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A Framework for Education Engineering for IT Service

삼성SDS ▌박 준 성

1. Introduction

This paper presents a framework for designing effective educational programs for professionals who provide IT services. Section 2 discusses the classification and the lifecycle of IT services that goes through *service marketing*, *service engineering* and *service engagement*. Section 3 decomposes the latter three functions into *service objects*(such as service opportunity, solution architecture, engagement process, education curriculum, etc.) and shows complex relationships among those objects. Section 4 suggests a systematic process of *resource planning* for IT services based on the architectural model of service objects. Section 5 elaborates on *education engineering* for IT services. The main idea underlying the education engineering framework presented in this paper is that education should be planned as a part of the *resource planning* and developed as a part of the *service engineering*. Section 6 provides some concluding remarks.

2. Classification and Lifecycle of IT Services

IT service is the service of planning, developing and operating computer-based systems for *service clients*. Table 1 shows a taxonomy of IT services. Each cell in the matrix is called an *IT service line* which is a collection of *service activities* that produce a package of *IT deliverables*. Each service line can be further classified along various dimensions such as the target market segment, business domain, delivery mode, technology used, etc. For example, a subclass of the Application Implementation service line can be the implementation of a packaged application for supply chain management in electronics industry.

IT service providers should create *value* for service clients. The IT service provider may be internal or external to the organization where the client belongs. The service provider should study, understand and even develop *service opportunities* for the client to innovate and improve its business exploiting IT. Once service opportunities are identified, the provider should make sure that it has the capability to successfully provide IT services for realizing those opportunities. If the client's demand exists and the provider's capability is prepared, the latter will propose and try to reach an agreement to deliver the service at some cost to the client. As such, IT service goes through a lifecycle of *service demand*, *service engineering*, and *service engagement* as shown in

Table 1 Sample Taxonomy of IT Services

		Architecting & Planning	Implementation	Operation
Business Model				
Application	User Interface			
	Process			
	Data			
Technical Infrastructure	Middleware			
	System Software			
	Hardware			
	Network			
Management of IT Service				

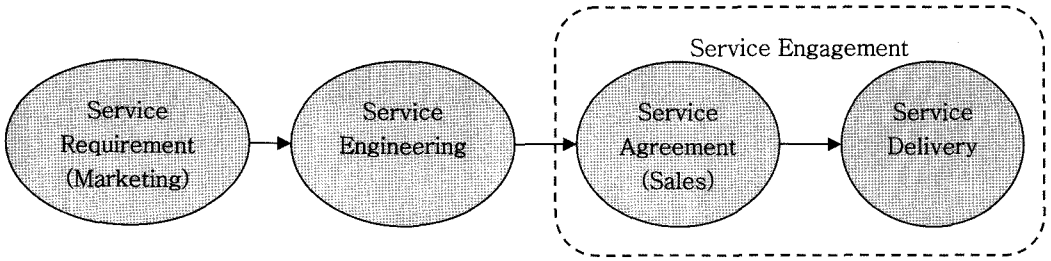

Figure 1 IT Service Lifecycle

Figure 1. The terms *marketing* and *sales* in parentheses are more appropriate in case of external service providers.

IT service engineering is to prepare the provider with the *service capability* to successfully deliver the IT service. It includes such activities as stipulating a *standard process* of service engagement(from sales through delivery), developing *methodology* guidelines for tasks carried out along the process, harvesting and generalizing artifacts produced from engagements to accumulate *reusable assets*, and educating service professionals to obtain proper levels of *competencies* for performing required tasks and turning the outputs into assets.

A *service engagement* for a client requires a service agreement or contract. It often requires several service lines to be delivered in combination. For example, an external service provider may conduct a system integration project for a client within a predetermined budget and time duration, where it develops an application along with supporting technical infrastructure. A service engagement hence requires a team of professionals with different competencies for different service activities for different service lines. Whenever there are gaps between competencies required for service engagements and those already possessed by service professionals, the service provider will need education of internal people or recruitment of people from outside.

In short, education is a part of service engineering to prepare sufficient competencies for intended service engagements.

3. Architectural Model of IT Service Business

An architecture of IT service business is shown in Figure 2 which shows important *service objects* in each service function and relationships among those objects.

