25 - $35 for offshore work in India [8]. Therefore, the IS development cost depends on the mix of onshore and offshore development effort.

Despite advances in information technology, estimating the development cost of an IS remains an art in many organizations. A meta-analysis of various studies shows that costs of system development projects have exceeded the estimates by more than 41 percent [17]. Several other studies show that cost estimates of IS development projects have been inaccurate [27]. Many organizations do not have any systematic method of cost estimation for IS development projects [13]. Whereas, this is the status of cost estimation for IS projects developed with users and developers in collocated places, no literature exists on cost estimation for IS projects with users and developers in a distributed environment such as in offshore outsourcing. This article fills the need for an accurate cost estimation of an offshore project based on the mix of expected onshore and offshore work in the project. Such an estimate is also critical to successful management of the development project.

The next section of this article briefly describes the cost estimation process for IS development projects with users and developers in collocated places, and indicates how it can be extended for offshore IS development. The third section describes systems development methods and how they influence onshore/offshore work mix. The fourth and fifth sections discuss application-related characteristics and technology-related characteristics respectively of an IS project that make certain activities amenable to offshore and certain other activities requiring onshore work. Since vendors charge differential rates for onshore and offshore work, identification of onshore and offshore activities is essential to accurate cost estimation. This section also describes how to determine the system cost based on the offshore/onshore mix. The sixth section illustrates the cost estimation for a system with varied application and technology characteristics. The last section concludes this article and indicates future research directions. Please note that this article assumes that the offshore vendor has experience, expertise, standards, and the necessary development and communication infrastructure to handle offshore IS development projects as these variables can affect not only the onshore/offshore activity mix but also the development effort and cost.

COST ESTIMATION

The need for cost estimation needs no elaboration because it is the basis for bidding and negotiating the price of any project. In addition, it determines the profits for the vendor and the savings for the outsourcing company. The data used in IS cost estimation is useful in preparing the project plan and in managing the project. In an offshore project, the IS cost estimation involves estimating the cost of onshore and offshore work separately. The amount of onshore or offshore work depends on the nature of IS being developed and varies among IS projects.

An accurate estimation of the mix of onshore/offshore activities is essential to determine the cost of offshore IS development. For example, a project estimated to take 100,000 person-hours would be priced at $3 million if all activities are performed offshore at the rate of $30 per hour and priced at $7 million if all activities are performed onshore at the rate of $70 per hour. If the project is estimated with a 60/40 offshore/onshore mix, the project would be priced at $4.6 million (= 60,000 x $30 + 40,000 x $70) and if it is estimated with an 80/20 offshore/onshore mix, the project would be priced at $3.8 million (= 80,000 x $30 + 20,000 x $70). An inaccurate estimate of the offshore/onshore mix would not only affect the profitability but also, the management of the project. A lower estimate of the project's onshore work can reduce profits and bring the manager under pressure to transfer some onshore work to offshore that may not be amenable to offshore activity. Currently, no published methods exist for estimating the cost of offshore projects that typically involve both onshore and offshore development activities.

If the amount of onshore work increases more than the estimate, the project loses the cost advantage. In fixed price projects, where the vendor is responsible for completing the project for a fixed price, the outsourcing firm needs a good picture of onshore and offshore activities because the vendor may be inclined to perform most activities offshore that may compromise the quality of the project. It is believed that a *new law that has increased H-1 visa application fees by $2,000 and L-1 visa application fees by $2,250 may drive may increase offshore work [28]*. Since offshore companies use H-1 and L-1 visas to bring software engineers to perform onshore work, the increasing cost of onshore work may motivate these companies to reduce onshore work. Major software companies perform an average of 60% offshore work and 40% onshore work, but they are striving for 80% offshore and 20% onshore to increase their profits [25]. Major outsourcing firms such as IBM use a large workforce in India to increase their profits on global projects.

Cost estimation for ISs with users and developers in a collocated place is a three-step process. It begins with an estimation of the system size, followed by an estimation of effort to develop a system of that size, and an estimation of cost for the required effort. Details of this process can be found in several references [6, 19]. Identification of the system development method during the cost estimation process is important because the development method affects the cost. The systems development method, following either an iterative and incremental approach or the waterfall model approach, defines the scope of various development activities, required effort and its costs. Please note that the choice of a development method depends on factors such as system size, complexity, and technology associated with the system being developed. An inappropriate development method increases the system development time and cost, and jeopardizes the system quality.

