

# The Construction and Investigation of Web Engineering for extending the enterprise's core competence related studies

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## ABSTRACT

*One can say that web applications are developed in an ad-hoc manner. Many also said that web engineering should be understood as a framework to provide a service with all kinds of web technologies, not a single, well-defined project. Obviously, it's difficult because of web technologies evolution such as web services, web 2.0, mobile devices popular, and cloud computing concept etc. To solve the all traditional problems there is a need of engineered development of web applications. Web Engineering, a rather new field of research, is however not yet explored in a very systematic way. They are not well documented and very difficult to maintain. In this paper, we present how methods of web frameworks/technologies and models of software engineering can be used for Web engineering with the implementation results and experience. This paper also describes various web application frameworks and related emerging technologies pertinent to the web engineering from a technical perspective. In summary, we propose the development disciplines to construct web engineering by using our development of computerization experience and business rules for extending the enterprise's core competence, has been proven to be successful for assisting the enterprise to do business and deliver more value services on the Internet.*

## Keywords

**Web Engineering, Web Vision, Web Evolution, Core Competence, Programming Technique, Cloud Computing, Virtual Machine.**

## 1. INTRODUCTION

The Internet is a technology for organizations providing means to communicate with the public. It also has the only one characteristic without geographical boundary or time limit, everyone interacts through one-to-many or many-to-many networks meeting matches to do business and provide or request services they want. The growth of the World Wide Web has already had a significant impact everywhere, on our personal life and working lives. About 15+ years ago, it all started with static HTML pages and some CGI programs and did not

really raise any engineering issues. The current steps towards user-friendly interactivity are popular pages whereby users could send data and information back to the application servers and simple "application sites" like guest books, many complex "dynamic applications" are possibly developed and work smoothly. The Internet also causes the evolution of web technologies and web frameworks, this action is a goal to match all users' requirements, user-friendly interfaces and performance of doing business. However, there has been a proliferation of different client-side scripting languages and server-side component programs and many web sites do not work reliably because of their extremely chaotic maintenance. So one may ask project managers and engineers whether they have forgotten everything they learned in their software engineering, programming and project management classes [1]. During the last 20+ years the web has evolved into a global environment addressing applications that range from small-scale and simple services to large-scale and complex enterprise applications distributed over Internet sites. Enterprises and companies are using the web to do business processes for their employees, to communicate with their partners and vendors, to integrate their back-end and databases, and to perform all kinds of e-commerce transactions including B2B, B2C and B2G.

This paper aims to give an indicative overview over development web engineering technologies and software engineering technologies-UML [23], SPICE (ISO/IEC 15504 also known as SPICE - Software Process Improvement and Capability Determination) [32], CMMI (Capability Maturity Model Integration) [18] that have proven to be useful for web engineering. We propose the development disciplines for web engineering and re-engineering according to our development experience and business rules. We point to ongoing research on the direction of development disciplines to address web engineering issues, i.e. web technology's evolution - Web Framework, Web-based server programming technique, Web Service, Cloud/Net Computing Utility,

Virtual Machine, Web 2.0 or above and Next-Generation Web Vision etc.

The rest of the paper is organized as follows: First, we discuss web engineering and objectives of constructing web engineering; we follow this with a presentation of web technologies of our implementation along with detailed description. Then, we present the implementation results and benefit evaluations of constructing web engineering with process models in the enterprise's e-business environment. Finally, we conclude the paper with future directions.

## 2. REVISITING WEB ENGINEERING

Based on this definition and on [2], many define Web Engineering as follows: 1. Web Engineering is the application of systematic and quantifiable approaches (concepts, methods, techniques, tools) to cost-effective requirements analysis, design, implementation, testing, operation, and maintenance of high-quality web applications. 2. Web Engineering is also the scientific discipline concerned with the study of these approaches [3].

Web engineering is concerned with establishing and using sound scientific, engineering and management principles for developing web-based applications. Conallen also had a definition that a web application being "a Web system (Web server, network, HTTP, browser) in which user input (navigation and data input) effects the state of the business" [4]. Traditional software engineering ensures efficient development and maintenance of software applications, web-based applications have to be "re-engineered", too. Though, it is not necessary to invent many new process models, notations or programming paradigms. Most web-based processes can be analyzed, designed, implemented and maintained by using existing techniques that have already been developed for object-oriented and component-based software. However, in contrast to software engineering, Web engineering is rather concerned with delivering a value service than a product around our life environment.

WIKIPEDIA is a fabulous collection of references, disciplines and resources to current knowledge and understanding to web sites engineering. Web engineering is multidisciplinary and encompasses contributions from diverse areas, Figure 1 show that: systems analysis and design, software engineering, hypermedia/hypertext engineering, human-computer interaction, user interface design, information engineering, information indexing and retrieval, testing, modeling and simulation, web service, cloud/net/mobile computing, web framework, web technology, project management, graphic design and presentation, and web 2.0, as a matter of fact, the perfect definition of Web 2.0 doesn't exist yet until now according to our survey. Web engineering is neither a clone, nor a subset of

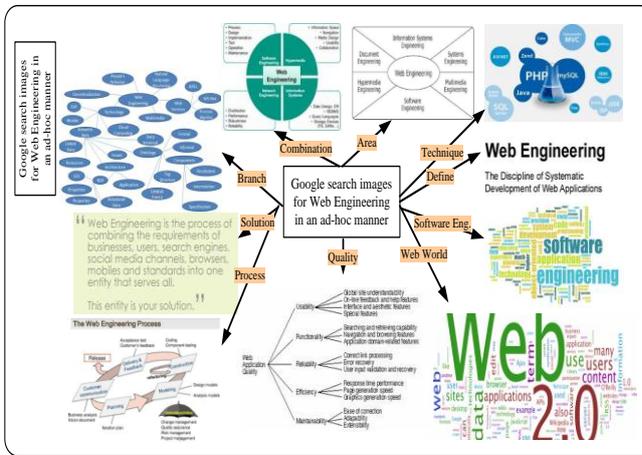
software engineering, although both involve programming and software development. While web Engineering uses software engineering principles, it encompasses new approaches, methodologies, tools, techniques, and guidelines to meet the unique requirements of web-based applications [35].