For a *service opportunity* and the ensuing *service engagement*, appropriate *engagement processes* are selected depending on the set of *service lines* involved in the engagement. An engagement process for a service line usually goes through multiple phases. The process defines *IT artifacts* to be produced in each phase and the *service activities* required to

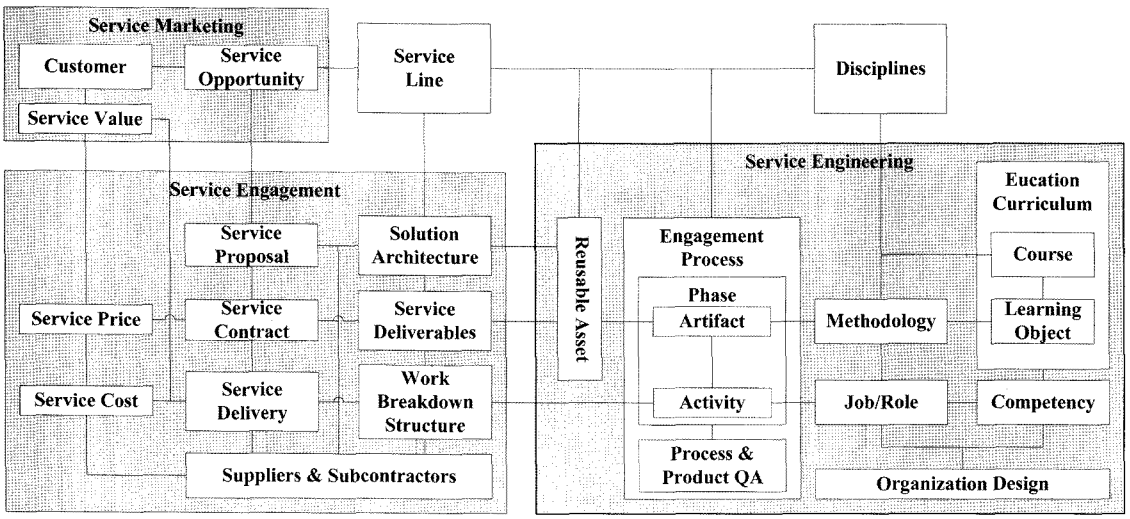

Figure 2 Sample Architectural Model of IT Service Business

produce those artifacts. *IT service disciplines*(such as component-based software engineering, project management, configuration management, etc.) are applied to specify *methodologies* for carrying out those service activities in the engagement process.

A standard process is essential for IT service engagements because it is that process which assigns professional *jobs* and *roles* to activities performed for different service lines. Professionals having a specific job and playing specific roles should be educated to possess sufficient *competencies* for the process activities they are assigned to perform. Competency comprises the fundamental *knowledge* of relevant *disciplines*, the *skills* of applying the knowledge at work, and the *process ability* to execute standard processes and methodologies[3].

Figure 2 demonstrates complex and intimate relationships between education and other service objects(such as service line, discipline, process, methodology, competency, job and role, etc.), and how education can systematically contribute to the value created for clients through engagements. To summarize, standard engagement processes and methodologies provide guidelines as to who(which jobs and roles) should perform what activities in order to create and deliver required artifacts to the client. Knowing the competencies required to perform those activities, one can recognize a gap between demanded and currently available types and amounts of those competencies. This gap can be filled by education programs.

4. Resource Planning for IT Service Business

4.1 Resource Planning Model

The question arises as to how a service provider can always keep the minimum required number of professionals who together have the right mix of competencies to deliver valuable services in all intended service engagements for clients. This question is generally about *resource planning for IT services*. This is a critically important management function for any service provider yet without many established best practices. It is contrasting that MRP, MRP II, ERP and extended ERP have evolved and reached a matured level for the manufacturing industry, but that corresponding disciplines have not been developed to a comparable maturity level for the IT service industry[2].