The size of a system is more than a measure of its bigness and includes a function of various factors such as its scope and complexity. Although lines of software code could be used as a measure of system's size, it is inadequate and a metric called function point is commonly used today [15]. Effort estimation involves translating the size into effort using productivity measures. Productivity measures are expressed as person-hours per unit size of the system (e.g. 20 person-hours/function point). An IS with a size of 500 function points would translate into 10,000 person-hours (= 500 x 20) of development effort. The last step is to translate the development effort into cost using the standard rate per hour. For example, for an organization having a standard rate of $70 per hour, the cost of developing the system in the above example would be $700,000 (= 10,000 x 70).

The cost estimation for an IS developed in a distributed environment needs additional steps. It involves determining various activities for the chosen development method and the effort required for each activity. In addition, it needs to determine whether an activity would be performed onshore or offshore. Using the respective onshore and offshore rate, the cost of development in the distributed environment can be estimated. The next section describes these important steps in estimating the cost of an offshore-outsourced system.

DEVELOPMENT METHOD AND ONSHORE/OFFSHORE WORK MIX

Systems development methods can be classified under 1) Iterative and incremental development methods and 2) Waterfall model and its variations. Selecting the right development method is necessary to address issues such as lack of users' knowledge of application domain, lack of users' involvement, incomplete requirements, incorrect requirements, evolving requirements, and risks associated with new technology [4, 5]. Using an inappropriate development method increases development time and cost, and jeopardizes quality. Using an inappropriate development method in offshore outsourcing would further jeopardize development objectives. Identifying the right development method before a sourcing decision is appropriate but this article does not concern with the process of selecting a development method. It assumes that the firm has identified the right method before deciding to outsource development.

Systems development methods largely influence the onshore/offshore work content ratio. For example, rapid application development (RAD) method has iterative activities in which users and developers interact intensively and develop a system in increments. As will be discussed, such methods require predominantly onshore work. In contrast, the waterfall development (WFD) method has activities that tend to be modular and somewhat linear. It is a preferred method for systems development in offshore outsourcing because development activities can be delineated for onshore and onshore execution.

Iterative & incremental approaches

Iterative & incremental approaches include the spiral model, RAD, and various agile development methods. The spiral model is often used in mission-critical systems in defense and its use in the development of business information systems is uncommon. The RAD method has several variations such as Martin's [20] and McConnell's [21] approaches. In general, it has requirements planning, design, construction, and cutover phases in which most activities need collaboration between users and developers. The RAD uses CASE tools and time boxing concepts to control development time, and group support systems to facilitate joint work by users and developers. The requirements planning phase often includes joint application development exercises that involve many participants. Since RAD calls for experienced users, analysts, and programmers to develop a system quickly, the development exercise requires intense collaboration between users and developers. During the iterative design and construction phases, the conveyance of user feedback with the help of a partially developed software product, a CASE tool and group support systems can manage the user-developer interactions. The design part would have moderate user-developer interactions and the construction

part would have a low to moderate interactions. The cut-over stage, with concurrent testing, training, and system conversion involve users. Since iterative collaborative work involving users and developers need to be performed onshore, RAD methods are suitable for onshore work. If RAD method is used offshore, the offshore work content would be restricted to construction part and it would be less than 20%. However, small systems can be developed offshore by sending users to the offshore company.

The Agile Development Methods (ADM) include Scrum, Dynamic Systems Development Method, Crystal Methods, Feature-Driven Development, Lean Development, Extreme Programming, and Adaptive Software Development [2]. These methods are generally incremental, co-operative, and adaptive involving joint work of users and developers. The ADMs emphasize individual interactions over processes and tools, working software over comprehensive documentation, user collaboration over contract negotiation, and responding to changes over following a plan. These methods cover different/certain phases of the software life cycle and lack proper project management support. In addition, these methods suggest universal solutions to various development situations and may not be suitable for large systems [1]. The ADMs need intensive and continuous participation of users and daily interactions, often face-to-face with developers that require onshore work. The interactions at all stages of ADMs require excellent communication and problem resolution methods. While developing small systems, ADMS can use partially developed software products, shared application development data repository, and group support systems to manage the interactions but for most other systems, the offshore work content would be less than 20%.