As an emerging discipline, web engineering actively promotes systematic, disciplined and quantifiable approaches towards successful development of high-quality, ubiquitously usable web-based systems and applications [3]. In particular, web engineering focuses on the methodologies, techniques and tools that are the foundation of web application development and which support their design, development, evolution, and evaluation. In virtue of the fact that Internet is popular everywhere, it deeply affects web application development. Thus, the kind of web-based requirement development has certain characteristics that make it different from traditional software, information system, or computer application development. We really confirm that all kinds of topics about web development and engineering are rather concerned and investigated than non-web ones.

## 3. OBJECTIVES OF CONSTRUCTING WEB ENGINEERING

### 3.1 Computer digitalization - All of Datas

One of computer digitalization's state-of-the-art technologies and emerging wisdoms - Web Engineering. Computer has been the most convenient and popular tool in business management. Formosa Plastics Groups (FPG), one of the biggest enterprises in Taiwan, adopted computer technologies since 1967. In 1976, FPG started computerization in portion of accounting business. As early as 1983, FPG completed ERP (Enterprise Resource Planning) among different corporations. However, the ERP of the whole groups didn't accomplish until 1989. Since then, Formosa went step by step to apply Customer Relationship



**Figure 1: Google Search images for the “Web Engineering”**

Management (CRM) and Supply Chain Management (SCM) systems, obtaining Electronic Data Interchange (EDI), Office Automation (OA), Internet/Web Engineering, etc. And eventually use computer to handle all purchasing and contracting business, i.e. Formosa Technologies Corp. (FTC) online E-MarketPlace.

FPG digitalization that connects administrative sections into the ERP covers six management systems including personnel, material, finance, business, production and engineering. It was a generation when information technology was rare and digitalization was difficult in 1980s. More than 30 years later, FPG is now proud of its excellence in management technologies which has become its core competitiveness.

The principles of digitalization are based on comprehensive planning, one-time inputting/multilevel transmitting, mutual auditing, and abnormal reaction and so on. State-of-the-art technologies help to integrate internal resources within groups and promote operation and management to reach its maxima efficiency. Moreover, FPC has a special global perspective. Where there are new factories there are digital technologies. No matter the new factories are in U.S., China, Vietnam or Indonesia, they all use the same computer system. It not only helps all related operation procedures to connect with and run smoothly, but also enhances vertical integration among corporations. In all, computer technology is a time saving and quality improving revolution.

### 3.2 Proposed definition - Web Engineering

Web engineering, computer digitalization’s state-of-the-art technologies, it is rather concerned with saving cost benefit under web applications development by the entrepreneurs, and here is the

other discovered development value of Web Engineering: the Extension of the Enterprise’s Core Competence, has been proven to be successful for assisting the enterprise to do business and deliver more value services on the Internet. Although many said that web engineering is multidisciplinary and collects contributions from diverse areas. We think web engineering encompasses two major areas including software engineering and web technologies. Obviously, software engineering as an engineering discipline has been specified in the guide to the Software Engineering Body of Knowledge (SWEBOK) [33]. The SWEBOK has already become an internationally accepted standard ISO/IEC TR 19759:2005 [34] and is also widely recognized as a foundational document within the software engineering community. As for web technologies, various technologies to develop web-based components from diverse areas have been proposed to achieve all kinds of users’ requirements. In other words, the evolution of web technologies only has a goal that satisfies all of web-based requirements.

Consolidating all the research reviews, analyses and multidisciplinary fields, here is the new definition of web engineering: Web Engineering is the combination from both of software engineering development principles and web technologies evolution based on computer network. It is a rather new field of research, always has a great effect upon our life and work today and the future.

### 3.3 Enable the Enterprise’s Core Competence

Web engineering, computer digitalization’s state-of-the-art technologies, it is rather concerned with saving cost benefit under web applications development by the entrepreneurs, and here is the other discovered development value of Web Engineering: the Extension of the Enterprise’s Core Competence, has been proven to be successful for assisting the enterprise to do business and deliver more value services on the Internet.

## 4. IMPLEMENTATION

### 4.1 Web-Based Programming Languages

#### 4.1.1 ASP (Active Server Pages)

Active Server Pages [6], [11] is a Microsoft promoted technology to enables HTML pages to be dynamic and interactive by embedding scripts, i.e. either VB Script or Jscript, Microsoft’s alternative of Java Script. Since the scripts in ASP pages (.asp) are processed by the server, any browser can work with ASP pages regardless of its support for the scripting language used therein. Introduced by Microsoft in the mid-1990s, this is the standard programming system for Internet applications hosted on Windows servers. ASP is a compile-free application environment in which you can combine HTML pages scripts, and ActiveX (DCOM, COM+) server components to create powerful Web-based business solutions. Active

Server Pages enables server-side scripting for IIS with native support for both VBScript and Jscript.

#### 4.1.2 PHP (Hypertext Preprocessor)

PHP was created in 1994 by Rasmus Lerdorf. Self-referentially short for PHP [7], [11] is Hypertext Preprocessor, an open source, server-side, HTML embedded scripting language used to create dynamic Web pages. In an HTML document, PHP script (similar syntax to that of Perl or C) is enclosed within special PHP tags. Because PHP is executed on the server, the client cannot view the PHP code. It also can perform any task that any CGI program can do, but its strength lies in its compatibility with many types of databases. Also, PHP can talk across networks using IMAP, SNMP, POP3, or HTTP. PHP is an open-source, server-side HTML embedded scripting language used to create dynamic Web pages. The web browser only sees the resulting HTML output of the PHP code. It can be used to create Internet-based applications with numerous uses, including e-commerce, e-business, e-project etc.