Resources used by an IT service provider in service engagements include people, computing facilities (such as desktop, mobile devices, servers, storages, system software, middleware, etc.), and intellectual properties(such as standard delivery process, application development methodologies, reusable software frameworks, etc.). IT service providers usually purchase computing facilities from hardware and software product vendors, while utilizing their own people and intellectual properties in delivering the services. The more reusable intellectual properties they have, the more cost, speed and quality of the services will improve. Therefore, an important business strategy for an external IT service provider is to make the transition from labor-based services to *asset-based services* where effort and cost of professionals engaged are saved due to the reuse of pre-built intellectual properties.

Figure 3 integrates resource management functions such as resource planning, acquisition and allocation into the IT service lifecycle shown in Figure 1.

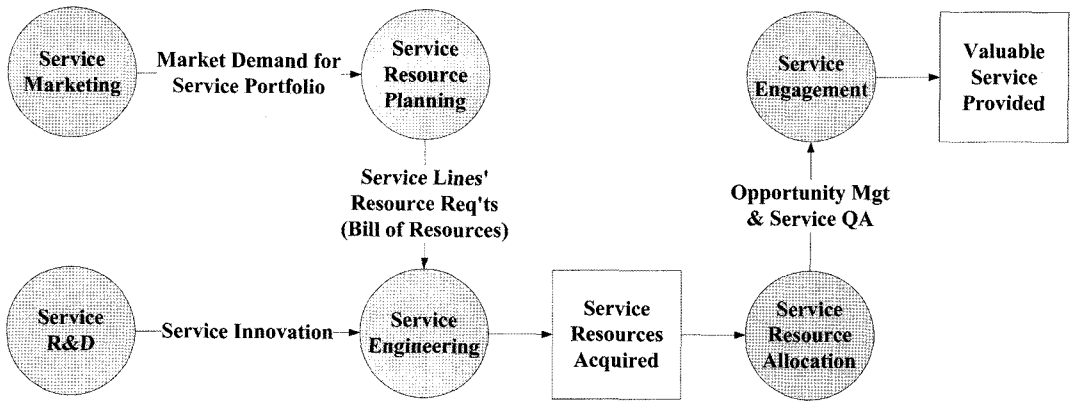

Figure 3 Resource Planning Model for IT Services

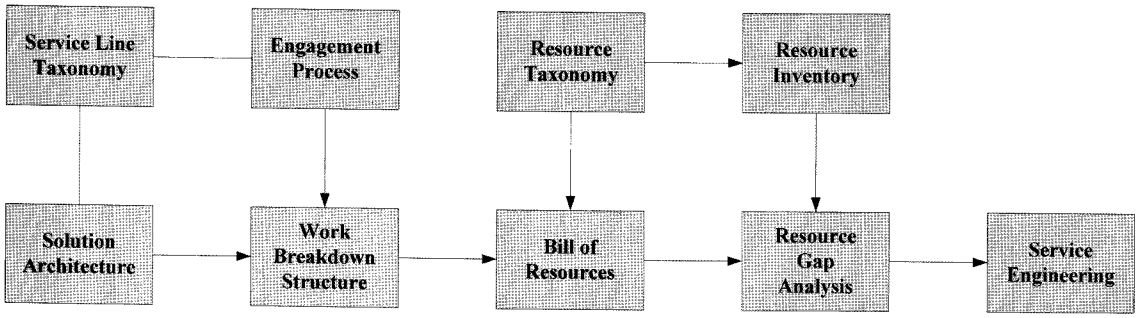

Figure 4 Resource Planning Process for IT Services

As shown in Figure 3, types and volumes of resources required for delivering valuable IT services to target clients must be planned based on the demand for services anticipated for the planning period. Long and mid term resource planning is necessary because it often takes more than a year to develop and roll out IT service resources such as a standard engagement process, IT engineering methodologies and competencies, and reusable IP assets. Short term resource planning is equally important to fill the gap between required and possessed capabilities caused by the fluctuation of demands for different service lines.

Given available resources, their allocation needs to be optimized over the pipeline of engagement opportunities and the existing portfolio of engagement commitments. The education to prepare professionals with required competencies should therefore be planned for varying time frames—anywhere from a month to prepare for an upcoming engagement project to a 2-year period to ride a new wave of technology trends.

4.2 Resource Planning Process

A systematic process for planning resources for IT services is suggested in Figure 4. This process can be applied for an individual service opportunity(and the ensuing engagement), or at an aggregate level, viz. at the level of service line or at the level of the entire services of a service provider.