If offshore-outsourced systems use iterative & incremental approaches, they would need excellent communication infrastructure with video conferencing, collaborative work products, and willingness of users and developers to work in odd hours. In addition, these methods are often associated with small and medium sized systems. With the small amount of offshore work and the requirement of expensive communication infrastructure, offshore-developed systems with these approaches may not produce the expected cost savings. In addition, offshore software firms may not have much interest in methods that have scope for small amount of offshore work. Therefore, development of an IS using an iterative and incremental approach is generally done onshore.

Waterfall model and its variations

Waterfall model provides for development of systems in stages such as requirements analysis, design, coding, testing, and implementation. Each stage of development can include detailed activities depending upon the type of system. The first column in Table 1 shows various development activities for an IS that uses generally known and accepted business processes with very little requirements volatility, employs well-developed technologies, has moderate size and complexity, and involves users with knowledge of the application domain and technology. For the sake of discussion in this article, let us call this a standard system.

Waterfall model provides modularity to development, and enables individuals and small groups to work independently in each stage. However, software development, an exercise in complex relationships, needs great efforts in communication among involved parties that diminish the benefits of modularity in certain stages [7]. The requirements analysis stage requires major user participation in organization analysis and business process design without which analysts would not be able to develop systems that meet user needs. The highest degree of interaction occurs between the user and the analyst during the requirements analysis stage [18]. Regardless of the methods and tools employed, the success of requirements analysis depends on how well the users and analysts communicate to determine user needs [12]. Therefore, most requirements analysis stage activities require face-to-face interactions and become candidates for onshore work. Requirements analysis involves frequent and long interactions between users and developers to transfer knowledge about the system needs and require developers to be in the proximity of users that is well- supported by onshore work. Advances in communication technologies and virtual work enable offshore developers to interact with onshore users, but virtual work is not suitable for most requirements analysis activities [22].

A study showed that most requirements are difficult to identify, and identified requirements are often unclear and not well organized [9]. The study also showed that these problems are exacerbated in global software development. Since the cost of detecting and correcting errors at a later stage is high, quality assurance procedures should detect and correct requirement errors at an early stage. Quality assurance of requirement definitions needs high user involvement with frequent and complex interactions. Therefore, requirement analysis and quality assurance of requirement definitions require onshore collaborative work of users and developers.

IS development activities that require developers to interact face-to-face with users are candidates for onshore work. Among the design activities, the user interface design needs an iterative group process with high user involvement and requires onshore work. Most other design activities, coding, and testing have low user interactions, providing requirements and design do not change frequently. Acceptance testing conducted by users in collaboration with testers and user training are onshore activities. Because the system implementation may need quick resolution of unforeseen problems, it is often an onsite activity. The second column of Table 1 shows onshore work (marked I) or offshore work (marked O) for each activity of such a standard system discussed above.

Based on studies and practices, the total development effort for a system can be distributed over each activity as shown in the third column of Table 1 [14]. The project in illustration is estimated to require 10,000 person-hours of development effort and the effort required for each activity is as shown in column four. At the rate of $70 per hour for onshore development and $30 per hour for offshore development, the cost of each activity is shown in column five or column six. The total estimated system cost for the illustrated standard system is $432,000.