#### 4.1.3 JSP (Java Server Pages)

A scripting language based on Java [8], [11] for developing dynamic Web pages and web sites. A JSP compiler is used to generate Servlets from the JSP page. JSP allows web pages to be generated dynamically using a combination of XML tags and Java Servlets. Java Server Pages are web-pages and produced by Sun Microsystems. Technology that facilitates the development of dynamic Web pages and Web applications that use existing components, such as JavaBeans, Enterprise JavaBeans (EJB) and Web Objects components. This is one of the technologies created to enable development of platform-independent web-based applications. JSP is an extension to Java Servlets allowing the dynamic generation of web pages. JSP is a technology that enables the mixing of regular static web pages (HTML) with content generated dynamically by Java Servlets. JSP can be used with Solaris and Linux (UNIX) platforms.

#### 4.1.4 PML (Program Macro Language)

PML was originally developed in 2001 by BCD (Business Computer Design Int'l Inc, <http://www.bcdsoftware.com>) [9], [10] WebSmart ILE. The main window of the WebSmart IDE lets you write free-hand code in a PML language. PML controls the entire flow of programs, and gives great flexibility to change the way programs work. Each program you create will contain some initial PML that comes from a template. You can then modify the code using the PML editor. Each template has PML embedded in it, with tokens, or placeholders, for information that is provided by the designer when they start to design a new program.

How to learn PML? If you are at all familiar with any programming language (Java, VB, Delphi, C++ etc) then you will quickly adapt to the syntax of PML. Of

all these languages, syntactically PML most closely resembles Java. If you don't know Java (or any of the other PC languages above). PML has not gone to the extent of incorporating all the complexities of Object Oriented programming. Coding in PML is very straightforward. If users are not familiar with these languages, you may have a bit of a learning curve as you adapt to the syntax of PML. However, BCD has provided many online tools to help users quickly become proficient and productive in this language.

#### 4.1.5 Survey Programming Community Index

According to TIOBE Software's latest Programming Community Index [25], TIOBE is a Netherlands-based provider of software quality assessment services based on the ISO/IEC 9126 standard. In August 2013, the index ranked Java at the top with the highest percent rating, just edging C, but with some distance from other top languages, including C++, Objective-C, C#, and PHP etc. Until September 2013, Java is still at the top ranking index.

Another reason Java continues to be popular, is that it is ever evolving. "Java is not static," one said. "And there are dozens and dozens of open source frameworks for Java out there. So if developers don't like the way the JDK works, there are a thousand other ways to do it. Java is incredibly entrenched technology, which is backed by some of the world's largest and most influential software companies, including IBM and Oracle, are two of the leading brands, IBM using WebSphere [21] as the core of its e-business and Oracle also adopting JDeveloper for e-commerce solutions. One said that these are companies that still have a strong influence and transaction-oriented applications on e-business. Consolidating these above, Java is still the most popular programming language in e-business field for the enterprise's web engineering from other top languages, including C++, C#, Objective-C, Python, VB.NET, and PHP etc.

## 4.2 MVC and 3-Tier Architecture

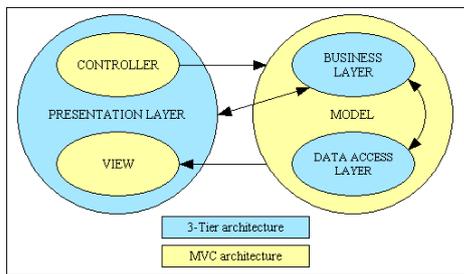
Model View Controller (MVC) was originally developed to map the traditional input, processing, output roles into the GUI realm [29]: Input (Controller)→Processing (Model)→Output (View). MVC design pattern has been widely adapted as an architecture for World Wide Web applications in all major programming languages. Several commercial and noncommercial application frameworks have been created that enforce the pattern. These frameworks vary in their interpretations, mainly in the way that the MVC responsibilities are divided between the client and server [12]. In the three top programming languages, i.e. Java, .NET and PHP, the MVC Design Pattern is described as having the three major components.

Three-tier architecture is a client-server architecture in which the user interface, functional

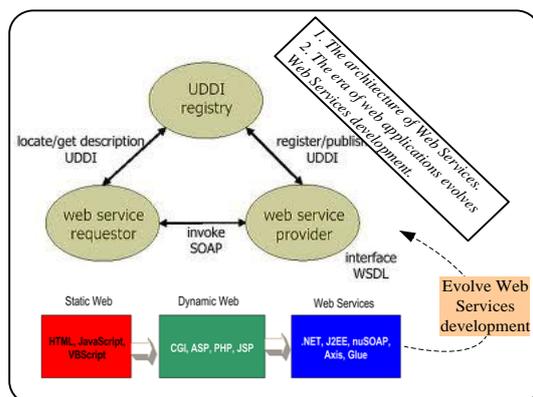
process logic ("business rules"), computer data storage and data access are developed and maintained as independent modules, most often on separate platforms [13]. It was developed by John J. Donovan in Open Environment Corporation (OEC). The three-tier model is a software architecture pattern. It has the following three tiers [14]: Presentation tier, Application (Logic) tier and Data tier. An overview of the three-tier application is shown as Figure 2. The relationship to combine MVC and three-tier is also shown as Figure 3.



**Figure 2: Overview of the three-tier application**



**Figure 3: The relationship to combine MVC and three-tier**



**Figure 4: web applications evolve Web Services development**

### 4.3 Web Services

There are four possible web service resources for collecting web services on the Web, i.e. Services Portals or Directories [26], [28]. In recent years,

several Web service portals or directories have emerged such as WebServiceList, RemoteMethods, WSIndex, and XMethods.net [26]. However, due to the fact that these Web-based service directories fail to adhere to original Web services' standards such as UDDI [27]. Based on these reasons, there is a need to establish a well-defined web service principle that can potentially be obeyed for web service development that hits a well-defined web Services architecture, Figure 4 show that web application evolve Web Services development. The trends of development technology programming languages for Web Services, the index ranked Microsoft C# at the top with the highest percent rating, followed by Java and PHP. The term "Web Services" describes a standardized way of integrating Web-based applications using the XML, SOAP, WSDL and UDDI open standards over an Internet protocol backbone. XML is used to tag the data, SOAP is used to transfer the data, WSDL is used for describing the services available and UDDI is used for listing what services are available. Web services are not tied to any one operating system or programming language. For example, Java can talk with Perl, Windows applications can talk with UNIX applications. It doesn't require the use of browsers or HTM and it is sometimes called by application services. The implementation codes for using Web Service applications are shown as Figure 5, return HTTP status codes (i.e. 200: OK, 401: Unauthorized 500: Internal Server Error, 503: Service Unavailable and so on), Table 1 show the breakdown of HTTP status codes.