Required resources are identified based on the *solution architecture*(see Figure 2). Designed for a service opportunity or a service line, this architecture specifies high-granule IT artifacts that should be created and delivered to the client. Figure 5 presents an example of solution architecture.

Given the solution architecture, one can develop a *work breakdown structure*(WBS) which shows what

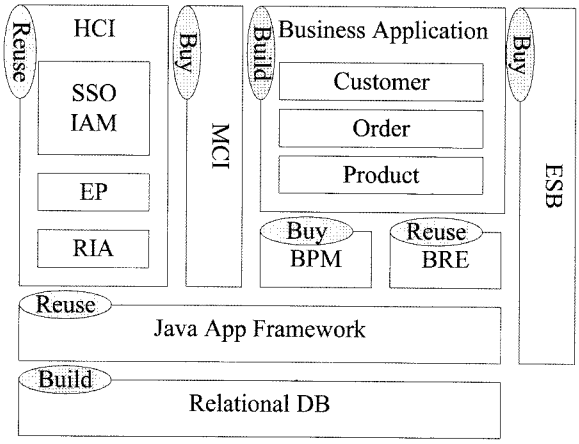

Figure 5 Sample Solution Architecture for Application Implementation Service Line

activities should be performed in each phase of the engagement process to create each component in the solution architecture and to manage engagement services. Table 2 shows a sample WBS.

Given the WBS, a *bill of resources* exhibited in Table 3 can be developed that determines the resources needed to successfully perform every activity in the WBS. For example, to perform the WBS in Table 2, one needs to implement BPM, which requires such resources as: a BPM product to purchase; process modelers with knowledge of the business domain, process modeling notation(such as BPMN) and methodology; skills to execute the process using a standard tool(such as BPEL), a process reference model pertinent for the target domain, etc.

The solution architecture, work breakdown structure, and the bill of resources are important tools for resource planning for IT services which should always include educational planning. For each type of resource required in the bill of resources, its demand is estimated for different planning horizons and the gap between the demand and the current inventory is

Table 2 Sample Work Breakdown Structure

		Engagement Process								
		Sales Process			Delivery Process					
Solution Components				...	Project Launch	Requirement Development	Architecture Design	Construction	System Test	Conversion
To Build	Business Application			...	...	· Requirement Elicitation and Analysis · Business Service Identification	· Application Architecture Design · Data Architecture Design · Technical Architecture Design · Reuable Assets Analysis · Dev't Standards and Templates · Implementation Architecture Design and Test	...	...	...
	Relational Database			...		· Business Vocabulary · Business Semantics Model		...		
To Buy	Multi-Channel Gateway			...		· Channel Req't Analysis · Package Gap Analysis		...		
	Business Process Management					· Business Event and Process Model				
	...			...				...		
Technical Infrastructure				...		· Current Infrastructure and Interoperability Analysis · Non-Functional Req't Analysis · Architectural Strategy		...		
Project Management				...	· Project Planning and Tracking · Requirement Management · Configuration Management · Product and Process Quality Assurance					

Table 3: A Sample Bill of Resources

Solution Component	Engagement Process for Transformation Service		Human Resource		Competency			Edu-cation Course	Reusable Asset
	Phase	Activity	Job	Role	Discipline	Metho-dology	Tool		
Business Application	Req't Dev't	Req't Analysis	System Analyst	System Analysis	Req't Engineering	Use Case Modeling	...	Req't Eng.	Business Reference Model
		Business Service Indentif'n			Service-Oriented Archi-tecture	Component Business Model	...	Service-Oriented Archi-tecture	
	Architecture Design	Application Architecture Design	IT Architect	App. Architecture	Software Archi-tecture	Software Architecture Design	...	Software Architecture Design	Application Reference Architecture
		...							
	Construction	...							
	...	...							
...									
Business Process Management	Req't Dev't	Business Process Modeling	System Analyst	Process Modeling	Business Process Management	Business Process Modeling Notation	...	Business Process Mgmt	Process Reference Model
	Construction	Business Process Execution	System Designer	Package Impl'n					
	...								

measured to develop resource acquisition plans. Service engineering is then invoked to acquire necessary resources. In the next section, we look into *education engineering* which is a part of service engineering.