Table 1: Activities, onshore/offshore work mix, effort, and cost to develop a standard system

Development Activity	Onshore (I) Offshore (O)	% of Project Effort	Effort in Person-Hours	Onshore Cost $70 per hour	Offshore Cost $30 per hour
Requirement Analysis	I	10%	1,000	$70,000	$0
Walk-through & Correction	I	2%	200	$14,000	$0
High-level Design (Architecture)	O	5%	500	$0	$15,000
DB Design	O	6%	600	$0	$18,000
Design Review	O	2%	200	$0	$6,000
Controls & Security Design	O	6%	600	$0	$18,000
Controls & Security Design Review	O	2%	200	$0	$6,000
Human-Machine Interface Prototype	I	4%	400	$28,000	$0
Human-Machine Interface Design	I	4%	400	$28,000	$0
Human-Machine Interface Review	I	2%	200	$14,000	$0
Program Design	O	4%	400	$0	$12,000
Program Design Review	O	1%	100	$0	$3,000
Unit Coding	O	15%	1,500	$0	$45,000
Test Plan and Scripts	O	4%	400	$0	$12,000
Unit Code Inspection	O	2%	200	$0	$6,000
Unit Testing	O	4%	400	$0	$12,000
Unit Integration	O	4%	400	$0	$12,000
Integration Testing	O	2%	200	$0	$6,000
Function Testing	O	4%	400	$0	$12,000
System Testing	O	2%	200	$0	$6,000
Acceptance Testing & Signoff	I	5%	500	$35,000	$0
User Manual	O	2%	200	$0	$6,000
Operations Manual	O	2%	200	$0	$6,000
User Training	I	3%	300	$21,000	$0
System Conversion	I	3%	300	$21,000	$0
Total		100%	10000	$231,000	$201,000

Total Project Effort is 10,000 person-hours
Total offshore project cost is $432,000 in comparison to the onshore project cost of $700,000.

Although activities and onshore/offshore mix in Table 1 are applicable to offshore develop a standard system, several application related and technology related characteristics would necessitate additional activities and effort as discussed below. These two types of characteristics warrant active user participation and contribution in the development of systems [11, 25]. Identification of these characteristics in a project would be useful in estimating the offshore/onshore mix of various development activities, and the cost of the each activity and the project accurately. For instance, an application having unclear requirements would need the development of a prototype to elicit clear requirements in collaboration with users and require elaborate onshore work for the requirements definition stage. On the other hand, an application identified as redevelopment of an existing system, most development activities could be done offshore.

APPLICATION CHARACTERISTICS AND ONSHORE/OFFSHORE WORK MIX

The discussion of various activities, effort, and onshore/offshore mix in this section is relative to the standard system discussed previously and shown in Table 1. This section highlights the variations from the standard system. A system that needs unique and differentiated business processes would need the collaborative efforts of many users, developers, and process experts to define the system requirements. Since these processes may not have a reference point, creation of a working prototype would be useful in eliciting clear user requirements. Such practices need consultation and frequent face-to-face interactions better facilitated by onshore work. The new requirements also need rigorous verification and validation to ensure consistency, correctness, and completeness that can be better accomplished onshore. These systems would need additional effort in the requirements analysis stage than standard systems that use accepted business processes. New processes that involve new way of doing business would also need new ways in which users interact with the systems, and therefore, the design of human-machine interfaces in these systems would need additional effort. An entirely new system with new processes and practices would need additional effort in testing and in training users. In summary, ISs employing unique business processes need not only additional on shore activities but also additional effort in these onshore activities.

Definitions of requirements that need consultation with users' clients require onshore presence and more effort than a standard system. If users are steeped in what they have been doing, if they are unable to look beyond their current practices, or if they had inadequate knowledge of their application domain, more intense and frequent interactions would be needed to define requirements. Since users are newly exposed to additional ways of performing processes, more effort would be needed in requirements analysis. In addition, prototyping combined with verification and validation of requirements would be necessary to define complete, correct, and consistent requirements. The newness of application processes would also need more effort than a standard system in designing and verifying the human-machine interfaces.

Volatility in requirements creates cost and time overruns. Unless it is carefully managed, it causes project failures. Such a system creates more risks when it is offshore outsourced. Changing requirements need more user-developer interactions, and therefore require more onshore work. Systems with volatile requirements would need prototyping to peg the requirements clearly and rigorous verification and validation to ensure all requirements are identified completely and correctly. Since volatility may take place during all stages, such systems require additional efforts in activities related to the design of human-machine interfaces and acceptance testing.