### 4.4 Web 2.0

Web 2.0 describes web sites that use technology beyond the static pages of earlier web sites. The term was coined in 1999 by Darcy DiNucci and was popularized by Tim O'Reilly at the O'Reilly Media Web 2.0 conference in 2004 [15], [16]. Although Web 2.0 suggests a new version of the World Wide Web, it does not refer to an update to any technical specification, but rather to cumulative changes in the way web pages are made and used. Currently, the term "Web 2.0" has clearly taken hold, with more than twenty million citations in Google. But there's still a huge amount of disagreement about just what Web 2.0 means, with some people decrying it as a meaningless marketing buzzword, and others accepting it as the new conventional wisdom [15]. Social Impact: The power of data connection and communication in Web 2.0 shows a potential of building up a closer society among virtual communities. The transparency of internet, in addition to speedy and widespread information transmission, is likely to become an efficient tool for public opinion collections and exchange. It will eventually help to improve domestic democracy in the near future. Commercial Impact: As a matter of fact, the definition of Web 2.0 varies from person to person and the perfect one doesn't exist yet. For

technical researchers, it showcases the prosperity of social softwares such as SNG and BLOG. For bloggers, Web 2.0 is a convenient environment for people to interact with one another in virtual world. As for venture capital providers, it represents new market opportunities and game rules in different walks of life. From entrepreneurs' point of view, Web 2.0 is a creative media, a cluster of social networks, and a brand new concept of business. For example, BLOG and Facebook are two of the popular and typical styles of Web 2.0 marketing. As Tim O'Reilly mentioned years before, if Netscape is the symbol of Web 1.0, Google undoubtedly represents the era of Web 2.0. Google discards traditional model to let companies look for target customers. On the contrary, it totally goes opposite direction to let consumers search for advertisements and products voluntarily. Many always ask about the difference between Web 2.0 and Web 1.0. Web 2.0 refers to how we are using the internet today. In virtue of no perfect one definition of Web 2.0 (some believe it is just a marketing term), ones say is that they don't think there's a trade or service mark on "Web 1.0." But O'Reilly has the service mark on Web 2.0. That's a big

difference too. To combine both of social and commercial impact in our surveys, we accept and vote it as the new conventional wisdom.

**Table 1: Breakdown of HTTP status codes for verifying Web Service**

Seq	Code	HTTP Responding Name	Description
1	200	OK/ Successful <sup>a</sup>	<sup>a</sup> : Users should verify that this value is 200 indicating that a good send/receive has occurred.
2	301	Moved Permanently	Service is removed or changed to the other sites.
3	400	Bad Request	Request is not valid.
4	401	Unauthorized <sup>b</sup>	<sup>b</sup> : the HTTP status code associated with the service call. A 401 value indicates a bad username or password.
5	403	Forbidden	Descriptions are the same with HTTP responding names.
6	404	Not Found	
7	405	Method Not Allowed	
8	406	Not Acceptable	
9	411	Length Required	
10	500	Internet Server Error	Server is not linked correctly or is down.
11	502	Bad Gateway	Gateway problem.
12	503	Service Unavailable	Service does not exist.
13	Others	Remote Server Error/ Invalid URL/ Invalid Service Response	Request isn't listed in service.
13	Customized definitions <sup>c</sup> (602/700/1001)	Unknown Address/ Outside USA/ Not retrieve ste codes	Address is not known. Address is not within USA. Link to Server Failed. <sup>c</sup> : Customized definitions depend on your request and development.

1. The implementation sample codes for **Web Services** by using .Net C# language.

2. Breakdown of HTTP status codes for verifying **Web Services**.

```

public String[] AddressLocationCode(strAddress[5])
{
    String[] addressInfo = new String[3];
    try
    {
        STE.setWebService(WebServiceType.STE_LOC_CODE,
            "http://cs2.symmetry.com/ste-location-ws/", "Proxy server", "userID", "userPswd", null);
        WebServiceLocationCodeV2 w = STE.webServiceGetLocationCodeV2(strAddress[5], null, null);
        int intHttpStatus = w.HttpStatus; //Get Web Service Status
        StringBuilder sbFaultcode = w.faultcode; //Fault code
        StringBuilder sbFaultstring = w.faultstring; //Fault string
        if (intHttpStatus != 200) //Please ref. Table 1: Breakdown of HTTP status codes
            //for verifying Web Service.
            Console.WriteLine("There is a error status code from getting Web Services!");
        addressInfo[0] = w.locationCode, addressInfo[1] = null, addressInfo[2] = null;
    }
    catch (Exception e)
    {
        Console.WriteLine("Use Web Service Exception:"+e.Message);
    }
    return addressInfo;
}
                    
```

```

STEPayrollCalculator STE = new STEPayrollCalculator("c:/ste/");
stePayrollWorldFPCCUSA.payrollCalculatorEntry pcEntry =
    new stePayrollWorldFPCCUSA.payrollCalculatorEntry();
String[] addressInfo = pcEntry.AddressLocationCode(strAddress[5]);
String strLocationCode1 = addressInfo[0] != null ? addressInfo[0].ToString() : "";
String strSchoolCode = addressInfo[1] != null ? addressInfo[1].ToString() : "";
String strMunicipalCode = addressInfo[2] != null ? addressInfo[2].ToString() : "";
                    
```

**Figure 5: the implementation codes (.Net C#) and breakdown of HTTP status codes for using Web Service applications**

### 4.5 Recovery Management

In our surveys, we introduce our recovery management solutions [17]. IBM's original designs of current system storage include DS4000/5000 series RAID (intermediate level), DS8000 series RAID (advance level) and SVC series (SAN Volume Controller) which is a virtual storage Gateway. All of the products mentioned above come with a storage replication adapter, a software which can work with VMware SRM (Site Recovery Manager), to establish an automatic disaster backup mechanism. The comparison of varies IBM recovery programs is shown as table 2.