5. Education Engineering for IT Services

5.1 Curriculum Design

In Section 4 we have seen that education must be planned as part of resource planning. It should start from forecasting and analyzing the opportunities of IT service engagements for all clients. The collection of solution architectures for all identified opportunities allows enumeration of high-level artifacts that should be created and delivered. Through the construction of the work breakdown structure and the bill of resources and an analysis of resource gaps, we can determine competencies of different jobs and roles to be developed through education.

Education builds required competences which consist of the knowledge of relevant disciplines, skills to apply them at work and the ability to execute standard engagement processes and methodologies. In order to design the high-level curriculum, we can map *IT service disciplines* to the IT service taxonomy matrix in Table 1. Table 4 shows an example of this mapping. In Table 4 Enterprise Architecture(EA) is a recently prevailing, very comprehensive discipline that spans all the rows in the Architecting & Planning column. Service-Oriented Architecture(SOA) is another recently growing discipline that addresses the intersection of the Application Process row and both Architecting & Planning and Implementation columns. Information Technology Infrastructure Library(ITIL) is a widely adopted best practice for Management of IT Service for Operation, while Capability Maturity Model Integration(CMMI) is the same for Management of IT Service for Implementation. Like the service line classification, IT service disciplines can be classified into many hierarchical levels. An example of a narrowly defined discipline can be the service-oriented development of a Java application for billing systems for mobile telecommunication services.

Although the service line-discipline mapping can provide a blueprint of what subject areas to cover in the curriculum, it is difficult to select an optimal set of disciplines to teach among a vast number of IT service disciplines given target clients and limited resources. New and better IT service disciplines evolve rather fast. It has to be determined when to introduce an emerging discipline into the curriculum. The resource planning model and process discussed in Section 4 provides a systematic and holistic approach to make such decisions on the composition of a detailed curriculum.

Given the curriculum designed, courses are developed that are delivered in class or online. Various Web communication technologies should be utilized for online courses—video, audio and documents played in sync as well as Web 2.0 style communication and collaboration. For both in-class and online courses, complete and detailed reference materials must be provided such as text books, reference manuals, journal articles, Web references, etc.

5.2 Education Management

The quality of course materials and instructors are critical success factors for IT service education. World-class materials and instructors should be employed

Table 2 Sample Mapping of IT Service Disciplines to the Taxonomy of IT Services

		Architecting & Planning	Implementation	Operation
Business Model		EA, BPM	Web 2.0	
App.	UI			
	Process	SOA		CBD, SODA
	Data	Metadata Mgmt		TDD, MDD
Tech. Infra.	Middleware		ESB	
	System SW			Grid Computing
	Hardware			
	Network	Network Design		
Mgmt of IT Service			CMMI	ITIL

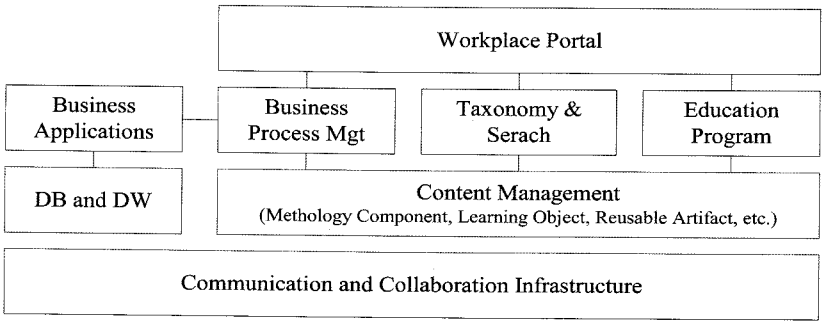

Figure 5 Information Systems Architecture for IT Service Providers

although they may be costly. It can help reduce the cost if one takes the *train-the-trainers* approach. In this approach the best-selected professionals are trained in world-class education programs. These in turn provide training and mentoring for other peer professionals. They should also be encouraged to generate intellectual properties from their own work, which are provided as reusable *best practices* to other professionals.