New systems that do not have one-to-one correspondence to existing system functions would take more effort in requirements analysis and need prototypes to determine complete system requirements. Requirements analysis for such systems needs active participation of onshore users. In addition, such systems also need elaborate verification and validation of requirements to ensure correctness, completeness, and consistency of requirements. A system replacing many existing functions and procedures without one-to-one correspondence with the existing system would need a conversion strategy with elaborate preparation, training, and coordination. Such systems may also involve many procedural changes and therefore, may need onshore presence for implementation. In addition, the implementation of these systems needs more onshore presence because each part of the system may be implemented in phases and each phase would need special effort in bridging to existing systems.

To facilitate operation and maintenance of the developed system, the vendor has to transfer knowledge about the system through documentation and training of in-house software engineers. Unless a firm uses total outsourcing that includes development, maintenance, and operations of all systems for a long term, the knowledge transfer is necessary. Systems that require elaborate knowledge transfer should co-opt in-house software engineers during all phases of development. The implementation phase would involve operations onshore.

A system may have the standard characteristics of a system described in a previous section and shown in Table 1, but it may be large and involve many departments or functions and many users. Such a system involves a lot of coordination in all stages of development and has great potential for conflicts in objectives and processes. These systems involve additional effort in requirements analysis and need verification of requirements to ensure completeness, correctness, and consistency of requirements. It would also need more effort in designing user interfaces for varied users, in acceptance testing, and in implementation.

The design, coding, and testing activities of ISs other than those discussed above can be done offshore. However, requirements analysis and implementation activities for these may still need some onshore work. In contrast, a system that involves predominantly coding and testing for well-defined requirements such as a project that involves systems redevelopment could use virtual work and performed predominantly offshore. Table 2 summarizes major development activities and their onshore/offshore mix for ISs with various application related characteristics.

TECHNOLOGY CHARACTERISTICS AND ONSHORE/OFFSHORE WORK MIX

Certain technological characteristics of the outsourced system can also drive the need for additional onshore effort. This section discusses these technological characteristics.

If the technology is new, its applications may be unclear or just evolving. An organization may not realize the full potential of new technology as it experiments with several applications and in refining the efficient use of technology. Applications with new technology are often untried, and therefore, need prototypes and pilot projects in consultation with users. In addition, they need rigorous verification and validation of these applications to define the requirements correctly. All of these activities require the active participation of users. All activities of requirements analysis for such projects require onshore presence of developers. In certain cases, technology may not be new but users may have inadequate knowledge and/or experience with the technology. Since they may not realize the potential of technological applications, requirements analysis for these projects will also require additional effort for onshore developers as in the case of new technology. New technology will also need additional onshore effort in acceptance testing and system conversion.

If a system requires extensive integration with existing systems, testing and implementation will have to be onshore. A system that needs interfaces to current systems and has dependence on these systems for development would also require onshore presence. Both types of systems will require prototyping in early stages to analyze integration issues and avoid major problems during implementation. Onshore presence is also essential when the new system development depends on the current hardware and software configuration that is not available with the vendor. Integration testing and system testing of these systems need the onshore facilities. Table 2 summarizes major development activities and their onshore/offshore mix for ISs with various technology related characteristics.

Table 2: Activities and onshore/offshore mix modified by application and technology characteristics (all systems have the same size)