**Table 2: The comparison of varies IBM recovery programs**

System Storage Product	Remote Replication Software	Type	
DS4000/5000	Enhanced Remote Mirroring	Metro Mirroring	synchronous
		Global Copy	asynchronous
		Global Mirroring	
DS8000	Metro Mirror	Global Copy	synchronous
		Global Mirror	asynchronous
		Global Mirror	
SVC	Remote Copy	Metro Mirror	synchronous
		Global Copy	asynchronous

\*: Only work with VMware SRM (Site Recovery Manager).  
Orange: we adopt recovery management solutions

#### 4.6 Cloud Computing and Virtual Machine

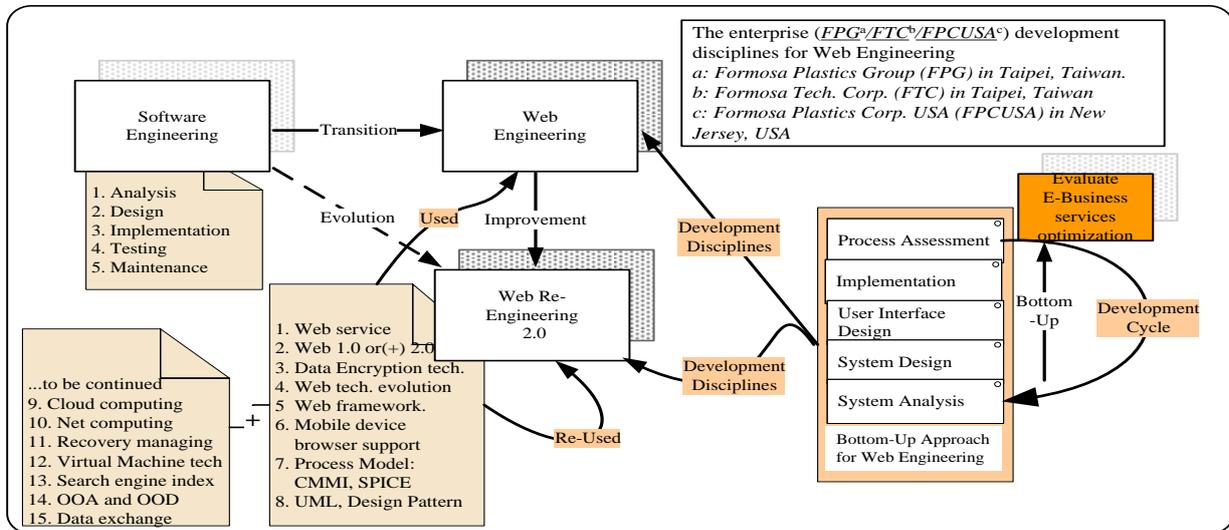
Cloud computing, or the cloud, used to describe a variety of different types of computing concepts that involve a large number of computers connected through a real-time communication network such as the Internet. Cloud computing is a term without the perfect and commonly accepted unequivocal scientific or technical definition. In science, cloud computing is a synonym for distributed computing over a network and means the ability to run a program on many connected computers at the same time. In marketing, cloud computing is mostly used to sell hosted services in the sense of application service provisioning that run client server software at a remote location. Such services are given popular acronyms like 'SaaS' (Software as a Service), 'PaaS' (Platform as a Service) [36], [37]. End users access cloud-based applications through a web browser, thin client or mobile application while the business software and user's data are stored on servers at a remote location. Consequently, the data-center hardware and software, as Software as a Service(SaaS), so we use that term, what we will call a cloud and adopt this concept to implement its service-oriented technique.

Virtual Machine Manager (VMM) is a management solution for the virtualized datacenter, enabling users to configure and manage virtualization host, networking, and storage resources in order to create and deploy virtual machines and services to enterprise, private or public clouds that users have created, depending on the requirements of users. The Virtual Machine Manager was developed by Red Hat in the Python language to control the life cycle of VMs, including provisioning, virtual network management, and statistics gathering and reporting as well as providing simple graphical access to the VMs [39]. The trends of development technology for VMM, the index ranked by some of the world's largest and most influential software companies, including IBM, Microsoft and Oracle, are three of the leading brands. In present IT's duty, the large-scale enterprise really needs to optimize their big-data center for delivering more value services and doing more business.

#### 4.7 Proposed Process Model

Reviewing software engineering development, it includes five major topics: 1. Analysis→2. Design→3. Implementation→4. Testing→5. Maintenance. Until Now, Software engineering also covers all the major topics associated with software architecture [31]. Various models to evaluate the process of software engineering have been proposed, among them CMM (1987-1997), CMMI (In 2002, version 1.1 was released) and SPICE. SPICE (ISO/IEC 15504 also known as SPICE - Software Process Improvement and Capability Determination) is especially appropriate for a small organization or company that needs to be able to show the results of specific improvement efforts. Because the result of a SPICE assessment is a profile of individual capabilities in many areas, it can make more small-scale improvements than the CMM assessment [32].

Capability Maturity Model Integration (CMMI) is a process improvement training and certification program and service administered and marketed by Carnegie Mellon University and required by many Government programs for government contracts, especially software development. Under the CMMI methodology, processes are rated according to their maturity levels, which are defined as: Initial, Repeatable, Defined, Quantitatively Managed, Optimizing. Currently CMMI Version 1.3 is supported by the Carnegie Mellon Software Engineering Institute (SEI). CMMI is registered in the U.S. Patent and Trademark Office by Carnegie Mellon University. Thus, we obey all processes of the CMMI development softwares, and Formosa Technologies Corp. (FTC) was certificated by CMMI Level 2 in November 10, 2006. Being a bottom-up approach, we promote UML [24] as a modeling language that can be used throughout all five major stages of software engineering. In fact, it is a very popular modeling language that many implementing software engineers use in their projects and works everyday. The enterprise development disciplines for constructing Web Engineering are shown as Figure 6. We evaluate e-business services depending on satisfaction of these, i.e. suppliers, purchasers, members, sellers, buyers and end users etc.