In addition to *explicit knowledge* learned individually from in-class and online courses, *tacit knowledge* mutually learned inside formal groups such as *centers of competency* and informal groups such as *communities of practice* is essential to build effective competency[5].

Figure 5 shows an information systems architecture for IT service providers that can facilitate organizational learning.

The architecture suggests that explicit knowledge such as methodology components, learning objects and reusable artifacts are made available as process content, leaning content and ad hoc search content from a common repository. The architecture also supports collaborative teamwork along formal business processes as well as via informal communications.

Education and human resource management must be tightly linked. The education program should provide certification of competencies for different jobs, roles and ranks. Certification may require passing the exit test of required courses as well as passing inspection by subject matter experts of actual artifacts the trainee produced in engagements. Another important thing to watch out for is if the trainee is repeatedly assigned the tasks for which education was provided, so that explicit knowledge gained through training be internalized to tacit knowledge through repeated learning by doing.

5.3 Economics of Education

A successful IT service provider should maintain that the value created for the client through a service engagement is greater than the price(or the charge-back in case of internal service providers) paid by the client, which in turn is greater than the cost of resources directly and indirectly used by the provider. Table 5 shows a sample financial model for external IT service providers[4].

Out of the revenue created from service deliveries, direct cost(including labor cost, cost of computing facilities and software purchased, cost of subcontracted services and other expenses) accounts for 67% generating a gross margin of 33%. The gross margin covers service marketing, service sales, service engineering expenditures, the cost of unutilized labor, and general and administrative expenses, leaving the remaining 15% of operating profit.

Education, as a part of service engineering, is costly because it lowers labor utilization in addition to incurring expenses. The contribution of education to profit should be greater than the investment in education. It should contribute to increasing the

Table 5 A Sample Financial Model for External IT Service Providers

Revenue	100%
Direct Cost of Service Delivery	67%
Gross Margin	33%
Cost of Service Marketing & Sales	8%
Cost of Service Engineering	2%
Cost of Unutilized Labor plus G&A	8%
Operating Profit	15%

revenue—through enabling delivery of new service lines to create new sources of revenue; through innovating and differentiating services from competitors thus raising the price of services; and by addressing increased demand for existing service lines to maintain the market share. It should also reduce the cost of sales and delivery by improving the knowledge, skill, productivity of professionals and decreasing the cost of quality that includes prevention cost, appraisal cost, and internal and external failure costs[1].

On the contrary, if investment in education is limited to an insufficient level to raise the operating profit in the short run, competencies of professionals will erode quickly resulting in declines of market share, service prices and eventually profit.

6. Conclusion

We have discussed a systematic and holistic approach to engineering education programs for IT services. This approach is characterized as market driven, architecture based, process centric and asset oriented. Education planning has to be market driven for the investment in education to have high returns. It has to be architecture based so as to allow an analysis of the bill of resources to be performed on detailed solution artifacts and hence to allow a selection of low-granule subjects to cover in the education curriculum. It needs to be process centric so that relevant subjects are taught for different jobs and roles, who are supposed to perform those process activities calling for competencies gained from the learned subjects. It should be asset oriented, meaning that education should enable professionals to harvest reusable intellectual assets from their engagements, which in turn are used for cost saving in future engagements and as learning materials for future employees.

Although the framework for education engineering suggested in this paper was illustrated for individual IT service providers, its basic structure and mechanism can be applied to workforce planning and educational planning at the national level.

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June Sung Park

Dr. Park is Executive Vice President and Chief Technology Officer leading IT service engineering and innovation at Samsung SDS. Prior to joining SDS in 2001, he was a tenured associate professor of Information Systems in the Henry B. Tippie College of Business in The University of Iowa. He obtained Ph.D. in Interdisciplinary: Computer Science and Industrial Engineering from The Ohio State University in 1988. He has published numerous articles in edited books, professional magazines and leading academic journals such as Management Science, INFORMS Journal on Computing, Telecommunication Systems, Information Systems, Information Technology and Management, International Journal of Technology Management, IEEE Transactions on Knowledge and Data Engineering, European Journal of Operational Research, Journal of Heuristics, Location Science, etc.

E-mail : june.park@samsung.com