System Characteristics / Development Activity	Standard system as discussed in Table 1	Application Related Characteristics								Technology Related Characteristics			
		Unique and differentiated business processes	Users' lack of knowledge of application domain	Volatile Requirements	Replaces many current functions	Involves many departments and users	Needs elaborate inputs from users' clients	Needs knowledge transfer from vendor	Involves system redevelopment	New technology	Users lack of knowledge/ experience with technology	Large scale integration with current systems	Dependence on existing systems
Requirement Analysis	I	I_m	I_m	I_m	I_m	I_m	I_m	I	I_l	I_m	I_m	I	I
Walk-through & Correction	I	I	I	I_m	I	I_m	I_m	I	I_l	I_m	I_m	I	I
Rigorous Verification & Validation		I	I	I_m	I	I		I		I_m	I		
Prototyping		I	I	I_m	I					I_m	I	I	I
High-level Design (Architecture)	O	O	O	O	O	O	O	O	O	O	O	O	O
DB Design	O	O	O	O	O	O	O	O	O	O	O	O	O
Design Review	O	O	O	O	O	O	O	O	O	O	O	O	O
Controls & Security Design	O	O	O	O	O	O	O	O	O	O	O	O	O
Controls & Security Design Review	O	O	O	O	O	O	O	O	O	O	O	O	O
Human-Machine Interface Prototype	I	I_m	I_m	I_m	I_m	I_m	I	I	I	I	I	I	I
Human-Machine Interface Design	I	I_m	I_m	I_m	I_m	I_m	I	I	I	I	I	I	I
Human-Machine Interface Design Review	I	I_m	I_m	I_m	I_m	I_m	I	I	I	I	I	I	I
Program Design	O	O	O	O	O	O	O	O	O	O	O	O	O
Program Design Review	O	O	O	O	O	O	O	O	O	O	O	O	O
Unit Coding	O	O	O	O	O	O	O	O	O	O	O	O	O
Test Plan and Scripts	O	O	O	O	O	O	O	O	O	O	O	O	O
Unit Code Inspection	O	O	O	O	O	O	O	O	O	O	O	O	O
Unit Testing	O	O	O	O	O	O	O	O	O	O	O	O	O
Unit Integration	O	O	O	O	O	O	O	O	O	O	O	O	O
Integration Testing	O	O	O	O	O	O	O	O	O	I_m	O	I	I
Function Testing	O	O	O	O	O	O	O	O	O	O	O	O	O
System Testing	O	O	O	O	O	O	O	O	O	O	O	I	I
Acceptance Testing & Signoff	I	I_m	I_m	I_m	I_m	I_m	I	I	I	I_m	I	I	I
User Manual	O	O	O	O	O	O	O	O	O	O	O	O	O
Operations Manual	O	O	O	O	O	O	O	O	O	O	O	O	O
User Training	I	I_m	I_m	I	I_m	I_m	I	I	I	I	I	I	I
System Conversion	I	I	I	I	I_m	I	I	I	I	I_m	I	I	I

O – Offshore, I – Onshore, I_m – More onshore effort than a standard system, I_l – Less onshore effort than a standard system

ILLUSTRATION OF COST ESTIMATION FOR AN IS WITH VARIOUS APPLICATION AND TECHNOLOGY CHARACTERISTICS

A previous discussion showed various activities in the development of an offshore-outsourced system with generally known and accepted business processes with very little requirements volatility, employing well-developed technologies, having moderate size and complexity, and involving users with knowledge of the application domain and technology (standard system). Table 1 illustrated the standard system with its mix of onshore/offshore work, required effort, and the estimated cost of offshore outsourcing the system. This section illustrates the mix of onshore/offshore work, required effort, and the estimated cost of a system with various application-related and technology-related characteristics. The new system plans to have unique and differentiated business processes about which users do not have much knowledge and involve many departments and functions. This system is also expected to have volatile requirements as the system evolves. It is also expected to use new technology about which users lack experience. Based on the discussion in the previous two sections, such a system would need onshore work in requirements analysis, walk-through, prototyping, rigorous verification and validation, various human-interface design activities, integration testing, acceptance testing, user training, and systems conversion as shown in Table 3. In addition, additional efforts would be needed in the above onshore activities than a standard system. For the purpose of comparing it with a standard system, this system is also assumed to take 10,000 person-hours. The effort required for each activity, onshore as well as offshore, would be as shown in Table 3. Please note that the example does not mean that offshore activities in this system require less effort than a standard system. The total effort (100%) is distributed between onshore and offshore activities, and a higher percentage of onshore effort would be required than in the standard system. Table 3 shows the onshore and offshore costs for the project under illustration.

In this illustration, the total offshore project cost for a system with certain application and technology related characteristics is estimated at $512,000. Since the onshore execution of this project would cost $700,000, offshore outsourcing could save $188,000 or about 26.85% of the onshore cost. Had the varied application and technology related characteristics been not considered, the project cost might have been estimated at $432,000 or $80,000 less than what would be incurred. Since it could be a loss of 18.51% for the vendor company, it may come under pressure to transfer some onshore work to offshore and thus jeopardize the system quality. Using the model suggested in this article not only saves money for the outsourcing company but it also allows profits for the vendor, and thus enable both the companies achieve their respective offshore outsourcing objectives.