**Figure 6: the enterprise development disciplines for constructing Web Engineering**

### 4.8 Quality of Web Engineering

At the end of every web project process there should be a high-quality web application, because maintenance and documents are so essential that they should rather be seen as a part of the development. To evaluate a web application's quality in eight dimensions [20]. There will be quality assurance if all match with your project development. But the CMMI Level 2 is adopted for quality assurance, and its core process areas are listed below for development model. Maturity Level 2 [18], [19] – Managed, a. CM - Configuration Management, b. MA - Measurement and Analysis, c. PMC - Project Monitoring and Control, d. PP - Project Planning, e. PPQA - Process and Product Quality Assurance, f. REQM - Requirements Management, g. SAM - Supplier Agreement Management.

### 4.9 Better Solutions for Enterprises

Consolidating all above, we summarize that Table 3 shows five possible solutions of the 3-tier architecture in web evolution's world after we were familiar with these five and had more experience about all kinds of web projects and system softwares implementation. It is also a chart concludes better solutions for enterprises and companies B2B, B2G, and B2C e-commerce, e-project or e-business in the era of Web Engineering.

**Table 3: five possible solutions of the 3-tier architecture in web evolution [38]**

## 5. BENEFIT ANALYSIS

### 5.1 Implementation Results

In the paper [38], to integrate e-business web applications for web engineering, it is also the successful presentation of implementing web engineering for the enterprise's e-business and e-commerce solutions. In the other paper [5], the implementation of integrating e-Procurement, e-Contracting and e-Invoice platforms for the B2B E-MarketPlace web-based system, it obeys totally the CMMI development processes and is a successful platform to do business for the enterprise and others, i.e. suppliers, purchasers, members, sellers, and buyers etc. Consequently, the integration of e-business web applications can be also doing easily if web engineering is adopted fully and executed successfully. Undoubtedly web engineering brings the enterprise's computer digitalization, can be both convenient and eco-friendly ways to do business.

Despite the fact that today's Internet sites are designed, implemented and maintained in an ad-hoc way, we are convinced that sound web engineering is possible with the tools and techniques already available, Table 5, such as we use the software and hardware techniques listing of implementing the enterprise E-Business systems, i.e. ERP, E-Commerce, E-MarketPlace and Information systems etc.

	Kernel Program	Web Program	Data Base	Application Server	O.S. Platform	Cross Platform	Description
1	C++/C# +DCOM	ASP/ ASPX	SQL Server	IIS	Window	No	N/A
2	C++/C	PHP	My- SQL	Apache	Window /Linux /Unix	Yes- No MFC <sup>a</sup>	N/A
3	JavaBean +EJB <sup>b</sup>	JSP	Oracle	Tomcat /WAS <sup>c</sup>	Window /Solaris/Unix	Yes	WAS: IBM WebSphere Java app. server
4	PML <sup>d</sup> + Java <sup>e</sup>	HTML	AS400/DB2	Apache +WAS <sup>f</sup>	i Series <sup>g</sup>	No	1. WAS: BCD WebSmart web app. server 2. i Series fully support Java if using Java
5	PHP <sup>h</sup> + Java <sup>e</sup>	HTML	AS400/DB2	Apache +Zend <sup>i</sup>	i Series/ Window /Linux/Unix	Yes	1. Zend: Zend Tech. PHP app. Server (free or CE versions) 2. Zend and IBM have worked together to support PHP

a. MFC: Microsoft Foundation Class Library, MFC was introduced in 1992 with Microsoft's C/C++ 7.0 compiler.  
b. EJB: Enterprise JavaBeans was originally developed in 1997 by IBM.  
c. WAS: WebSphere Application Server is the IBM Application Server software.  
d. PML: Programming Macro Language was originally developed in 2001 by BCD WebSmart ILE BCD (Business Computer Design Int'l Inc. website <http://www.bcdsoftware.com>), and PML has 170+ functions. BCD's PML is also extendable—you can create your own functions into the tool's utilities.  
e. The IBM System i fully supports the Java language, including a 32/64-bit Java Virtual Machine (JVM).  
f. If the program is a WebSmart program, the WebSmart Web Application Server (WAS) is used to provide all the supporting functions for the programs to interact with a browser.  
g. The platform developed and manufactured in 1985 by IBM and was first introduced as the AS/400 (Application System/400) on June 21, 1985 and later renamed to the eServer iSeries in 2000. The latest version of IBM System i is 7.1, (announced on April 13, 2010 and) released on April 23, 2010. Version Support Schedule: <http://www-047.ibm.com/systems/support/i/planning/upgrade/suptschedule.html>  
h. BCD WebSmart PHP programs are written entirely in PHP and HTML 5000+ PHP functions cataloged and integrated into the WebSmart IDE.  
i. Zend Server refers to a PHP application server product line offered by Zend Technologies, released in 2009 with production support available for Windows and Linux. It is available in two versions, Zend Server and Zend Server Community Edition (CE versions).

## 5.2 Benefit Evaluations

a. Share all members information from both buyers and sellers, and the half month quantities of member and case in B2B E-MarketPlace and E-Commerce shown as Table 4. Members in the E-MarketPlace are qualified to apply for Purchase Order Financing from 7 banks working with Formosa Plastics Group ([http://www.efpg.com.tw/j2sp/mgt/mgt\\_logon.jsp](http://www.efpg.com.tw/j2sp/mgt/mgt_logon.jsp)). However, banks make final decision according to clients payment and credit records.

b. FPG computer digitalization saves up 4134 people and up to NTD \$3.8 billions (USD \$126 millions) of personnel cost [22] (the author is FTC's president), and the computerization brings much invisible and visible benefits every year. This is a huge incentive for e-commerce and web engineering development.

c. Reduce invoice related cost (issuing, printing, mailing and storage etc), according to Celent Communications LLC, an international financial research and consulting firm, sellers save up to USD\$15 per invoice while buyers save USD\$6~\$10 per invoice by using digital ones. Statistic indicates Taiwanese companies uses 8 billion paper-based invoice a year. However, if they switch to e-invoice, the whole country can save up to NTD\$2 billions (USD\$ 66 millions) every year [30]. These show time and cost-saving are the direct benefits coming from using e-invoice under web application development.