Table 3: Illustration of cost estimation for a system with various application and technology characteristics

Development Activity	**Onshore (I)** / **Offshore (O)**	**% of Project Effort**	**Effort in Person-Hours**	**Onshore Cost** **$70 per hour**	**Offshore Cost** **$30 per hour**
Requirement Analysis	I_m	10%	1,000	$70,000	$0
Walk-through & Correction	I_m	2%	200	$14,000	$0
Rigorous verification & validation	I_m	2%	200	$14,000	$0
Prototyping	I_m	10%	1,000	$70,000	$0
High-level Design (Architecture)	O	4%	400	$0	$12,000
DB Design	O	4%	400	$0	$12,000
Design Review	O	1%	100	$0	$3,000
Controls & Security Design	O	4%	400	$0	$12,000
Controls & Security Design Review	O	1%	100	$0	$3,000
Human-Machine Interface Prototype	I_m	5%	500	$35,000	$0
Human-Machine Interface Design	I_m	5%	500	$35,000	$0
Human-Machine Interface Design Review	I_m	2%	200	$14,000	$0
Program Design	O	2%	200	$0	$6,000
Program Design Review	O	1%	100	$0	$3,000
Unit Coding	O	12%	1,200	$0	$36,000
Test Plan and Scripts	O	3%	300	$0	$9,000
Unit Code Inspection	O	1%	100	$0	$3,000
Unit Testing	O	2%	200	$0	$6,000
Unit Integration	O	2%	200	$0	$6,000
Integration Testing	I_m	3%	300	$21,000	$0
Function Testing	O	4%	400	$0	$12,000
System Testing	O	2%	200	$0	$6,000
Acceptance Testing & Signoff	I_m	6%	600	$42,000	$0
User Manual	O	2%	200	$0	$6,000
Operations Manual	O	2%	200	$0	$6,000
User Training	I_m	4%	400	$28,000	$0
System Conversion	I_m	4%	400	$28,000	$0
Total		100%	10,000	$371,000	$141,000

O – Offshore effort
I – Onshore effort
I_m – More onshore effort than a standard system
I_l – Less onshore effort than a standard system

Total offshore project cost is $512,000 in comparison to the onshore project cost of $700,000.
The offshore project cost for a standard system of the same size is $432,000 per Table 1.

CONCLUSION

This article discussed that offshore outsourcing is essentially dual shore outsourcing involving both onshore and offshore activities. It discussed that waterfall model is the preferred method of development in offshore outsourcing because it facilitates delineation of activities for onshore and offshore work. Although activities such as requirements analysis, human-machine interface, and implementation need onshore effort, additional onshore activities and effort may be needed depending upon certain application and technology characteristics. Determining these characteristics in advance help to estimate the onshore and offshore effort for use in accurate cost estimation and project planning.

Since the iterative and incremental approaches are preferably done onshore, future research can explore how these methods can be modified to fit the dual shore development approaches. In addition, research on virtual work and groupware tools can help to move more onshore activities to offshore. Such research will help distributed systems development in which experts from various geographical regions can participate.

REFERENCES

[1] Abrahamson, P., Salo, O., Ronkainmen, J., and Warsta, J. *Agile Development methods: Review and Analysis*, VTT Publications 478, Technical Research Centre of Finland, Espoo, Finland, 2002. http://www.vtt.fi/inf/pdf/publications/2002/P478.pdf

[2] *Agile Manifesto* at http://www.agilemanifesto.org, 2004.

[3] Ang, S. and Straub, D.W. Production and Transaction Economies and IS Outsourcing: A Study of the U.S. Banking Industry, *MIS Quarterly*, Volume 12, Number 4, December 1998, pp. 535-548.

[4] Boehm, B.W. *Software Risk Management*, IEEE Computer Society Press, Washington, D.C., 1989.

[5] Boehm, B.W. *Software Risk Management: Principles and Practices*, IEEE Software, January 1991, pp. 32-41.

[6] Boehm, B., Abts, C., and Chulani, S. Software development cost estimation approaches - A survey, *Annals of Software Engineering*, Volume 10, Number 1, pp. 177-205.

[7] Brooks, F.P. *The Mythical Man-Month*, Addison-Wesley, Reading, MA, 1995.

[8] Bullhound Sector Report, *Offshore Outsourcing*, January 2005.

[9] Damian, D.E., and Zowghi, D. The impact of stakeholders' geographical distribution on managing requirements in a multi-site organization, *Department of Software Engineering Technical Report*, 2002.1, University of Technology, Sydney, Australia.

[10] FY2012 Outlook: Software and Services, NASSCOM, 2011, emerge.nasscom.in/2011/02/Indian-it-bpo-industry-fy2011-performance-future-trends/ posted February 4, 2011.

[11] Healey, M., End Users: Ignore Them at Your Peril, *Information Week*, September 6, 2010, pp. 19-27.

[12] Holtsblatt, K., and Beyer, H.R. Requirements Gathering: The Human Factors, *Communications of the ACM*, Volume 38, Number 5, 1995, pp. 30-32.

[13] Jones, C. (1998). Sizing up Software, *Scientific American*, Volume 279, Number 6, pp. 104-109.

[14] Jones, C. How Software Estimation Tools Work, Version 5, February 27, 2005. Accessed on September 3, 2010 from http://www.compaid.com/caiinternet/ezine/capers-estimation.pdf

[15] Jorgensen, M. and Shepherd, M. A Systematic Review of Software Development Cost Estimation Studies, *IEEE Transactions on Software Engineering*, January 2007, Volume 33, Number 1, pp. 33–53.

[16] Lacity, M.C., and Willcocks, L.P. *Global Information Technology Outsourcing: In Search of Business Advantage*, John Wiley & Sons, New York, NY, 2000.

[17] Lamswede, A.; "Requirements Engineering in the Year 00: A Research Perspective," *Proceedings of the 22nd International Conference on Software Engineering (ICSE 2000)*, ACM Press, Ireland, 2000.

[18] Lauer, T.W. , Peacock, E., and Jacobs, S.M.Questions, Generation and the Systems Analysis Process in T.W. Lauer, E. Peacock, A.C. Grasser (Eds.), *Questions and Information Systems*, Lawrence Erlbaum Publishers, Hillsdale, NJ, 1992.

[19] Lum, K., Bramble, M., Hihn, J., Hackney, J. Khorrami, J., and Monson, E. *Handbook for Software Estimation*, May 30, 2003, JPL D-26303, Rev. 0, Jet Propulsion Laboratory, Pasadena, CA.

[20] Martin, J. *Rapid Application Development*, Macmillan Publishing, New York, NY, 1991.

[21] McConnell, S. *Rapid Development*, Microsoft Press, Redmond, WA, 1996.

[22] Sakthivel, S. Virtual Workgroups in Offshore Systems Development, *Information and Software Technology*, 2005, Volume 47, pp. 305-318.
[23] Sengupta, S. Awake and Hungry, *Business World*, November 21, 2005, pp. 30–37.
[24] Smith, M.A., Mitra, S., and Narasimhan, S. Information Systems Outsourcing: A Study of Pre-Event Firm Characteristics, *Journal of MIS*, Volume 15, Number 2, 1998, pp. 61-93.
[25] Spender, J.D., and Strong, B., Who has Innovative Ideas? Employees, *The Wall Street Journal*, August 23, 2010, R5.
[26] The Outsourcing Institute, It's no longer about saving money, http://www.outsourcinginstitute.com/oi_index/no_longer.html, February 26, 2003.
[27] The Standish Group, Extreme Chaos, USA, 2001.
[28] www.cio.com/article/603483/H_1B_and_L-1_Via_Fee_Hike_Could_Lead_to_More_Offshoring "H-1B and L-1 Visa fee Hike Could Lead to More Offshoring," Updated August 16, 2010.
[29] www.thehindubusinessonline.com/industry-and-economy/info-tech/article2692084.ece "NASSCOM reiterates growth forecast 16-18% for industry, December 6, 2011.

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