## 6. CONCLUSION

The days of creative chaos are gone and project managers and engineers have never forgotten everything they learned in their software engineering, programming and project management classes. It is the soundness of web engineering principles that is here to stay and go for Next-Generation Web Vision. In future, The CMMI Level 3 – Defined and Level 4 – Quantitative Managed will be adopted and obeyed for development process model and quality assurance. We also continue totally support to improve the enterprise's

digitalization and computerization, follow the soundness of web engineering principles for extending the enterprise's core competence.

**Table 4: Quantities of member and case in Formosa Plastics Groups E-Business (September/25/2013 - October/10/2013)**

Date	Suppliers	Vendors	E-Invoice members	Purchase cases	Contracting cases	E-Invoice Quantities	Bidding cases <sup>d</sup>	Web Bidding Vendors <sup>e</sup>	Web Bidding cases <sup>e</sup>
9/25	13925	9451	7871	11868	1771	277	165	11357	191
9/26	13705	9439	7871	12110	1750	182	180	11362	360
9/27	13729	9446	7871	11645	1720	301	162	11372	313
9/28	13737	9446	7871	11464	1862	127	134	11372	0 <sup>e</sup>
9/29	13740	9445	7871	11383	1827	96	127	11372	0
9/30	13746	9449	7871	11378	1498	189	146	11373	252
10/1	13755	9454	7871	12453	1693	195	159	11392	500
10/2	13760	9457	7871	12114	1756	214	188	11393	261
10/3	13772	9456	7871	11577	1895	247	215	11394	180
10/4	13779	9459	7871	11982	1920	196	259	11397	454
10/5	13780	9460	7871	12162	2214	85	253	11397	0
10/6	13782	9461	7871	12098	1952	107	244	11397	0
10/7	13789	9464	7871	12118	1953	184	271	11400	233
10/8	13807	9464	7871	13811	1861	244	280	11402	279
10/9	13813	9468	7871	14474	1904	215	288	11407	445
10/10	13827	9471	7871	13904	2043	281	247	11410	273

a: Buyers: 13, Contractees: 7, E-Invoice Core members: 162, Bidders: 6, b: E-Invoice core members in Buyer side: 84, E-Invoice core members in Seller side: 78, c: Formosa Technologies Corp. (FTC) open website in Chinese <http://www.efpg.com.tw>, d: Bidding cases in Taiwan, e: Bidding vendors and cases in USA, and there is no bidding cases on Saturday and Sunday

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## 8. REFERENCES

- Computing Conference, pp. 118–127, September 2001.
- [13] Fowler, M., Patterns of Enterprise Application Architecture, Addison Wesley, 2002.
- [14] Wayne W. Eckerson, "Three Tier Client/Server Architecture: Achieving Scalability, Performance, and Efficiency in Client Server Applications" Open Information Systems 10, no. 1, pp. 3-20, January 1995.
- [15] O'Reilly, T., "What Is Web 2.0". O'Reilly Network, September 2005, <http://oreilly.com/web2/archive/what-is-web-20.html>, Retrieved, Sep. 1 2013.
- [16] O'Reilly, T., "Web 2.0 Compact Definition: Trying Again", O'Reilly Network, December 2006, <http://radar.oreilly.com/2006/12web-20-compact-definition-tryi.html>, Retrieved, Sep. 1 2013.
- [17] IBM, "Recovery Management", Software and Hardware Documentation, <http://www.ibm.com>, Retrieved, March 1 2013.
- [18] Software Engineering Institute, "CMMI Overview", Carnegie Mellon Univ., <http://www.sei.cmu.edu/cmmi/>, Retrieved, Sep. 1 2013.
- [19] Software Engineering Institute, 2006, "Standard CMMI Appraisal Method for Process Improvement (SCAMPISM) A, Version 1.2: Method Definition Document", CMU/SEI-2006-HB-002, Retrieved, Sep. 1 2013.
- [20] T.A. Powell, D.L. Jones and D.C. Cutts, "Web Site Engineering: Beyond Web Page Design", Prentice Hall, 1998.
- [21] F. Budinsky, G. DeCandio, R. Earle, T. Francis, J. Jones, J. Li, M. Nally, C. Nelin, V. Popescu, S. Rich, A. Ryman, and T. Wilson, "WebSphere Studio overview". IBM Systems Journal, volume 43, issue 2, pp. 384-419, 2004.
- [22] R.-Y. Wang (FTC's president), M.-J. Tang, "A case study: Formosa Technologies Corp. (FTC), the extension of the enterprise's Core Competence", EMBA Master Thesis in Chinese, National Taiwan University, 2002.
- [23] P. Pinheiro da Silva and N.W. Paton, "User Interface Modeling with UML", Proc. of the 10th European-Japanese Conference on Information Modeling and Knowledge Bases, pp. 208-222, May 2000.
- [24] IBM, "Rational Unified Modeling Language", UML Resource Center, <http://www-01.ibm.com/software/rational/uml/>, Retrieved, Sep. 1 2013.
- [25] TIOBE SOFTWARE, "TIOBE Programming Community Index for August 2013", TIOBE Index, <http://www.tiobe.com/index.php/content/paperinfo/tpci/index.html?date=jan2013>, Retrieved, August 1 2013.
- [1] E. Weippl, I. K. Ibrahim, W. Schwinger, W. Winiwarter, "Web Engineering for Intranets: Rethinking Software Engineering", 4th Int'l Conference on Information Integration and Web-based Applications & Services, Sep. 10 2002.
- [2] Y. Deshpande and S. Hansen, "Web Engineering: Creating Discipline among Disciplines", IEEE Multimedia, Vol. 8, No. 1, pp. 81-86, January 2001.
- [3] G. Kappel, B. Proll, Seiegfried, and W. Retschitzegger, "An Introduction to Web Engineering", in Web Engineering, Gerti Kappel, et al. (eds.) John Wiley and Sons, Heidelberg, Germany, 2003.
- [4] J. Conallen, "Modeling Web application architectures with UML", Communications of the ACM, 42: pp. 63-70, 1999.
- [5] Hsien-Yu Lee, N.-J. Wang, "the Implementation of Integrating e-Procurement, e-Contracting and e-Invoice platforms for the B2B E-MarketPlace web-based system", International Journal of Engineering Research, Volume 2, Issue 4, pp. 300-309, August 1 2013.
- [6] Microsoft website, Study: <http://www.microsoft.com/net>, Retrieved, Sep. 1 2013.
- [7] PHP website, Study: <http://www.php.net>, Retrieved, Sep. 1 2013.
- [8] Java website, Study, <http://www.java.com>, Retrieved, Sep. 1 2013.
- [9] BCD website, Study, <http://www.bcdsoftware.com>, Retrieved, March 1 2013.
- [10] BCD, ESDI, "WebSmart ILE User Guide", Software Documentation, <http://www.bcdsoftware.com>, Retrieved, March 1 2013.
- [11] WIKIPEDIA resource website, Study: <http://en.wikipedia.org/wiki/ASPX>, Retrieved, Sep. 1 2013. <http://en.wikipedia.org/wiki/PHP>, Retrieved, Sep. 1 2013. [http://en.wikipedia.org/wiki/JavaServer\\_Pages](http://en.wikipedia.org/wiki/JavaServer_Pages), Retrieved, Sep. 1 2013.
- [12] A. Leff, James T. Rayfield, "Web-Application Development Using the Model/View/Controller Design Pattern". IEEE Enterprise Distributed Object

- [26] Web service portals and directories, Study: <http://www.webservicelist.com>, Retrieved, Sep. 1 2013. <http://www.remotemethods.com>, Retrieved, Sep. 1 2013. <http://www.wsindex.org>, Retrieved, Sep. 1 2013. <http://www.xmethods.net>, Retrieved, Sep. 1 2013.
- [27] UDDI Version 3.0.2 Specifications, October 2004, [http://uddi.org/pubs/uddi\\_v3.htm](http://uddi.org/pubs/uddi_v3.htm), Retrieved, Sep. 1 2013.
- [28] E. Al-Masri and Q. H. Mahmoud, "Investigating web services on the world wide web", Proc. Of the 17th Int'l Conference on World Wide Web, pp. 795-804, April 2008.
- [29] Fowler, M., GUI Architectures, July 18 2006, <http://martinfowler.com/eaaDev/uiArchs.html#ModelViewewController>, Retrieved, Sep. 1 2013.
- [30] Hsu, Y.-T., "E-Invoice topics in Chinese". iTHome Network, May 16, 2007, <http://www.ithome.com.tw/itadm/article.php?c=43350>, Retrieved, Sep. 1 2013.
- [31] L. Bass, P. Clements and R. Kazman, Software architecture in practice, Addison-Wesley, Bonn, Paris, Reading, MA, 1999.
- [32] The Spire Project Team, The SPIRE Handbook: Better, Faster, Cheaper Software Development in Small Organizations, The European Community, 1998.
- [33] P. Bourque and J.W. Moore, SWEBOK: Guide to the Software Engineering Body of Knowledge - Version 3-Draft. Joint IEEE Computer Society - ACM committee, <http://www.swebok.org>, September 18, 2011.
- [34] ISO/IEC TR 19759:2005, SWEBOK: Guide to the Software Engineering Body of Knowledge, International Organization for Standardization, [http://www.iso.org/iso/iso\\_catalogue/catalogue\\_tc/catalogue\\_detail.htm?csnumber=33897](http://www.iso.org/iso/iso_catalogue/catalogue_tc/catalogue_detail.htm?csnumber=33897), Retrieved, Sep. 1 2013.
- [35] WIKIPEDIA resource website, Study: [http://en.wikipedia.org/wiki/Web\\_engineering](http://en.wikipedia.org/wiki/Web_engineering), Retrieved, Sep. 1 2013.
- [36] X. Chu, K. Nadiminti, C. Jin, S. Venugopal, and R. Buyya, "Aneka: Next-Generation Enterprise Grid Platform for e-Science and e-Business Applications", Proc. 3rd IEEE Int. Conf. on e-Science and Grid Computing (e-Science 2007, IEEE CS Press, CA, USA), pp. 151-159, Dec. 10-13, 2007, Bangalore, India.
- [37] R. Buyya, C.-S. Yeo, S. Venugopal, "Market-Oriented Cloud Computing: Vision, Hype, and Reality for Delivering IT Services as Computing Utilities", Proc. 10th IEEE Int. Conf. on High Performance Computing and Communications, pp. 5-13, September, 2008.
- [38] Hsien-Yu Lee, N.-J. Wang, "The Implementation and Investigation of Integrating e-business web Applications for Web Engineering", International Journal of Scientific Engineering and Technology, Volume 2, Issue 10, pp. 967-978, October 1 2013.
- [39] M. Tim Jones, Managing VMs with the Virtual Machine Manager, IBM developer Works, October 31 2012, <http://www.ibm.com/developerworks/cloud/library/cl-managingvms/>, Retrieved, Sep. 1 2013.

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**Table 5: the software and hardware techniques listing of implementing the enterprise E-Business system for Web Engineering**

IJSHRE

IJSHRE

Techniques Listing	Manufacturer	Product name (VaaS) Techniques/skills	Program Languages /Services	Embedded(Default) Specifications	Location* (ITSA, Tamara)	Evolve Immense
Cloud Net computing	Oracle	8.1.7(2000), 9.2(2002), 10.2(2005)	Database tools and skills(Item 5)	The data-center hardware and software, as Software as a Service(SaaS), so we use that term,	Both	Yes
	IBM	V5R4(2006), V6R1(2008),				

IJSHRE

		BCD <sup>+</sup> +ESDF <sup>+</sup>	BCD.com	WebSmart reference	Consulting questions		
	Hardware	Sun RISC <sup>+</sup>	SPARC <sup>+</sup> -based: Sun 4	Built in default or upgrade	For Oracle Solaris OS, Default or	Taiwan	N/A
12	specifications		(ORACLE <sup>+</sup> 11.1.1.4/2000-2002) or later		upgrade		
		IBM	IBM Power 4 or later		For IBM AIX OS, Default or upgrade	Both	